Embolization of Non-Ruptured Aneurysms

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Summary

Options for treatment of intracranial aneurysms have expanded with the advent of the Guglielmi Detachable Coil (GDC) eight years ago. We have reviewed 435 cases of intracranial aneurysms treated at UCSF by endovascular means using the GDC system. Of these, 55% represent anterior circulation aneurysms, and 45% are located in the posterior circulation. Additionally, 55% of the aneurysms presented with subarachnoid hemorrhage (SAH) and 45% were unruptured. Factors which hindered optimal coiling include the following: wide aneurysm neck in relation to the overall aneurysm size, mural thrombus, giant aneurysm, arteries originating from the aneurysm sac, and middle cerebral location. After initial experience was gained, we tended to avoid these aneurysms especially in the non-ruptured group. This may be especially important in light of new epidemiological data suggesting that the natural history of unruptured aneurysms is significantly lower than previously thought.

New technical developments which may reduce the risk of treating unruptured aneurysms include the two-dimensional coil, the three-dimensional coil, the balloon-assist technique for wide-necked aneurysms, and combined stent-coil procedures.

Introduction

For decades, surgical clipping has represented the mainstay therapy for the treatment of ruptured and unruptured intracranial aneurysms. Endovascular therapy developed in an effort to provide treatment in those difficult cases which had no reasonable surgical option.

Initially, embolic devices for aneurysm therapy consisted of detachable and nondetachable balloons [1-4]. Later, standard pushable coils were used [5]. Finally, the Guglielmi Detachable Coil (GDC) system was developed [6,7], which has become the endovascular device of choice for over eight years [8-14].

Controversy remains over which treatment method, surgical or endovascular, should be used as primary aneurysm therapy [15,16]. This controversy expands when discussing the treatment of unruptured aneurysms [17,18], as the theoretical risk of non-treatment is less in this patient group compared to the ruptured aneurysm group.

Therefore, the risks of treatment need to be less as well. In this paper, we will discuss the factors we have identified which we believe hinder optimal aneurysm coiling from a review of our aneurysm cases treated using the GDC system.

Materials and Methods

Since 1991, we have treated over 600 aneurysms using the GDC system. We have collected adequate follow-up data to allow analysis in 435 of these patients. Aneurysm characteristics are summarized in table 1. Of these 435 aneurysms, 55% were located in the anterior circulation and 45% in the posterior circulation. This demonstrates a referral bias in favor of posterior circulation aneurysms, as the natural history dictates that only 10% of aneurysms are found in the posterior circulation. Additionally, 55% of our treated aneurysms had ruptured, and 45% were unruptured.

We reviewed the anatomical and epidemiological factors that prevented optimal GDC treatment. Suboptimal treatment includes cases in which the aneurysm was packed incompletely due to anatom-

