Thrombosis in Giant Basilar Tip Aneurysms during Coil Embolization

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Summary: Two patients with giant basilar tip aneurysms underwent coil embolization, one with both platinum fiber and platinum Guglielmi detachable coils and the other with Guglielmi detachable coils only. In both cases, spontaneous intraaneurysmal thrombosis occurred outside the coil mass, presumably a result of disruption of the intraaneurysmal flow pattern.

Index terms: Aneurysms, embolization; Interventional instruments, coils

During the last decade, endovascular treatment has been accepted as a therapeutic alternative to surgery in the management of giant vertebrobasilar aneurysms, which are considered inoperable or pose an unacceptable surgical risk. Surgical treatment of these aneurysms is difficult even in the most experienced hands and is associated with a mortality rate of 25% to 50% (1, 2).

Until recently, endovascular treatment of intracranial aneurysms has depended mainly on the use of detachable balloons to obliterate the aneurysm or parent vessel. However, the inability of the balloons to adapt to the irregular shape of the aneurysm may result in stress and strain on the aneurysm during balloon placement and detachment, with the risk of aneurysm rupture.

Recently the placement of soft metallic coils within the lumen of the aneurysm has become possible. With the advent of Guglielmi detachable coils (an experimental device currently under review by the Food and Drug Administration), which use the principle of electrothrombosis and which allow more controlled coil placement and detachment (3, 4), coil use may increase significantly.

Our experience with coil embolization in two patients with giant basilar tip aneurysms is described. Thrombosis within the coil mesh work is well recognized, but in both patients, spontaneous intraaneurysmal thrombosis occurred remote from the coils. This phenomenon is likely to result from alteration of the blood flow pattern within the aneurysm.

Case Reports

Case 1

A 30-year-old woman presented with a long history of episodic, severe frontal headache. At the time of admission, the headaches were daily, worse in the morning, lasted up to 10 hours, and lately had been associated with vomiting. Physical examination revealed no abnormality. Contrast-enhanced cranial computed tomography and magnetic resonance revealed a giant basilar tip aneurysm. This was confirmed by vertebral angiography (Fig 1A and B), which demonstrated rapid and rotatory flow within the aneurysm lumen.

It was decided to treat the aneurysm by coil embolization using Guglielmi detachable coils, in a staged procedure. A 6F guiding catheter was introduced into the left vertebral artery; through it was passed a Tracker 18 Guglielmi detachable coil variable-stiffness catheter (3F tapering to 2.5F) with a steerable guide wire (Target Therapeutics, San Jose, Calif). The variable-stiffness catheter was introduced into the aneurysm, and through this catheter five platinum Guglielmi detachable coils (Tracker 18, 8-mm helix by 40-cm length) were inserted sequentially, without complication. The detachment time for four of the coils ranged from 11 to 25 minutes, but the fifth coil had still not detached at 100 minutes. The delivery wire was torqued, and the fifth coil was successfully released. At this stage the procedure was terminated, and it was estimated that approximately 40% of the aneurysm had been occluded (Fig 1C and D). The patient remained well.

Four days later, a repeat angiogram was performed (Fig 1E and F) with the intent of further coil embolization. It was noted that a significant proportion of the aneurysm had completely thrombosed, not only within the coils but also over the aneurysm dome, anteriorly, and on the right, outside the coil mass.

Five more coils (Tracker 18, one 8-mm helix, 40-cm length, and Tracker 10, three 8-mm helix, 40-cm length,

