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ORIGINAL ARTICLE

Endovascular treatment of intracranial aneurysms with Barricade coils: Feasibility, procedural safety, and immediate postoperative anatomical results

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KEYWORDS
Aneurysm;
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Endovascular;
Coils;
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Summary
Background and purpose: The safety of bare platinum coils has been widely described in the literature. This study aimed to report the first series of intracranial aneurysms treated with Barricade bare platinum coils with a comprehensive evaluation of their procedural safety and postprocedural anatomical results.
Methods: Patients with intracranial aneurysms treated between October 2013 and December 2015 by simple coiling or balloon-assisted coiling with Barricade coils (Blockade Medical, Irvine, California, USA) were prospectively included in a database and retrospectively studied. For all included patients, the patient and aneurysm characteristics, procedural complications, technical issues, postoperative anatomical results, and one-month clinical outcome (modified Rankin Scale) were evaluated by an independent interventional neuroradiologist.
Results: Eighty-eight patients harboring 97 aneurysms were included. Procedural complications and technical issues were encountered in 17 and 5 patients (19.3 and 5.7%, respectively), but clinical worsening in only 2 patients (2.2%). There was no treatment-related mortality. After one month, morbidity (mRS $\geq$ 1) was observed in 19 patients (21.8%), 17 related to subarachnoid hemorrhage (SAH) in patients with ruptured aneurysms (19.4%) and 2 related to thromboembolic events in patients with unruptured aneurysms (2.3%). Nine patients initially presenting with a ruptured aneurysm were deceased at 1 month as a consequence of SAH (10.2%). Adequate occlusion was observed postoperatively in 94.8% of the aneurysms (complete occlusion in 81.4% and residual neck in 13.4%).

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Conclusion: Endovascular treatment of intracranial aneurysms with Barricade coils is feasible and the demonstrated overall safety results are within the ranges found in the literature for other coils. Immediate anatomical results are satisfying.
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Introduction

Since their introduction 25 years ago, detachable platinum coils have become the first line treatment modality for many intracranial aneurysms, both ruptured and unruptured [1,2]. Aneurysm coiling is a minimally invasive alternative to open surgery and was proven to be associated with superior functional outcomes in patients harboring ruptured intracranial aneurysms [3]. The occurrence of aneurysm recanalization in about 20% of the cases (necessitating endovascular retreatment in around 10%) with subsequent potential risk for rebleeding has conducted to the development of new endovascular tools for aneurysm treatment, including surface-modified coils, stents, flow diverters, and flow disrupters [4—6]. However, these new devices have some technical limitations, the need for double antiplatelet treatment with stents and flow diverters being the most important one in the setting of a ruptured aneurysm. Moreover, current indications for flow diversion or intrasaccular disruption are large and giant sidewall aneurysms and wide-neck bifurcation aneurysms, respectively. This is why aneurysm coiling — sometimes in conjunction with the remodeling technique — is still the first line treatment method for most ruptured intracranial aneurysms [7—9].

The safety of bare platinum coils, in general, has been studied and widely described in the literature both for ruptured and unruptured intracranial aneurysms [1,2]. However, each coil even with the same structural compositions has unique mechanical properties depending upon the manufacturing process and metal composition (metal alloy), which cause different degrees of stiffness or softness and also account for specific configurations during deployment as well as volume and packing density variations. Furthermore, different mechanisms for coil detachment are currently available, including electrolytic or mechanical mechanisms. For these reasons, it seems important to evaluate precisely the performance of a new coil in terms of safety and efficacy.

Barricade coils (Blockade Medical, Irvine, California, USA) are bare platinum coils that were introduced into the European market in July 2012. In the USA, they were released in March 2013. The present study aimed to report a consecutive series of intracranial aneurysms treated with these coils and to make a comprehensive evaluation of their safety and immediate efficacy.

Patients and methods

Study settings

All cases of intracranial aneurysms treated in our academic center from October 2013 to December 2015 were prospectively included in a database and reviewed by an independent neuroradiologist (M.Z., 6 years experience). Consecutive patients with an intracranial aneurysm treated during this time frame by coiling or balloon-assisted coiling with the Barricade coil system (Blockade Medical, Irvine, California, USA) were included. Patients receiving additional stents, flow diverters, or flow disrupters were excluded as the use of these devices may modify the rate of complications or occlusion. Patients with dissecting aneurysms and aneurysms related to an arteriovenous malformation were also excluded. In accordance with French law, the study did not require approval by an ethics committee nor patients' informed consent because it only involved retrospective analysis of anonymized data obtained during routine clinical care.

Data collection and analysis

For all patients, a thorough review of the medical charts and available imaging studies (pre- and postprocedural) was conducted by an independent experienced interventional neuroradiologist. The following data were collected:

- patient and aneurysm characteristics (including aneurysm status, i.e. ruptured, unruptured, or recanalized, aneurysm size, neck size);
- technical success in coiling of the aneurysms (aneurysm occlusion grade);
- procedural complications (thromboembolic event and/or aneurysm rupture);
- technical issues (coil non-detachment, coil migration, coil protrusion).

Occurrence of a thromboembolic event during the procedure was defined as thrombus formation near the neck of the aneurysm in the distal branches, or parent vessel occlusion. Aneurysm rupture during the treatment was defined as depiction of the catheter tip or the coil outside of the aneurysm sac or extravasation of contrast with or without blood pressure modification.

Morbidity (defined by a mRS > 1) and mortality rates were evaluated at 1 month.

The immediate aneurysm occlusion was evaluated using a simplified 3-grade scale (Montreal/Raymond): complete occlusion, neck remnant, or aneurysm remnant [10].

Patients and aneurysms

From October 2013 to December 2015, 98 patients harboring 110 saccular intracranial aneurysms were treated with the Barricade coil system (Blockade Medical, Irvine, California, USA). Ten patients with 13 aneurysms were treated with coils in adjunction with stents or flow diverters ($n = 11$) or

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