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CORRESPONDENCE

Early Fatal Hemorrhage After Endovascular Treatment of a Giant Aneurysm with Flow Diverter Device and Coils

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Introduction

Flow Diverter Devices (FDD) are important tools for treating intracranial aneurysms [1–3]. Preliminary results suggest a favorable outcome, but there is not negligible risk of early and delayed rupture, especially for large and giant aneurysms [4, 6–11]. This complication significantly limits the efficacy of this technique. Several recent studies [7, 8] recommend use of coils in addition to the FDD to prevent delayed aneurysm rupture. We present a case of early fatal hemorrhage (< 24 h) after endovascular treatment of a giant supraclinoid carotid-ophthalmic aneurysm treated with FDD and coils.

Case Report

A 41-year-old woman was observed with progressive visual loss and ophthalmoplegia on the left side. Computed Tomography Angiography (CTA) and Digital Subtraction Angiography (DSA) showed a broad-based saccular aneurysm of the posterior wall of the left supraclinoid carotid artery. Its maximum diameter was 35 mm and the neck/sac ratio was 0.6 (Fig. 1).

Due to the aneurysm size and neck and the carotid localization, an endovascular approach with FDD was planned. A double antiplatelet therapy (75 mg daily of clopidogrel, in association with 150 mg of Aspirin) was administered 5 days before the procedure; the platelet response to the therapy was not tested before and after the treatment.

Under general anesthesia, a femoral access was obtained by means of single-wall puncture with an 8F vascular sheath. The patient received a heparin bolus of 5000 IU (to achieve a targeted activated clotting time of 200–300 s after femoral puncture) followed by bolus injections of 1000 IU after 60 min. A 8F guiding catheter (Guider, Boston Scientific) was advanced into the left common carotid artery. Diagnostic angiograms were obtained to define the optimal projections.

An intermediate catheter (Reflex 072 Catheter, Covidien) was advanced through the guiding catheter and placed into the left internal carotid artery (ICA); before the placement of the FDD, a micro-catheter (Echelon, Covidien) was introduced into the aneurysm sac. The length and size of the pipeline embolization device (PED) were chosen using the proximal ICA diameter near to the aneurysm neck, which was slightly ectatic. The distal tip of the first PED was placed into the proximal M1 segment, to improve the stability of the system; using the 'jailing' technique, a single PED (Covidien, Mansfield) (size 3.0 × 20 mm) was deployed, then 15 coils (Axium 3D, Covidien) were placed (Figs. 2 and 3).

Due to the large defect of the vessel wall at the neck and lack of radial force of the PED, after the deployment, when

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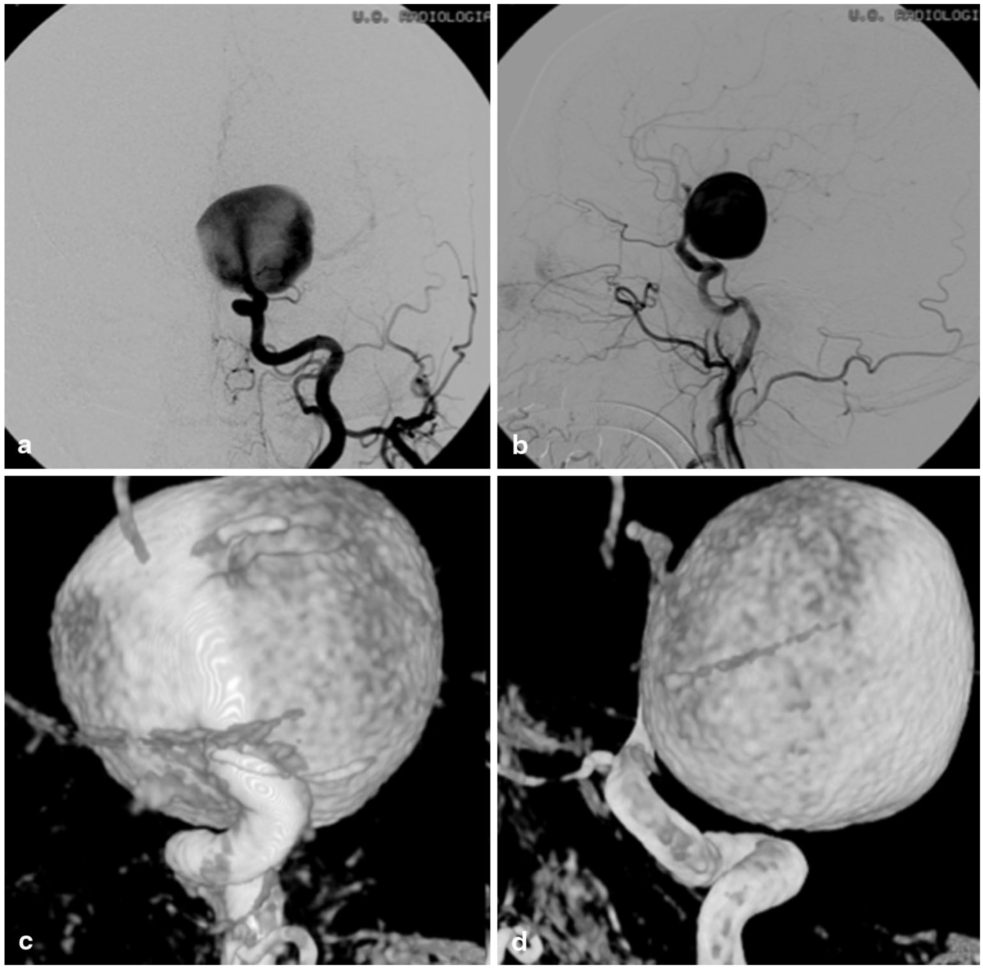