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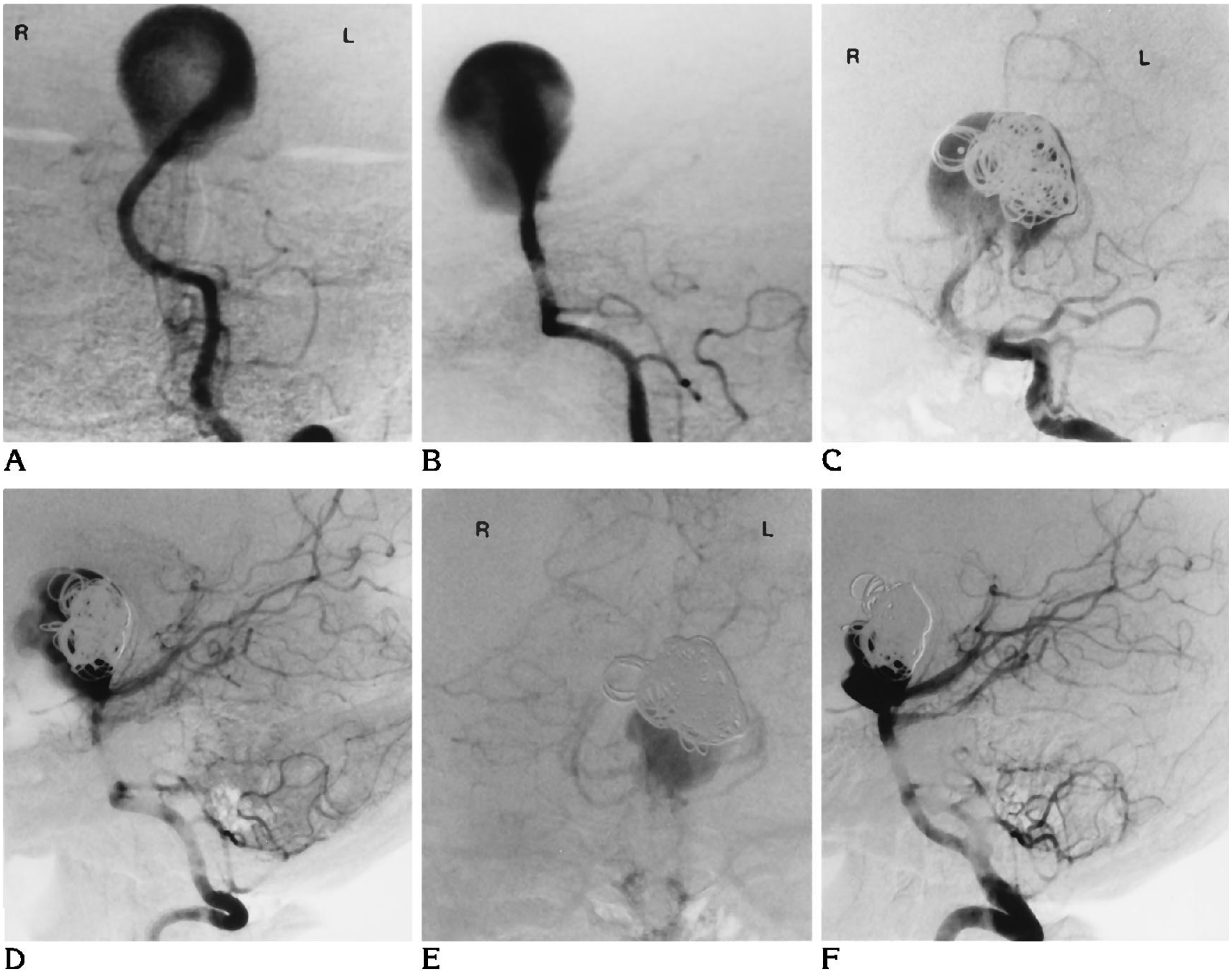


Fig 1. *A* and *B*, Anteroposterior and lateral digital subtraction angiographic image of the posterior fossa arterial circulation confirms the presence of a giant basilar tip aneurysm (a termination-type aneurysm). The basilar artery is angled to the left. The direction of the inflow jet of contrast is upward and to the left, and its passage is predominantly anterior and to the right over the dome of the aneurysm.

C and *D*, Anteroposterior and lateral subtraction left vertebral angiogram performed at the end of the first Guglielmi detachable coil embolization procedure demonstrates approximately 40% aneurysm occlusion. The coils are positioned directly in the path of the high-velocity inflow jet entering the aneurysm neck. Note the appearance of the anterior aspect of the aneurysm, suggesting thrombus formation, remote from the coils.

