AJNR

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AJNR Am J Neuroradiol published online 6 June 2013
http://www.ajnr.org/content/early/2013/06/06/ajnr.A3614.citation

Published June 6, 2013 as 10.3174/ajnr.A3614

Does Stent-Assisted Coiling Still Have a Place in the Management of Intracranial Aneurysms?

The article by Chalouhi et al[1] in this issue of the *American Journal of Neuroradiology* is an interesting contribution to the debate about the present place of stent-assisted coiling (SAC) in the management of intracranial aneurysms.

Endovascular treatment plays an important role in the management of intracranial aneurysms but still has some limitations, including complex aneurysms (wide-neck, fusiform, large, and giant) and the risk of aneurysm recanalization.[2-5] Stabilization of the coils in wide-neck aneurysms can be difficult; therefore balloon-assisted coiling (BAC) was developed to overcome this technical limitation of coiling.[6,7] BAC is not associated with a higher rate of complications as compared with standard coiling, and some studies have even shown better anatomic outcome after BAC.[8,9]

Initially, SAC was introduced into the armamentarium for aneurysm treatment 10 years ago, for the treatment of wide-neck aneurysms. Clinical evaluation of this technique is mostly limited to single-center retrospective series with a limited number of patients. However, Shapiro et al[10] provided a literature review in 2012 showing that the overall complication incidence was 19%, with an overall death incidence of 2.1%. Thromboembolic and hemorrhagic complications were observed in 10% and 2.2%, respectively, and stent-related technical complications in 9%. At the first treatment session, 45% of aneurysms were completely occluded, but this increased to 61% on the follow-up imaging. In-stent stenosis was seen in 3.5% of cases and stent occlusion was observed in 0.6% of cases at angiographic follow-up. A learning curve was also clearly demonstrated. These results were disappointing because the morbidity of SAC was somewhat higher as compared with standard coiling, and complete occlusion rates were low.

Similar results were reported in large recent series.[11,12] Lee et al,[11] in a series of 289 patients, demonstrated a procedure-related complication rate of 13.8%, with permanent neurologic sequelae in 1.5% of patients. Follow-up imaging of 229 patients' aneurysms demonstrated a minor recanalization rate of 7.4% and major recanalization of 12.7%. In-stent stenosis was observed in 12.7% of cases, stent migration in 4.5% of cases, and late delayed infarction in 4.2% of patients. Gao et al,[12] in a large series of 232 patients with 239 wide-neck aneurysms treated with Neuroform SAC, also reported a high rate of procedural complications (14.7%), with a high procedure-related morbidity of 4.2% and a mortality rate of 1.3%. The overall recanalization was also relatively high, at 14.5%.

Recent multicenter studies show contradictory results, including a retrospective study involving 9 US neurointerventional centers.[13] There were 229 patients with 229 aneurysms, which included 32 ruptured aneurysms. The death rate was 3.5% of patients (16% for all patients with SAH and 1.5% for elective patients). Nonfatal intracranial hemorrhage was seen in 1.0% of patients, and immediate or delayed thromboembolic events were seen in 4.4% of patients.[13] In the ruptured aneurysm group, 3 of 5 deaths were related to the treatment. In patients with angiographic follow-up data, complete occlusion was observed in 59%. Nineteen patients (8.3%) had retreatment of their aneurysms, and in-stent stenosis was observed in 3.4%.

In the French multicenter registry, treatment of 107 patients with 107 aneurysms with SAC was performed.[14] The postprocedure rate for complete occlusion was 66.4%. The rate of progressive occlusion at 12–18 months was 14%, and the rate of recurrence was 9.7%. The rate of subsequent treatment was 4%. The thromboembolic rate in the periprocedural period was 3.7%, and the rate of delayed thromboembolic events was 3%. Overall, the mortality rate at 12–18 months was 1%, and the permanent morbidity rate was 1%.