Fig. 1 Left Common Carotid Artery Angiogram—Frontal projection (**a**), lateral projection (**b**), and rotational reconstruction (**c**, **d**): DSA shows a broad-base giant (35 mm) aneurysm of the posterior wall of the internal carotid artery

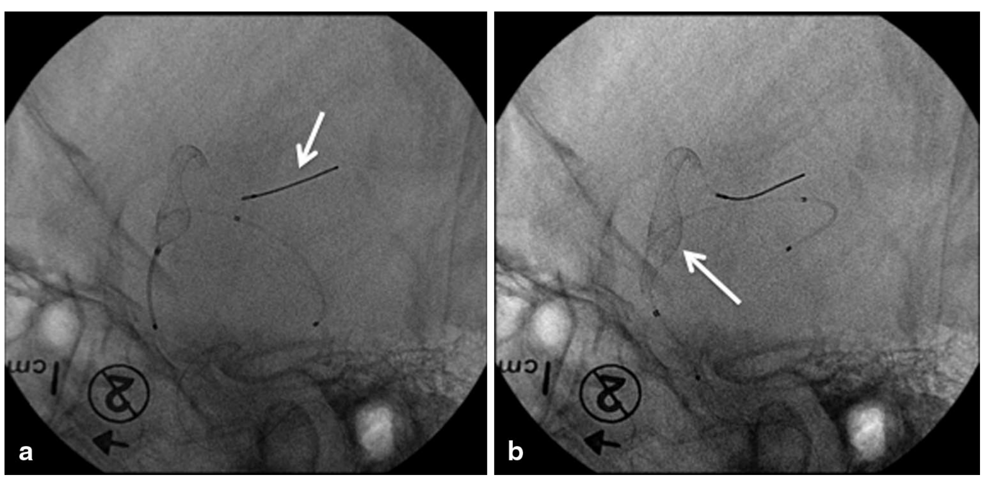


Fig. 2 Pipeline embolization device (PED) deployment—Non-subtracted lateral projection. Micro-catheter jailing into the aneurysm sac. The distal tip of the first PED is placed into the proximal M1 segment, to improve the stability of the system (**a**). Due to the large wall defect of the vessels at the neck, after the deployment the diameter of the device became larger and the length shorter (**b**)

the Echelon micro-catheter was removed, the device shortened and fell into the aneurysm sac; probably the length of the PED was underestimated, because of the device enlargement.

The ICA was then re-catheterized: the distal tip of the second PED was positioned just before the ICA bifurcation and a second device, longer than the first one (3.5 × 25 mm), was deployed with a good angiographic result (Figs. 4 and 5).

The procedure was well tolerated and the immediate post-procedural course was regular, with no neurological symptoms. However, 12 h later, during the night, the patient became comatose and was immediately intubated.