E and *F*, Anteroposterior and lateral subtraction left vertebral angiogram taken at the start of the second procedure, 4 days later, demonstrates progressive intraaneurysmal thrombosis, not only in the mesh work of the coils but also significantly over the dome, anteriorly, and on the right, remote from the coils. Comparing this image with *C* and *D*, it seems likely that thrombus formation remote from the coils commenced actually *during* the first procedure. The percentage of aneurysm occlusion is now approximately 70%. *Figure continues.*

and one 6-mm helix, 20-cm length) were successfully inserted, as described above, without complication. Detachment times ranged from 7 to 20 minutes, and at the end of the procedure, approximately 90% aneurysm occlusion was achieved (Fig 1G and H).

Six weeks later, follow-up angiography (Fig 1I) showed that the residual lumen had significantly increased in size. Further Guglielmi detachable coil embolization using two 8-mm × 40-cm coils, two 6-mm × 20-cm coils, and two 5-mm × 15-cm coils resulted in 100% occlusion (Fig 1J).

Case 2

A 47-year-old hypertensive man was admitted in an emergency after a generalized convulsion; he had a history of increasing headache over a period of weeks. Physical examination findings were normal apart from diplopia on right lateral gaze. Cranial computed tomography demonstrated blood in the third and fourth ventricles and basal cisterns.

Vertebral angiography revealed a giant basilar tip aneurysm; again, rapid rotatory blood flow was noted within

the aneurysm lumen (Fig 2A and B). We decided to perform coil embolization using 20-mm and 30-mm platinum fiber complex helical coils (Target Therapeutics) (Guglielmi detachable coils were not available at the time).

A 6F guiding catheter was introduced into the left vertebral artery, and 18 coils were placed within the aneurysm via a Tracker 18 unibody variable-stiffness catheter (3F tapering to 2.5F) achieving 40% to 50% aneurysm occlusion (Fig 2C and D). The patient remained well.

One week later, the patient was reexamined angiographically as a prelude to repeat embolization. At the beginning of the second procedure, considerable thrombosis of the aneurysm had occurred spontaneously, superior, anterior, and to the right of the coils (Fig 2E and F). The remaining loculus was embolized with two 3-cm-long coils and five 2-mm-diameter coils. At the end of the procedure, a small loculus still remained (Fig 2G and H). We decided not to embolize this further in case of coil impingement into the basilar termination.

The patient remained well and was reexamined 2 months later when significant enlargement of the residual aneurysm had occurred. An additional three 30-mm and two 20-mm coils were placed into the aneurysm, and once more a small residuum remained. Although the patient remained asymptomatic, angiograms performed 4 and 16 months subsequently again demonstrated progressive enlargement of the lumen without change in the external diameter but with circumferential redistribution of coils (Fig 2G).

