Journal of Clinical Neuroscience 34 (2016) 202–206

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical commentary

Balloon-in-stent assisted coiling for treatment of intracranial overwide and undertall aneurysms

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ARTICLE INFO

Article history:
Received 15 May 2016
Accepted 10 August 2016

Keywords:
Balloon
Endovascular treatment
Intracranial aneurysm
Stent

ABSTRACT

This study reports our experience of balloon-in-stent assisted coiling for the treatment of morphologically unfavorable aneurysms located in the internal carotid artery (ICA). From July 2007 to April 2014, twelve patients with twelve aneurysms located in the ICA were coil embolized by simultaneously using balloon and stent assistance. Five aneurysms were ruptured and seven were unruptured. All the aneurysms were overwide (dome-to-neck ratio ⩽1.2) and undertall (aspect ratio ⩽1.2) anatomically. The procedure-related adverse events, clinical and angiographic results were retrospectively analyzed. Intraprocedural aneurysmal bleeding occurred for one unruptured aneurysm but was stopped immediately after the balloon was inflated. Periprocedural thromboembolism occurred for two ruptured aneurysms, leading to death in one patient and severe neurological deficit for the other one. Procedure-related permanent morbidity and mortality rates were 8.3% (1/12) and 8.3% (1/12). Satisfactory (total and subtotal) occlusion was obtained immediately in 11 (91.7%) cases. Nine aneurysms received digital subtraction angiography follow-up (mean 25.1 months, range 6–55), and all of them except one were totally obliterated. No aneurysmal bleeding occurred during a mean period of 59.1 months, clinical follow-up for eleven patients. Balloon-in-stent assisted coiling might be a therapeutic alternative to prevent growth or rupture of overwide and undertall aneurysms. Nevertheless, it should be used prudently for ruptured ICA aneurysms, for its disadvantage of technical complexity and relatively high rate of adverse events.

1. Introduction

Flow diverters have probably simplified the endovascular treatment (EVT) of even the most complex aneurysms, regardless of aneurysm size, neck or shape in geometry [1]. However, they are not widely available in developing countries and are relatively expensive. Safety and effectiveness data of flow diverters is also limited so far [1,2]. Under the circumstance, coiling is still the main EVT method for intracranial aneurysms. Endovascular coiling of morphologically unfavorable aneurysms remains a technical challenge due to their poor-retainer characteristics for coils retention and hazards of coils herniation. Adjunctive technical advances such as balloon remodeling and stent assistance have allowed successful coil therapy of wide-necked aneurysms. Nevertheless, as the balloon's protecting effect is temporary and coils could compromise the parent artery through stent interstices, separate use of conventional balloon or stent assisted coiling frequently fails to manage aneurysms that are more complicated than simple wide-necked ones. Several studies have reported combined balloon and stent assisted coiling for EVT of circumferential or fusiform aneurysms [3–9].

The study by Brinjikji et al. [10] discovered that endovascular coiling of overwide (with aspect ratios, defined as aneurysm height-to-neck width, ⩽1.2) or undertall aneurysms (with dome-to-neck ratios, ⩽1.2), almost always required adjunctive techniques. In their series, three aneurysms with an average dome-to-neck ratio of 1.36 and an average aspect ratio of 1.00 were treated with both balloon and stent assistance. However, due to the complexity of the procedure, a combined usage of balloon and stent might increase the periprocedural adverse event rate, especially for aneurysms located in the tortuous internal carotid artery (ICA). The aim of this retrospective study is to report our experiences of balloon-in-stent assisted coiling of morphologically unfavorable aneurysms, with an assessment of its feasibility, efficacy and safety.

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http://dx.doi.org/10.1016/j.jocn.2016.08.011
0967-5868/

2. Materials and methods

2.1. Patients and aneurysms

From June 2007 to April 2014, twelve patients (7 men and 5 women, aged 44–77 years, mean 59.7 years) with twelve aneurysms, were treated by balloon-in-stent assisted coiling. Five aneurysms were ruptured and seven were unruptured. The aneurysm width or the dome (D) was measured as the longest diameter of the fundus parallel to the aneurysm neck (N). The aneurysm height (H) was measured as the longest diameter of the fundus vertical to the neck [11]. The measurement did not take into account daughter sacs on the aneurysms. All the lesions were ICA aneurysms, and their locations were as follows: the clinoid segment ($n = 1$), the ophthalmic segment ($n = 3$), and the communicating segment ($n = 8$). The mean aneurysm size was 4.28 mm (range 2.0–8.0 mm). The mean dome-to-neck ratio was 0.91 (range 0.62–1.18) and the mean aspect ratio was 0.76 (range 0.44–1.00). All the aneurysms were overwide and undertall anatomically (Fig. 1) according to Brinjikji et al.'s [10] definitions. Of the five patients with small (5 mm or smaller) unruptured aneurysms, indications for EVT were subarachnoid hemorrhage (SAH) from another aneurysm in patient 6 (Fig. 2), patient's strong preference with emotional distress in patient 12, and complicating with ischemic cerebrovascular disease and requiring long-term antiplatelet therapy in the other three patients. In particular, the aneurysm in patient 8 was recurrent from previous coiling (Fig. 3). Table 1 summarizes the characteristics of patients and their aneurysms.

2.2. Technique

During the procedure, balloon assistance was used additionally to stent-assisted coiling for the following purposes: (1) to secure the parent artery, as coils always protruded into the parent artery through stent struts, or it was very difficult to confirm whether coil protrusion had happened; (2) to facilitate a dense coil packing and reduce neck remnant (particularly the "dog-ear" remnant [12]); (3) to be available for controlling of aneurysmal bleeding should rupture occur during the procedure; (4) to avoid the stent being squashed by coil mass and ensure its sufficient expanding; (5) to stabilize the microcatheter.