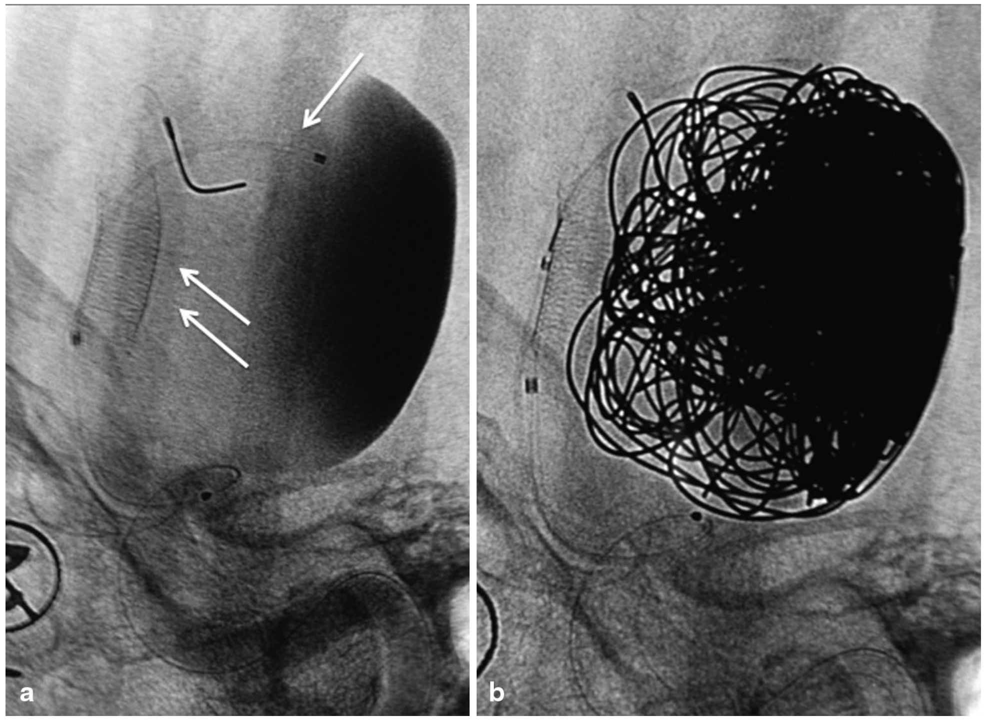


Fig. 3 Non-subtracted lateral projection: Echelon micro-catheter is jailed into the aneurysm sac and the first PED (3 × 20 mm) is deployed (**a**); the aneurysm dome is filled with 15 coils (**b**)

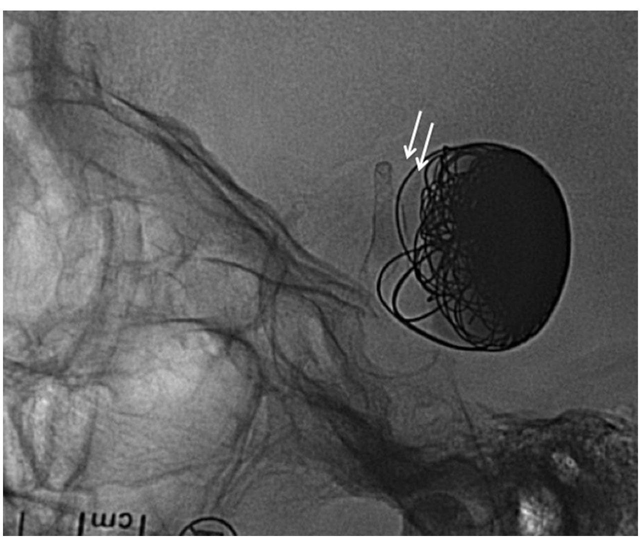


Fig. 4 Non-subtracted lateral projection: the first PED is displaced into the aneurysm sac (*arrow*); the second PED is placed in the left supraclinoid ICA

A CT scan showed diffuse subarachnoid hemorrhage (SAH) with ventricular spread (Fig. 6). No further treatment was decided. Rapid worsening up to brain death occurred and the patient died 24 h later.