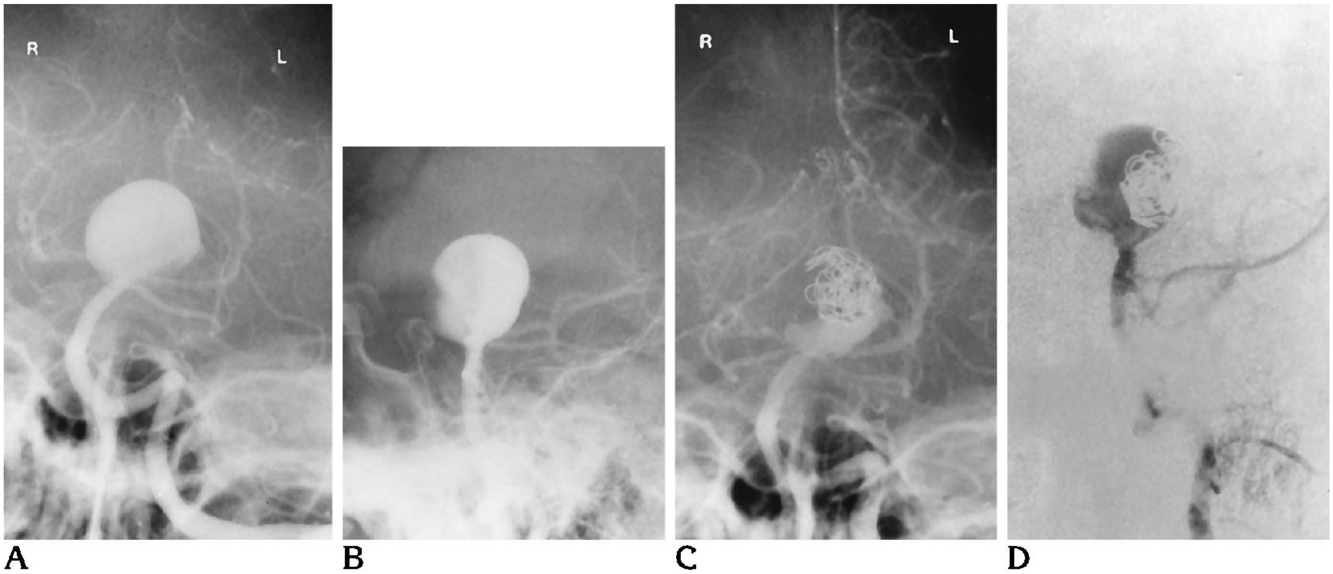


Fig 2. *A* and *B*, Anteroposterior and lateral left vertebral angiogram before embolization.
C and *D*, Lateral subtraction image of a left vertebral angiogram shows approximately 40% aneurysm occlusion at the end of the first procedure. The coils are again positioned directly in the path of the high-velocity inflow jet. Thrombosis has already commenced anteriorly away from the coil mass. *Figure continues.*

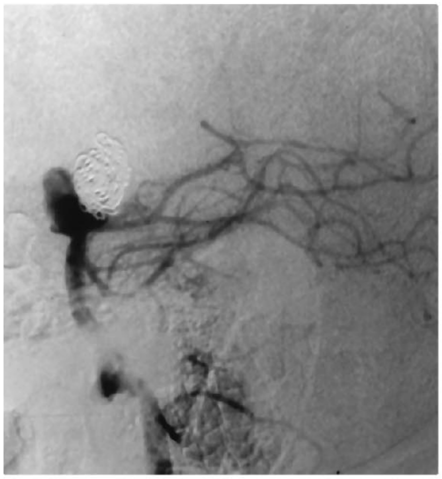
Guglielmi detachable coil embolization was then performed via a Guglielmi detachable coil Tracker 18 variable-stiffness catheter (3F tapering to 2.5F). Six 8-mm × 40-cm coils, one 8-mm × 40-cm, and two 6-mm × 20-cm coils were successfully inserted, and 95% or greater aneurysm occlusion was achieved (Fig 2H). If the aneurysm is not completely occluded at follow-up, then further Guglielmi detachable coil embolization is planned.

Discussion

Coil embolization is described in two patients with giant basilar tip aneurysms. The thrombogenicity of platinum-fiber coils is enhanced by the attached dacron fibers. These coils are extruded through the variable-stiffness catheter using a coil pusher. Guglielmi detachable coils are platinum spiral coils with a circular memory, soldered to a stainless steel delivery system. When this coil is positioned within the variable-stiffness catheter, it adopts a straight shape and may be easily advanced into the aneurysm. When the coil has been placed in a satisfactory position, a low-voltage positive direct electric current (0.5 to 1.0 mA) is applied to the stainless steel guide wire. The platinum coil, now positively charged, attracts the negatively charged blood particles, resulting in electrothrombosis. The electric current also induces electrolysis at the solder joint, and the coil is gradually detached (3). The size and weight of the thrombus is directly proportional to the coulombs (milliamperes times minutes) of electricity delivered.