In our series, the stents used included Neuroform-3 ($n = 11$) (Boston Scientific Corp., Fremont, CA, USA) and Solitaire stent ($n = 1$) (ev3, Irvine, CA, USA). Hyperglide balloon catheters (Micro Therapeutics, Irvine, CA, USA) were selected in all cases. The coils used included various types of Guglielmi detachable coils (GDCs) (Boston Scientific Corp.), Microplex or Hydrosoft coils (Microvention Inc., Aliso Viejo, CA, USA), and Axium coils (Ev3).

All the procedures were performed on a dedicated biplane neuroangiography suite with patients under general anesthesia, systemic heparinization (activated clotting time 2–3 times above

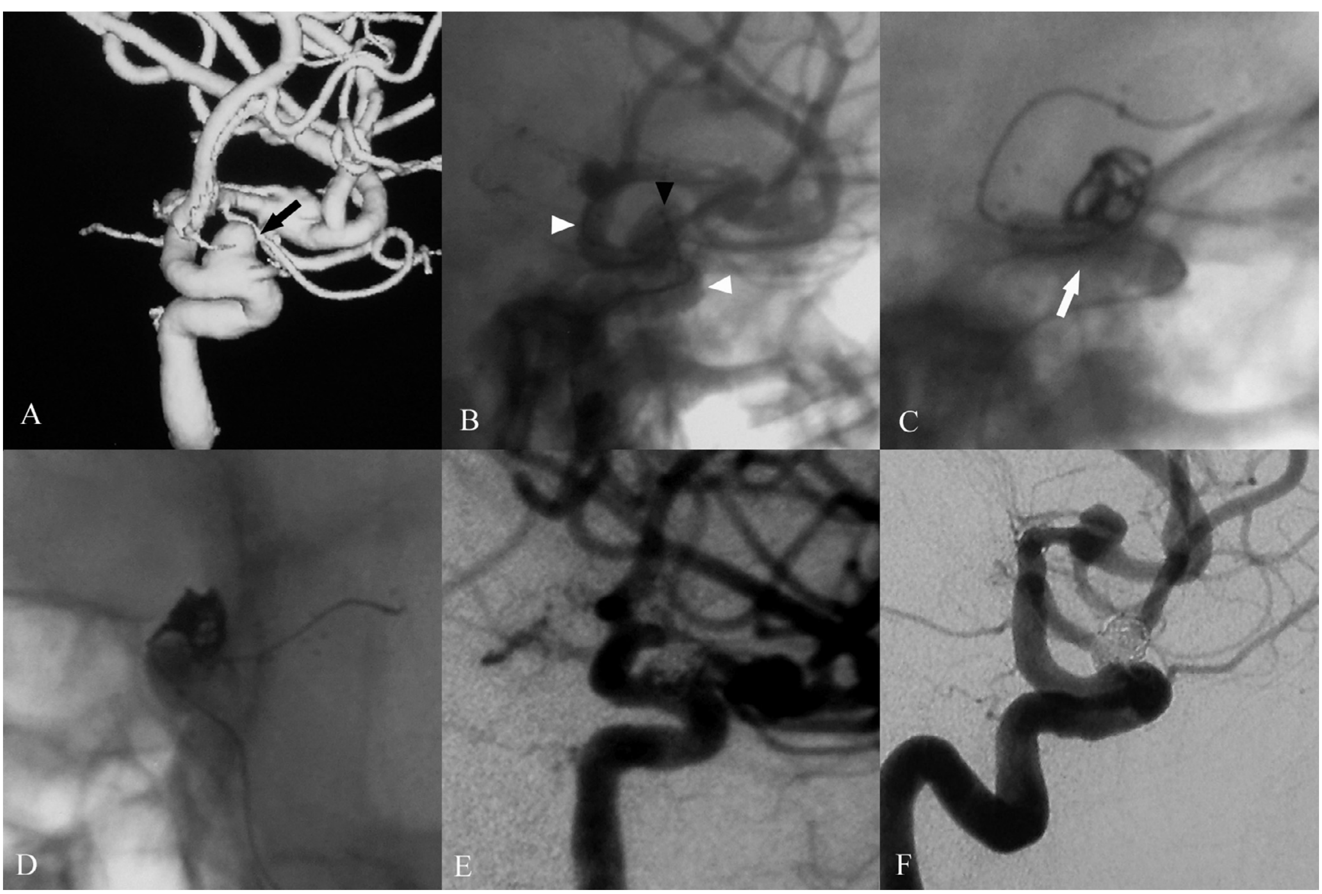

Fig. 1. Balloon-in-stent assisted coiling of an aneurysm with unfavorable morphology in patient 1. (A) Three-dimensional angiogram image of the aneurysm (black arrow). (B) A 4.5 × 20 mm Neuroform-3 stent (white arrowheads, ends of stent), an Achelon-10 microcatheter (black arrowhead, tip of microcatheter), and a 4.0 × 15 mm Hyperglide balloon catheter are placed. (C) During coil delivery, the remodeling balloon is temporarily inflated (white arrow). (D) Another working projection view displays that the parent vessel is surrounded by coils inserted. (E) Angiogram acquired at the end of embolization reveals subtotal aneurysm occlusion. (F) Angiographic follow-up at 28 months shows exclusion of the aneurysm.