Journal of Neuroradiology (2016) 43, 167—175

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REVIEW

Endovascular techniques for the management of wide-neck intracranial bifurcation aneurysms: A critical review of the literature

Laurent Pierot[a,*], **Alessandra Biondi**[b]

[a] *Service de neuroradiologie, hôpital Maison-Blanche, CHU Reims, université Champagne-Ardenne, 45, rue Cognacq-Jay, 51092 Reims cedex, France*
[b] *Department of Neuroradiology and Endovascular Therapy, Jean-Minjoz Hospital, CHRU Besançon, Franche Comté University School of Medecine, Besançon, France*

Available online 11 March 2016

KEYWORDS
Intracranial aneurysm;
Endovascular treatment;
Stenting;
Flow diversion;
Flow disruption

Summary Endovascular treatment is the first line treatment for intracranial aneurysms, but wide-neck aneurysms are often difficult to treat due to the difficulty in stabilizing the coils inside the aneurysm. It is singularly true for wide-neck bifurcation aneurysms (WNBA) as bifurcation branches often arise from the aneurysm neck. To overcome these difficulties, several approaches are available to treat both ruptured and unruptured aneurysms (balloon-assisted coiling and intra-aneurysmal flow disruption), while some techniques are essentially restricted to unruptured aneurysms due to the need of concomitant use of antiplatelet medications (stent-assisted coiling and flow diversion). Several ways of performing balloon-assisted coiling have been proposed for WNBA. Two stent-assisted techniques are available for WNBA (Y-stenting and the waffle-cone technique), but these techniques have yet to be evaluated in large, prospective series. Off-label use of flow diverters in WNBA has been proposed but efficacy has still to be established, and the technique presents unique potential safety issues (the potential modifications of bifurcation branches covered by the flow diverter) that has to be assessed. Intrasaccular flow disruption devices are promising tools for the endovascular treatment of WNBA. The WEB device has been extensively evaluated with prospective, multicenter studies showing high safety and good efficacy.

Abbreviations: EVT, endovascular treatment; ISAT, International Subarachnoid Aneurysm Trial; WEB, Woven Endobridge; WNBA, wide-neck bifurcation aneurysms.

* Corresponding author. Tel.: +33326788764; fax: +33326787594.
E-mail address: lpierot@gmail.com (L. Pierot).

http://dx.doi.org/10.1016/j.neurad.2016.02.001
0150-9861/

Key points

- Wide-neck intracranial bifurcation aneurysms are difficult to treat with standard coiling.
- Remodeling technique and flow disruption is used in ruptured and unruptured aneurysms.
- Stenting and flow diverters can be used in unruptured aneurysms.

Introduction

The overall prevalence of intracranial aneurysms is estimated as 3.2% in a population without comorbidity [1]. Most aneurysms are sacciform and are anatomically classified in 2 groups: sidewall and bifurcation aneurysms. In both groups aneurysm neck can be narrow (< 4 mm) or wide (≥ 4 mm).

After the publication of International Subarachnoid Aneurysm Trial (ISAT) results, coiling became progressively the first line treatment for ruptured and unruptured aneurysms [2—5]. However, a limitation of the coiling treatment became rapidly obvious in wide-neck aneurysms due to the high risk of coil protrusion in the parent vessel. Subsequently, another limitation became evident, which was the relatively high rate of aneurysm recanalization, this phenomenon having a higher frequency in wide-neck bifurcation aneurysms (WNBA). These 2 limitations prompted the development of more complex endovascular techniques, such as balloon-assisted coiling, stent-assisted coiling, flow diversion, and flow disruption [6—13].

The endovascular treatment (EVT) of WNBA is singularly difficult as it is necessary to simultaneously stabilize the coils in the aneurysm sac and preserve the permeability of the different branches of the bifurcation. The latter are frequently arising from the aneurysm neck making endovascular (and also surgical) treatment technically difficult. This subgroup of aneurysms includes aneurysms located at ICA terminus, MCA bifurcation, anterior communicating artery, and apex of the basilar artery. Different strategies and tools have been progressively developed over time for the EVT of WNBA. In the present review, these techniques and devices are described and their clinical and anatomical results analyzed. The pertinent literature was collected with a systematic research of papers dealing specifically with the treatment of WNBA.

Balloon remodeling (or balloon-assisted coiling)

This technique is probably the more frequently used in the treatment of ruptured WNBAs and also plays an important role in the management of unruptured WNBAs.

The use of a balloon temporarily inflated in front of the neck rapidly emerged as an effective approach especially for the treatment of wide-neck sidewall aneurysms [6]. For WNBAs, the use of this technique was more complicated to use, as it was mandatory to close completely the aneurysm neck and to protect the different branches of the bifurcation. Several techniques were proposed including:

- use of a hyper compliant balloon that will bulge in the aneurysm neck;
- use of 2 balloons inflated simultaneously in 2 different branches of the bifurcation (kissing balloon technique);
- navigation of a balloon through the Circle of Willis placing it parallel to the aneurysm neck: for example, placement of a balloon in both posterior cerebral arteries (P1 segments) through a posterior communicating artery to protect the neck of a basilar tip aneurysm or placement of the remodeling balloon in A1 and M1 segments through the anterior communicating artery to protect the neck of a WNBA located at the ICA terminus;
- use of a double lumen balloon microcatheter with one lumen used for the balloon inflation and the second one to deposit the coils [6].

The safety and efficacy of these different techniques were not specifically evaluated for the treatment of WNBA. However in large series dealing with ruptured and unruptured aneurysms, the remodeling technique was shown to be safe and to potentially improve anatomical results [6—8].

In addition, balloon remodeling may improve angiographic results of stent-assisted coiling (Fig. 1) [14].

Stent-assisted coiling

This technique is frequently used singularly for the treatment of unruptured WNBA.

Stents

The initial experience of intracranial aneurysm stenting showed relatively poor safety of the treatment with high morbidity and mortality. In Piotin et al. series, the mortality was significantly higher in patients treated with stent compared to patients treated without stents (respectively, 7.4 and 3.8%) [15]. However, in the Matrix and Platinum Science (MAPS) trial that included both sidewall and bifurcation aneurysms, the rate of periprocedural serious adverse events was similar in both the stent-coiling and the coiling groups (respectively, 6.6 and 4.5%), but the rate of stroke at one year was significantly higher in the stent-coiling group (8.8%) compared to the coiling group (2.2%) [16].

However, as the treatment of WNBA was still a challenge, the use of stents remained potentially a good option. A single stent is sometimes helpful for the treatment of WNBA, singularly when the neck is not exactly centered on the bifurcation and is extending more on one of the bifurcation branches. In this case, the deployment of a single stent in the branch where the aneurysm neck is predominantly located will potentially allow aneurysm treatment.

However, when the neck is centered on the bifurcation it will be difficult to protect 2 bifurcation branches with a single device. For this purpose, the use of 2 stents, or Y-stenting, has been proposed (Fig. 2). The second stent crosses the first one and the distal end of both stents are placed in 2 different branches. Several authors have evaluated this technique in retrospective single center series, mostly including unruptured aneurysms [17—19]. The safety was relatively limited with 10.0% procedure-related permanent neurologic deficits and 1.0% death in Bartolini series