Does electrothrombosis occur immediately after embolization of an aneurysm with Guglielmi detachable coils?

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Does Electrothrombosis Occur Immediately after Embolization of an Aneurysm with Guglielmi Detachable Coils?

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Summary: Current options for treating cerebral aneurysms include surgical clipping and placement of Guglielmi detachable coils (GDCs). The latter system is reported to induce acute aneurysmal occlusion by a mechanism of electrothrombosis. We report our observations in the case of a ruptured aneurysm treated with GDCs and then surgically exposed 2 hours later. The lack of thrombus within the aneurysm and around the coils led us to question the mechanism of action of GDCs.

Index terms: Aneurysm, embolization; Interventional instruments, coils

Aneurysmal subarachnoid hemorrhage (SAH) occurs in approximately 28 000 persons a year in the United States. Current management options for ruptured and unruptured aneurysms include watchful waiting, hunterian ligation, trapping, clipping of the aneurysmal neck, and placing coils within the aneurysmal fundus and neck. The latter treatment may involve the use of both detachable and nondetachable coil systems.

Our approach toward the management of SAH can be considered aggressive. As with many other centers, we favor early open surgical intervention and aneurysmal obliteration in patients with Hunt and Hess scores of 1 to 3. Embolization by means of Guglielmi electrothrombotic detachable coils (GDCs) (Target Therapeutics, Fremont, Calif) tends to be reserved for patients with Hunt and Hess grades of 3 or 4, those who medically cannot tolerate an open surgical procedure, those with anatomy more favorable for coils, and those who refuse to undergo a craniotomy. Early aneurysmal obliteration provides an opportunity to reduce the likelihood of subsequent rerupture and to treat vasospasm with medical regimens, papaverine infusions, and balloon angioplasty.

Case Report

A 61-year-old right-handed woman was admitted to our hospital after a computed tomographic (CT) head scan showed diffuse interhemispheric, pericallosal SAH, intraventricular hemorrhage, and hydrocephalus (Fig 1A and B). The patient was arousable to voice yet quite lethargic, her speech was clear, and motor function was 5/5 on the right and 4/5 on the left (Hunt and Hess grade 4, Fisher grade 4). An arteriogram showed an aneurysm of the right middle cerebral artery (MCA) and a 4-mm aneurysm arising from the right pericallosal and callosomarginal bifurcation distal to an azygos A2 segment (Fig 1C and D). Because of the pattern of bleeding, it was believed that the SAH was caused by the lesion in the anterior cerebral artery (ACA), and, in view of the patient's clinical condition and the imaging findings, GDCs were selected as the first-line therapy.

With the patient under endotracheal general anesthesia, the aneurysm was embolized by using two GDCs in the manner described by Guglielmi et al (1, 2). Heparinization was not instituted (1–4). The first coil placed was a 4 mm × 10-cm GDC-10 and the second coil placed was a 3 mm × 8-cm GDC-10. Detachment times were 2:09 and 1:36 minutes, respectively. An attempt was made to place a third 2 mm × 8-cm GDC-10 coil; however, it proved too difficult to advance into the fundus and was subsequently removed. We suspected at this time that our catheter had perforated the aneurysm. A repeat contrast injection through the Tracker-10 (Target Therapeutics) catheter showed extravasation into the subarachnoid space. An arteriogram performed via the introducer catheter showed patent parent vessels and neither extravasation nor aneurysmal filling, leading us to conclude that the tip of the Tracker-10 catheter was through the aneurysmal fundus and resting in the subarachnoid space. The microcatheter was withdrawn into the azygos A2 and a repeat arteriogram showed neither extravasation nor aneurysmal filling (Fig 1E and F). The hole in the aneurysm appeared to have been occluded by the coils.