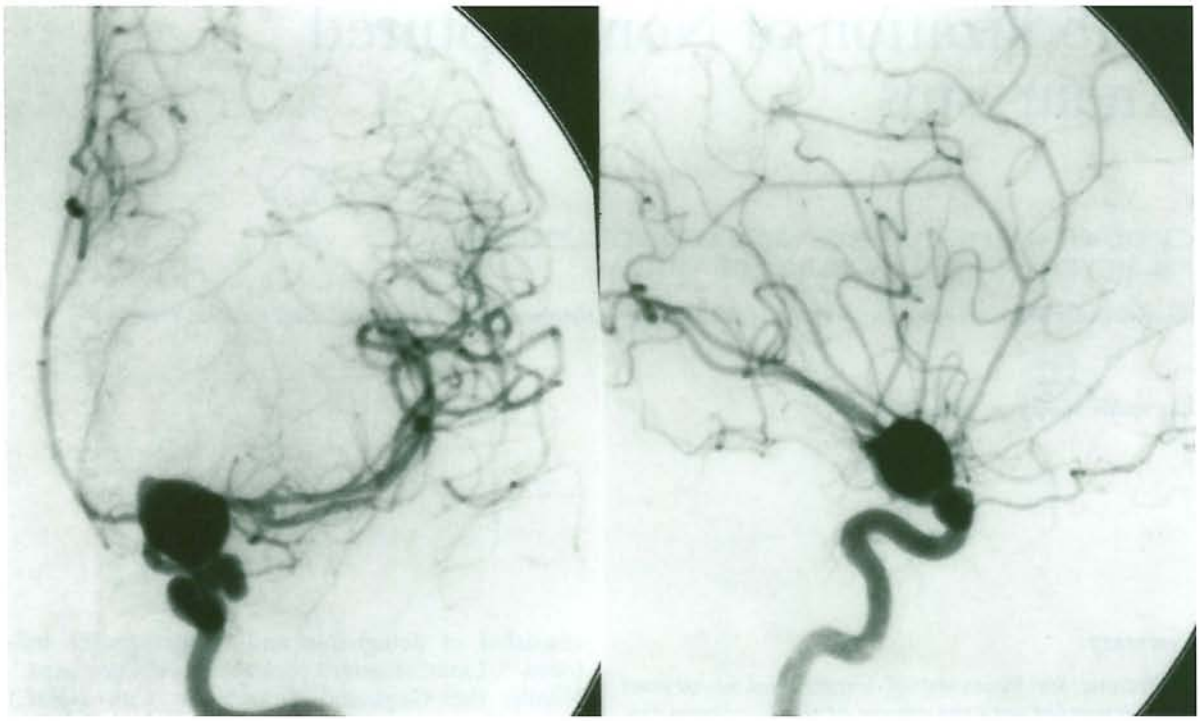


Figure 1 Left internal carotid angiograms, frontal and lateral projections, demonstrate a 17 mm carotid-ophthalmic aneurysm in a 60 year-old man. Note the second smaller, more proximal aneurysm.

ical constraints, demonstrated luminal recanalization on angiographic follow-up, required placement additional coils at a later date, caused subarachnoid hemorrhage, or underwent later surgical clipping.

Results

From our data, we identified the following as the primary factors which prevented optimal GDC treatment: wide aneurysm neck in relation to the overall aneurysm size, mural thrombus, giant aneurysm, arteries originating from the aneurysm sac, and middle cerebral location. These factors are discussed in detail to highlight the important implications of each in the therapy of non-ruptured aneurysms.

Discussion

Wide aneurysm neck

Many endovascular therapists have commented on this as the primary anatomical feature which determines whether an aneurysm can be treated effectively using the GDC system. The important determinant is the ratio of the diameter of the aneurysm neck (where the aneurysm originates from its parent artery) to the diameter of the aneurysm lumen. An optimal ratio is 0.4. The smaller the ratio, the more likely one can effectively and thoroughly coil the aneurysm. The larger the ratio, the more likely one is to encounter coil herniation into the normal parent artery. This ratio becomes meaningless in fusiform aneurysms. Large aneurysms can be treated effectively as long as the neck is relatively small (figures 1 and 2). Conversely, some smaller aneurysms should not be treated using coils because they lack adequate necks to prevent coil herniation. Thus, the wide aneurysm neck prevents the placement of additional, appropriately-sized coils which will provide dense packing of the aneurysm [19], necessary for aneurysm thrombosis and prevention of delayed recanalization.

Mural thrombus

Thrombosis along the inner wall of the aneurysm can develop, especially in larger aneurysms. This can be identified on cross-sectional imaging (using CT or MRI) or can be detected by the lack of concordance of the diameter of the aneurysm as seen angiographically (smaller) as compared to the cross-sectional imaging diameter (larger). Mural thrombus can allow the migration of coils over time into the thrombus, which can result in reopening of an aneurysm neck. This may necessitate retreatment.

Giant aneurysm

While the major determinant of the coilability of giant aneurysms is the comparative width of the aneurysm neck, most giant aneurysms do exhibit wide or absent necks. Therefore, one should view