In both patients spontaneous thrombosis in the aneurysm occurred outside the coil mass. The responsible mechanism is thought to be altered aneurysm hemodynamics. Hemodynamic forces are known to be important in aneurysm thrombosis and are also important in terms of the occurrence, growth, enlargement, and rupture of intracranial saccular aneurysms (5–7). Although the precise factors are not known, the geometrical relationship between an aneurysm and its parent artery; the size of neck and aneurysm volume are thought to be important in determining the intraaneurysmal flow pattern (6–8). The aneurysm flow characteristics in both patients are of the terminal type, with rapid rotatory flow and a high-velocity jet within the inflow zone located at the side of the ostium nearest an imaginary line passing through the long axis of the parent vessel (9).

In both patients, the coils were deposited directly in the path of the high-velocity jet entering the aneurysm neck, thereby decreasing aneurysm volume and obstructing the inflow track and subsequent passage of blood within the aneurysm. It is considered likely that the coil mass, by reflecting the inflowing blood, would initiate stasis within the aneurysm and precipi-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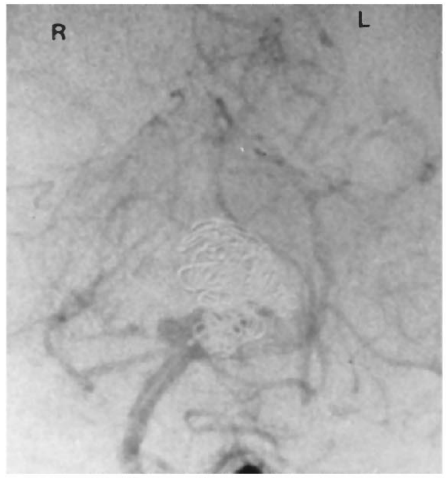

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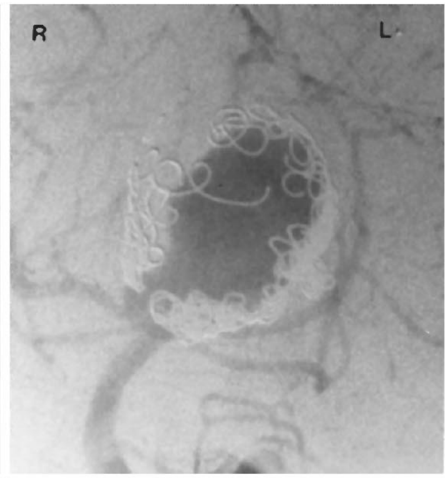

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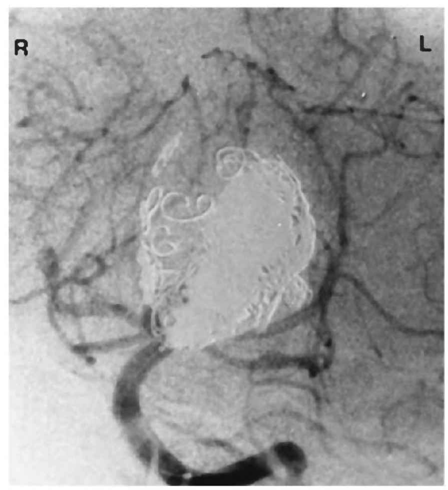

H

Fig 2—continued.

E, Image corresponding to that of *D*, taken at the beginning of the second procedure, 1 week later, demonstrates progressive spontaneous intraaneurysmal thrombosis, superiorly over the dome, anteriorly and to the right of the coil mass. The residual lumen is now approximately 30%, with 70% intraaneurysmal thrombosis.

F, Anteroposterior subtraction image of a left vertebral angiogram at the end of the second coil embolization demonstrates a small residual loculus inferiorly, posteriorly, and on the right. Once again, the inflow is neither obstructed nor displaced.

G, Anteroposterior subtraction image of the left vertebral angiogram demonstrates progressive luminal enlargement of the aneurysm with circumferential rearrangement of the coils. Recanalization has taken place within the coil mass. Redistribution of the coils must have occurred as a result of thrombolysis. Note that the aneurysm has enlarged in the direction of the high-flow velocity jet demonstrated at the aneurysm neck on the original angiogram.