Discussion

The post-procedural hemorrhage following treatment of giant aneurysm with FDD is not unusual regardless of its early or late occurrence. In a series of 897 patients Arrese et al. [1] reported an early mortality rate of 2.8 % and a late mortality rate of 1.3 %. Brinjikji et al. [2] found post-operative SAH in 3.6 %, cerebral hemorrhage in 3 % and ischemic stroke in 6 % in their meta-analysis.

Patients with small aneurysms had a significantly lower rate of post-operative SAH, with no correlation with the aneurysm location. In the Italian multicenter study Briganti et al. [3] reported a 2.5 % rate of delayed aneurysm rupture after FDD placement.

In the retrospective analysis of delayed aneurysm ruptures after flow diversion (RADAR) study a multicenter, worldwide survey on delayed rupture after flow diversion treatment, 1421 aneurysms were retrospectively reviewed. [4] Delayed rupture occurred in 1 % of all treated cases, with a higher rate (2.1 %), in the subgroup of aneurysms larger than 10 mm. In this survey all except one aneurysm with delayed rupture were larger than 19 mm (average size 24 mm). These data confirm that post-procedural rupture mainly occurs in large and giant aneurysms.

The present case experienced very early and fatal post-procedural hemorrhage, in spite of the attempt to treat a giant wide-neck carotid aneurysm with multiple devices (FDD and coils).

The evidence for adequate treatment of intracranial giant aneurysms in clinical trials is insufficient. Greving et al.

Fig. 5 Left common Carotid Artery Angiogram—Frontal projection (**a**) and Lateral projection (**b**): Aneurysm appearance after embolization procedure

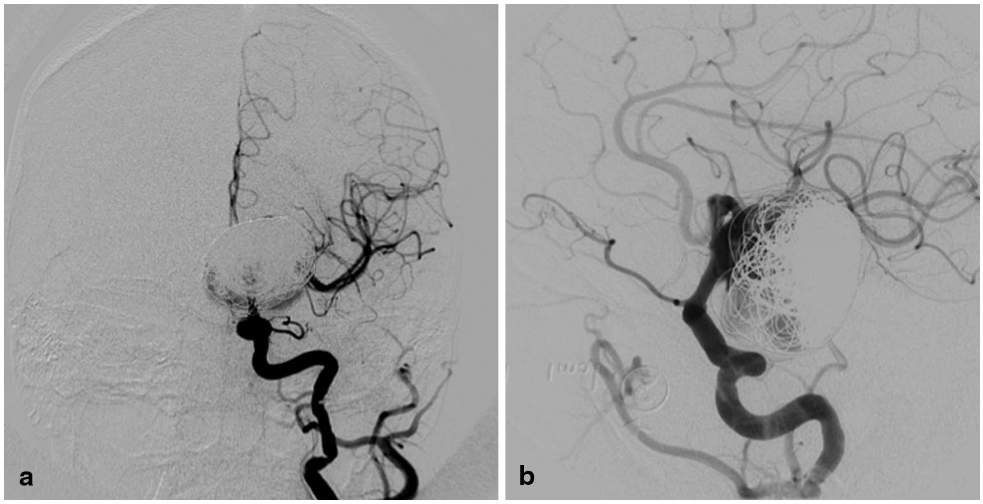
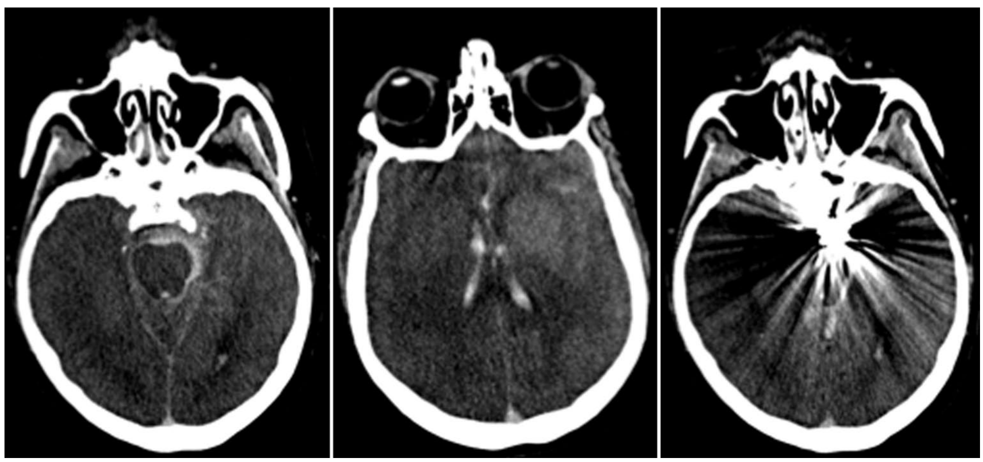