The most important point is to have a direct comparison between patients treated with SAC and standard coiling (or BAC). Few series are available for this comparison, and most are single-center, retrospective series with a limited number of patients and significant differences regarding the aneurysms treated with both techniques. Piotin et al[15] reported a large, retrospective, single-center series of 1137 patients with 1325 aneurysms treated without (1109 aneurysms) and with stents (216 aneurysms). Aneurysms were different in the nonstented and stented groups, according to anatomic characteristics (bifurcation/sidewall, aneurysm size, neck size), making the comparison of clinical and anatomic results of limited value. Per-

manent neurologic procedure-related complications occurred in 7.4% of the procedures in the stent placement group versus 3.8% in the nonstented group ($P = .644$). Procedure-related death occurred in 4.6% in the stent placement group and 1.2% in nonstented group ($P = .006$). Follow-up was available in only 52.7% of the patients, and angiographic recurrence was observed in 14.9% in the stent placement group versus 33.5% in the nonstented group.

Jahshan et al[16] reported different results in a single-center series dealing with 489 aneurysms in 459 patients with similar permanent event-related morbidity in nonstented and stent placement groups, with higher rates of complete occlusion in stented aneurysms.

On the contrary, in a retrospective, single-center series by Hwang et al,[17] in a relatively small group of 86 aneurysms treated with coils alone and 40 aneurysms treated with stent and coils, the rates of progressive occlusion at 2-year follow-up (42.5% in the stent placement group and 39.5% in the nonstented group) and recanalization (17.5% in the stent placement group and 21.0% in the non-stented group) did not statistically demonstrate any significant difference.

In the current article, in their single-center, retrospective series, Chalouhi et al[1] compare 69 patients treated with SAC and 32 patients treated with BAC. The 2 groups were comparable except for aneurysm status; in the BAC group, 65.6% of the aneurysms were ruptured, and in the SAC group, 11.5% of the aneurysms were ruptured ($P < .001$). The rates of complete aneurysm occlusion were significantly higher in the SAC group (75.4%) versus the BAC group (50%; $P = .001$). In the incompletely coiled group, progressive aneurysm occlusion occurred more frequently in the SAC group (76.6%) than in the BAC group (42.8%, $P = .02$). The retreatment rates were significantly lower with SAC (4.3%) than with BAC (15.6%, $P = .05$). The aneurysm rupture status plays an important role in recanalization, and as the BAC and SAC groups are different regarding this status, it is difficult to know the true significance of these results.

SAC has been used for more than 10 years, and the data are lacking to know precisely whether the safety and efficacy are different between SAC and standard coiling. The only way to answer these important questions is to build a randomized, controlled trial comparing stent placement versus nonstenting in a large group of patients to determine whether the addition of a stent to standard coiling can decrease the recurrence rate without increasing morbidity and mortality.[18]

The development of new techniques such as flow diversion and flow disruption will also modify the global strategy of aneurysm treatment, and the respective places of stenting, flow diversion, and flow disruption must be defined according to their safety and efficacy profile.[19,20] Currently, flow diverters are indicated and recommended in sidewall, unruptured aneurysms, singularly those located on the ICA, but these aneurysms are also a good indication for stent placement. Flow disrupters are used in wide-neck bifurcation aneurysms (ruptured and unruptured). Aneurysm locations treated with flow disruption are the MCA, basilar tip, ICA bifurcation, and the anterior communicating artery. For these locations, stent placement can also be used (singularly for unruptured aneurysms), including more complex techniques such as Y and X stent placement. A direct comparison of stent placement and coiling versus flow diversion or flow disruption will be mandatory in the future to directly compare the safety and efficacy of these techniques and to specify their respective place in aneurysm management.

Disclosures: Laurent Pierot—*RELATED: Consultancy*: Codman, Covidien/ev3, MicroVention, Penumbra, and Sequent. Christophe Cognard—*RELATED: Consultancy:* Codman, Covidien/ev3, MicroVention, Sequent, and Stryker.

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http://dx.doi.org/10.3174/ajnr.A3614