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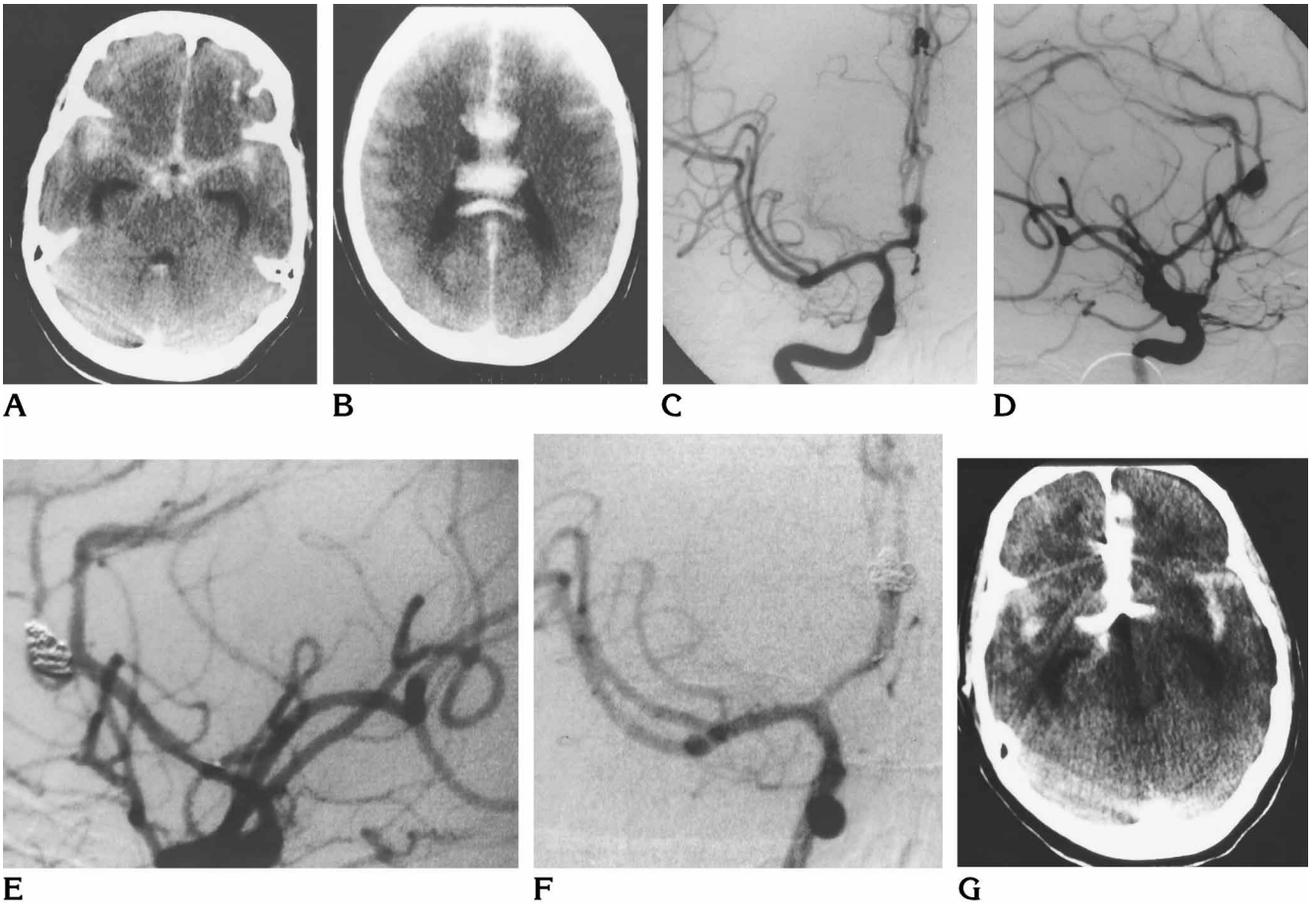

Fig 1. A 61-year-old woman with a ruptured aneurysm treated with GDCs.

A and *B*, Axial head CT scans show blood in the sylvian, suprasellar, and interpeduncular cisterns, interhemispheric fissure, and above the corpus callosum.

C and *D*, Lateral (*C*) and anteroposterior (*D*) right internal carotid artery arteriograms show an aneurysm at the origin of the pericallosal and callosomarginal arteries.

E and *F*, Lateral (*E*) and anteroposterior (*F*) views of the aneurysm after embolization with GDCs.

G, Axial head CT scan immediately after the procedure shows extravasated contrast material.

We immediately obtained a head CT scan, which showed no mass effect. The degree of SAH, intraventricular hemorrhage, and hydrocephalus was unchanged from the pretreatment study. Extravasated contrast material from the arteriogram was layered beneath the frontal lobes (Fig 1G). Over the next 2 hours, however, the patient failed to return to her previous level of function and was comatose. Two unsuccessful attempts were made to place a ventricular drain. Because of the neurosurgeon's concern about increased intracranial pressure, the patient was taken to the operating room where she underwent a right frontotemporal craniotomy, partial frontal and temporal lobectomy, and clipping of the ACA and MCA aneurysms.