Fig. 6 CT scan 12 h after the procedure: diffuse subarachnoid hemorrhage with ventricular spread



[5] by using the PHASES score (Population, Hypertension Age, Size, Earlier SAH, and Site) for prediction of risk of rupture of intracranial aneurysms found that the size is the most important factor. Thus, the endovascular or surgical treatment is mandatory for giant aneurysms.

In the present case, both surgical clipping and coiling were considered more difficult, due to the large aneurysm size and wide-neck. Thus, an endovascular treatment with FDD was decided.

FDD are rapidly becoming an alternative to traditional endovascular treatment with coils. They provide the potential for the reconstruction of the diseased parent artery and cure, with an expected lower risk of recurrence [1–3].

Infact, FDD seem to induce changes of the arterial and intra-aneurysmal hemodynamics, resulting in progressive thrombosis, occlusion, and healing of the aneurysm.

The mechanisms leading to post-procedural aneurysm rupture are controversial. Two main theories have been suggested. The hemodynamic theory [12] hypothesizes that the reduction of flow in the aneurysm, after FDD deployment, corresponds to an increase of the pressure in the sac. In an experimental hemodynamic model, the increase of intra-aneurysmal pressure produces more stress on the aneurysm wall, especially in the distal portion of the neck ("in-flow" point); in large and giant aneurysms, with very weak wall, a small pressure increase could cause its rupture. In fact, the FDD does not seem to protect the aneurysm from the stress induced by pressure or pressure changes within the lumen; thus the increase of the intra-aneurysmal pressure can lead to rupture, especially for giant aneurysms.

This mechanism may explain the early rupture, as in the present case. It is likely that the inhomogeneous coil packing has probably turned the slow vortex flow to a smaller cavity with a more pulsatile and direct jet flow. Being exposed to the jet, the unprotected portion of the sac adjacent to the neck has ruptured.

The second theory (phlogistic) [6, 13] suggests that the rapid formation of the "red thrombus" is associated with high concentration of macrophages producing lytic enzymes, such as elastase; thus it can result in the progressive destruction of the aneurysm wall. This mechanism may explain some cases of delayed aneurysm rupture.

Table 1 Delayed ruptures of aneurysms treated with FDD in addition to coils

Author	Number of aneurysms treated with FDD + coils	Localization	Size (mm)
Kulcsár et al. 2011 [7]	1	SC ICA	>20
Siddiqui et al. 2012 [8]	1	MCA	>25
McAuliffe et al. 2012 [9]	2	SC ICA	>20
O'Kelly et al. 2013 [10]	1	NS	>15
Turowski et al. 2011 [11]	1	SC ICA	>15
Present report. Briganti	1	1 SC ICA	>25

SC ICA Supraclinoid internal carotid artery, *MCA* Middle cerebral artery, *NS* Not specified

The filling of aneurysm sac with coils in the same procedure should prevent aneurysm rupture after treatment with FDD; however, the rupture may occur despite additional coiling. [7–11]

We have found, in the recent literature, six cases of delayed aneurysm rupture after combined endovascular treatment with FDD and coils. [7–11] (Tab. 1) All patients had large (15–25 mm) aneurysms.

Conclusion

The endovascular treatment with FDD represents a good management option for large–giant wide-neck aneurysms. However, the risk of post-procedural early or late aneurysm rupture is not negligible. The coiling does not prevent the rupture, probably because of the difficulty of complete coil packing of large and giant aneurysms. Moreover, inhomogeneous packing with FDD may generate unfavorable flow conditions in a small portion of the aneurysm, potentially resulting in rupture of hemodynamic origin, as in this case. Further randomized studies on large patient population may define the best endovascular management of large–giant aneurysm to significantly reduce the risk of post-procedural hemorrhage.

Conflict of Interest F. Briganti serves as proctor for Covidien and receives a modest remuneration.
The other authors have no conflict of interest.

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