H, Anteroposterior subtraction left vertebral angiogram after Guglielmi detachable coil embolization demonstrates 95% or greater aneurysm occlusion. A tiny loculus remains on the *right*, posteriorly, but the inflow is now obstructed.

tate to thrombus formation. In both cases, the direction of the inflow jet was upward and to the left, followed by its passage over the dome, anteriorly and to the right. By impeding the initial flow, the coils inhibited blood making this passage; hence, stasis and subsequent thrombosis would result.

In the canine model, complete aneurysmal thrombosis has been shown to depend on complete obstruction of the inflow zone, displacement of the inflow zone, and complete luminal filling (10). None of these factors had been achieved initially in either patient, and it is therefore hardly surprising that aneurysm recanalization occurred in each case. Thrombus formation and dissolution is the product of an unstable dynamic balance between coagulation and fibrinolysis. Unfortunately, detailed histopathologic information about thrombus evolution and organization within aneurysms is not available. Thrombus evolution involves fibrinolysis with potential subsequent embolization and organization. Completely organized thrombi are converted to smooth muscle and collagen. Mononuclear cells within the fibrinous matrix differentiate into either macrophages responsible for hematoclasia and hematophagocytosis. Endothelial cells that line autolytic slits in the fibrinous matrix form new capillaries. Last, fibroblasts and smooth-muscle cell precursors form connective tissue. Persistence of any aneurysm lumen inhibits complete thrombus organization.

It is interesting to note that in case 1 aneurysm recanalization occurred outside the coil mass where Guglielmi detachable coils had been used. This contrasts with case 2, in which platinum-fiber coils were used and recanalization occurred within the coil mass with circumferential redistribution of the coils. The inflow jets were similar in both aneurysms, and it is postulated that the different sites of recanalization are related to the type of thrombus and the type of coil. It is suggested that the thrombus formed by the Guglielmi detachable coils differs from that formed in association with the non-Guglielmi detachable coils, and both are different to the thrombus formed outside the coil mass. The latter is formed secondary to blood stasis and is likely to resemble venous thrombus rather than arterial thrombus. Although the initial nidus in venous thrombus is composed of platelets, the bulk of the propagating thrombus comprises largely fibrin and red blood cells. In the case of the non-Guglielmi detachable coils, the thrombus is likely to resemble arterial thrombus, formed in a high-blood-flow location. The platinum-fiber coils act as a foreign body on which fibrinogen is adsorbed and platelets are deposited and aggregate. Thrombin is released by the aggregating platelets, and this enhances further platelet aggregation and fibrin formation, which may be associated with the entrapment of red and white cells. Arterial-type thrombus is, however, composed mostly of fibrin and platelets. In the case of the Guglielmi detachable coils, electrothrombosis also contributes to the thrombotic process, whereby red and white blood cells and fibrinogen in addition to platelets are attracted to and deposited on the foreign-body surface. The Guglielmi detachable coils also provide a larger surface area for this to occur than the small discrete non-Guglielmi detachable coils. It is suggested that Guglielmi detachable coils also form a stable framework and mesh to hold a possibly more stable thrombus and prevent recanalization within the coil mass. The inflow jet was deviated by the Guglielmi detachable coil mass and resulted in thrombolysis and recanalization outside the coil mesh in the "venous-type" thrombus. The discrete non-Guglielmi detachable coils may not form such a stable framework and may not prevent lysis and contraction of the thrombus between the coils. Recanalization therefore occurred within the coil mass with redistribution of the coils.

In conclusion, we have shown in two patients that by altering aneurysm hemodynamics in giant aneurysms, spontaneous intraaneurysmal thrombosis remote from the coil mass may occur. This observation may be used beneficially by staging coil embolization, but it is recommended that there be only a short delay between procedures, because failure to obliterate the aneurysm totally or to obstruct or displace the inflow zone may result in prompt aneurysm recanalization and possible rupture.

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