Upon exposing the ACA aneurysm, the surgeon could see the coils through the aneurysmal dome. At the most superior aspect of the dome, a free portion of coil could be seen penetrating into the subarachnoid space. Blood could be seen swirling in the fundus around the coils and when the aneurysm was punctured with a 26-gauge needle, profuse bleeding was encountered. Proximal and distal control were obtained with temporary aneurysmal clips and the coils were removed from the aneurysm before the neck was clipped. No thrombus was encountered within the fundus. An initial attempt to clip the aneurysm with the coils in place was impossible owing to inadequate clip closure.

The patient was ultimately discharged to a rehabilitation program 1 month later. The CT scan revealed a left MCA infarct. Examination was notable for monoparesis of the right upper extremity. The patient intermittently followed commands, opened her eyes to stimulation, and was nonverbal (Glasgow outcome score of 3).

Discussion

In 1991, Guglielmi et al published their work describing the GDC system and its mode of

action in both experimental and naturally developing aneurysms (1, 2). These authors theorized that a positively charged electrode in the bloodstream would attract negatively charged white and red blood cells, platelets, and fibrinogen, thus promoting clot formation, an idea previously put forward by Sawyer et al (5, 6). Guglielmi et al went on to state that "during the passage of current, and by electrolysis, the uninsulated part of the stainless steel (introducer wire) dissolves, detaching the platinum coil within an acutely clotted aneurysm" (1, 2).

In 1995, F. Viñuela (personal communication) reviewed the results obtained in 735 ruptured aneurysms treated with GDCs by the USA Multicenter GDC Study Group. Complete obliteration of aneurysmal opacification was achieved in 33% to 62% of cases, depending on the size of the neck and fundus. Neck remnants alone were seen in 28% to 59% of cases. Postembolization hemorrhage occurred in 1% of cases. Aneurysmal recanalization was seen in 8% to 31% of cases, again depending on the aneurysm's size and the presence of pretreatment thrombus. This study clearly showed a reduction in short-term rehemorrhage rates when GDC technology was used. Long-term results are pending.

Despite these results, the mechanism of action of GDCs remains to be elucidated. Our experience with this case suggests that immediate aneurysmal thrombosis may not be as common as expected after the initial placement of GDCs and application of a positive current within the fundus before coil detachment. In our case, arteriography performed immediately after coil placement revealed a tight coil packing configuration in the aneurysm with no aneurysmal opacification, leading one to believe that the dome was filled with coils and had been isolated from the cerebral blood flow. Nevertheless, 2 hours later, the aneurysm contained swirling blood under high pressure and a paucity of thrombus.

The first step involved in the analysis of our finding consisted of calculating the aneurysmal volume and the volume of coils placed during the procedure. The maximum fundus diameter measured 4 mm. If we assume this to be a sphere (ideal configuration), the total aneurysmal volume would be 31.92 mm^3. The two coils used were 100 mm and 80 mm in length, respectively, and 0.010 in (0.254 mm) in diameter. Using the coil volume formula of $V = (r^2)$(coil length), we can calculate the volume of the 100-mm coil as 5.06 mm^3 and the volume of the 80-mm coil as 4.05 mm^3, for a total volume of 9.11 mm^3. Therefore, only 28% of the aneurysm is filled with coils when a tight packing is obtained. This degree of packing is consistent with that which the manufacturer found ideal in the treatment of experimental aneurysms (Target Therapeutics, personal communication).

We suggest, therefore, that the findings in this case can be explained in the following manner. The aneurysm failed to opacify not because it was filled with coils or because it was thrombosed and no longer filled with blood, but because the volume of contrast-laden blood entering the aneurysm was too small to be detected by the angiographic image intensifiers. GDCs, therefore, may provide protection from rehemorrhage in the period immediately following SAH, not by thrombosis of the aneurysm but possibly by buffering the pulsatile forces within the aneurysmal fundus and reducing the transmural pressure. Thrombosis of the aneurysm eventually occurs, but may do so because of turbulent flow within the fundus, which activates the clotting cascade, a situation analogous to the thrombosis induced in pseudoaneurysms by stents placed across the aneurysmal mouth (7).

Conclusion

The availability of GDCs expands the neurosurgeon's and neuroradiologist's armamentarium in the battle against intracranial aneurysms. While this technology reduces the frequency of secondary bleeding following SAH, the mechanism by which the coils occlude aneurysms has yet to be satisfactorily elucidated. The findings in this case argue against acute thrombosis of the aneurysm after coil deployment. More experimental studies are needed to understand better the means by which aneurysms are successfully treated with the GDC system.

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