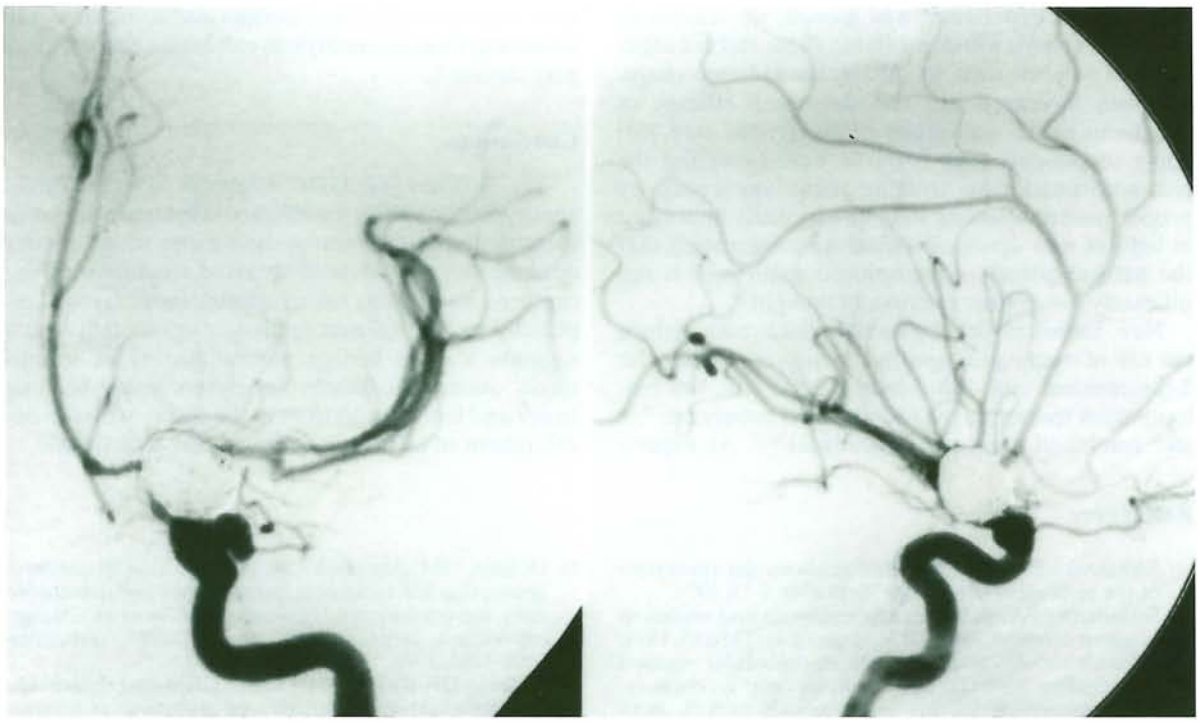


Figure 2 Left internal carotid angiograms, frontal and lateral projections, after GDC embolization, demonstrate an excellent post-treatment appearance. The aneurysm is fully obliterated without coil encroachment on the normal parent internal carotid artery.

giant aneurysms *per se* with suspicion when evaluating them for endovascular treatment.

Artery originating from aneurysm sac

This anatomical arrangement renders it difficult to fully treat the aneurysm and to avoid occlusion of the arterial branch which takes its origin from the aneurysm itself. Treatment options include subtotal occlusion of the aneurysm, intentional occlusion of the exiting branch artery, preliminary placement of a bypass graft to the affected branch prior to coil embolization, aborting the endovascular procedure in favor of a primary surgical approach, or no treatment. The augmented risk of embolization in causing stroke is less acceptable in the treatment of an unruptured aneurysm.

Table 1 **Case summary of aneurysms treated by GDC embolization**

Total number of aneurysms treated:	**435**
Location	
Anterior circulation	55%
Posterior circulation	45%
Clinical history	
Ruptured	55%
Unruptured	45%

Middle cerebral location

Only 3% of our GDC-treated aneurysms were located at the middle cerebral trifurcation, in contradistinction to the natural history of aneurysms in this location, which comprise roughly 25% of intracranial aneurysms. In part, this low percentage represents referral bias, as middle cerebral aneurysms are technically easier to access for surgical clipping than many other aneurysms. This also indicates the relative difficulty of treatment of many middle cerebral aneurysms by embolization. Factors involved in this difficulty include the frequent occurrence of incorporation of an exiting middle cerebral branch origin into the aneurysm sac, and the relative angiographic inability to allow complete understanding of the angioarchitecture of the aneurysm due to the complex three-dimensional anatomy in this location. Further development of advanced imaging techniques, such as rotational angiography, CT angiography, and MR angiography, with rapid three-dimensional reconstruction capabilities, may overcome some of these problems.

We have identified the above-listed factors which hinder optimal endovascular aneurysm treatment.

After initial experience was gained, we tended to avoid aneurysms which exhibited these factors, especially in patients without subarachnoid hemorrhage, although increased risk and decreased efficacy of treatment in this sub-group of aneurysms may also apply to patients with SAH as well. Lowering the risk associated with treating these aneurysms by proper patient selection may be especially important in light of new epidemiological data suggesting that the natural history of unruptured aneurysms is significantly lower than previously thought [20].

New technical developments which may reduce the risk of treating unruptured aneurysms include the 2-dimensional coil, the 3-dimensional coil, the balloon-assist technique for wide-necked aneurysms [21-23], and combined stent-coil procedures [24,25]. As experience is gained with these devices and techniques, the treatment risks of aneurysms exhibiting these factors may diminish.

Conclusions

The efficacy of GDC therapy of intracranial aneurysms has been established. However, we have identified specific anatomical factors which hinder optimal therapy. We tend to avoid treatment of unruptured aneurysms which exhibit these factors, especially in light of new epidemiological data which suggests a more benign natural history of unruptured aneurysms. Such aneurysms may become easier and less risky to treat in the future with the development of advanced endovascular techniques.

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