Balloon-Assisted Coiling in Subarachnoid Hemorrhage Cases

Balloon remodeling with a newer, more compliant balloon may increase the safety and feasibility of treating ruptured aneurysms endovascularly.

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Spontaneous subarachnoid hemorrhage (SAH) secondary to rupture of a cerebral aneurysm is a life-threatening medical emergency that requires immediate treatment once it has been diagnosed. Microsurgical clipping had been the historical method of choice for treating ruptured cerebral aneurysms until publication of the initial analysis of ISAT (International Subarachnoid Aneurysm Trial), which favored endovascular coil occlusion.[1] ISAT has become a milestone for improving neurointerventional techniques, with its further extension of indications and promotion of growing interest in the endovascular management of ruptured cerebral aneurysms.

The management of ruptured cerebral aneurysms differs from the management of unruptured aneurysms because of the well-known possible risks of rebleeding and vasospasm development associated with SAH. Interventions should be aimed at reducing risk as soon as possible, including safer and denser packing of the aneurysm sac. However, aneurysm geometry (ie, shape, angulation with the parent artery, and dome-to-neck ratio) is a limiting factor for consideration when treating aneurysms using detachable coils without any adjunctive balloon assistance.[2] Aneurysms with an unfavorable dome-to-neck ratio and wide-necked aneurysms with a favorable dome-to-neck ratio were exposed to the risk of coil protrusion or lower packing densities in early series.[2,3]

The balloon remodeling technique, as described by Moret et al,[4] primarily offers temporary balloon inflation during coil delivery to achieve homogeneous packing density of wide-necked, complex-shaped cerebral aneurysms that otherwise would not be amenable to primary coiling without any coil protrusion into the parent artery. Their series included 56 aneurysms in 54 patients, of whom 37 (70%) presented with SAH. The remodeling technique was reported to be used in 52 aneurysms successfully, with a resultant complete occlusion rate of 77%, subtotal occlusion rate of 17%, and any patient mortality and procedure-associated morbidity were 0.5%.

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Despite the revolutionizing effect of the balloon remodeling technique on the era of wide-necked aneurysm treatment, low-compliant, over-the-wire balloons were limiting the applicability of the technique to sidewall aneurysms, while more compliant latex balloons glued to a flow-dependent microcatheter were providing less directionality, less stability, and less accurate balloon positioning across the aneurysm neck.[2,5] In the subsequent years, a new, more compliant balloon microcatheter (HyperForm, ev3 Inc., Plymouth, MN) appeared on the market, offering trackability and accu-

rate positioning over a specified 0.01-inch guidewire, along with the ability to adapt its shape to the anatomy of the arterial bifurcation by bulging into the aneurysm neck or the branches coming off the sac.[6]

It is obvious that the aim of coil embolization in the endovascular treatment of ruptured intracranial aneurysms should be to achieve complete and stable occlusion to prevent recanalization and lower the risk of rebleeding. In our department, ruptured cerebral aneurysms that are located either proximal to or involve small arteries distal to the circle of Willis are treated using the balloon remodeling technique whenever technically possible. It is our belief that balloon assistance offers many advantages over standard coiling, such as reconstruction of the bifurcation with the protection of the parent artery, improvement of the applicability of coil embolization by bulging into the branches emerging from the sac, uniform and denser packing with the creation of better coil conformation, and increased procedural safety during an inadvertent intraoperative rupture situation by limiting the blood extravasation with inflation of the balloon at the neck of the aneurysm accompanied by rapid coil occlusion.

When treating acute SAH cases, which show a higher tendency to rupture during coil delivery, having the microcatheter in a more stable position with the aid of the balloon[5] helps improve this safety issue because the microcatheter tip can be left just inside the entrance of the aneurysm sac when necessary.[7] Because coil conformation in the aneurysm is often easier in such situations, catheter tip repositioning may be avoided, which is frequently required during simple coiling. These features are especially important when coiling an acutely ruptured, small, shapeless aneurysm with very tight angulation to the parent artery.

Another potential devastating complication of SAH is vasospasm, which can lead to severe constriction of the arteries and restricts microcatheter passage from reaching the target aneurysm. Moreover, delineating the aneurysm neck in relation to the parent artery and the neighboring branches may be difficult in some cases with severe vasospasm. In such instances, use of the same HyperForm super-compliant balloon microcatheter for performing gentle angioplasty helps vessels enlarge to allow the passage of a microcatheter and balloon microcatheter for further embolization of the aneurysm sac under balloon assistance. Thus, delayed ischemia, which is characterized by new neurologic symptoms due to restricted blood flow, could potentially be prevented.

Certainly, not every aneurysm must be coiled with balloon assistance. However, the previously mentioned advantages of balloon assistance enable us not only to treat the aneurysms that cannot otherwise be treated with primary coiling but also allow us to achieve a more durable occlusion during the long-term follow-up because of the existing inverse relationship between higher initial occlusion rates and recanalization.[8,9]

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In our recent published series of 800 consecutive patients having 864 aneurysms treated with HyperForm balloon assistance,[7] there were 647 patients (80.8%) with existing SAH. The patients were referred to us with acute SAH and were treated within 24 hours of admission to our hospital. To control the neck of the aneurysm, the HyperForm balloon was placed in the appropriate bifurcation vessel, bridging the neck of the aneurysm under simultaneous biplanar roadmapping. Overall, in this series, the initial occlusion rates were 73% class 1 occlusions, 20.4% class 2 occlusions, and 6.6% class 3 occlusions. The follow-up angiograms, which were obtained for 87.6% of the patients, revealed a recanalization rate of 12% and further thrombosis in 17%, resulting in complete obliteration (class 1 occlusion) in 82%; the retreatment rate was 9%.

Nevertheless, there exists concern that the adjunctive use of balloon remodeling may be associated with increased adverse events after endovascular coiling of cerebral aneurysms. In the analysis of their large series including 1,811 aneurysms, Henkes et al[10] reported a significantly increased complication rate (38.5%) with the balloon remodeling technique. However, there was a potential bias because balloon remodeling was used in only 26 cases (1.4%). Similarly, Sluzewski et al[11] found a significantly higher complication rate in the group treated with balloon assistance (14.1%) compared to the group treated with unassisted traditional coiling (3%), which was associated with death or disability. However, the adjunctive use of balloon assistance was limited to 8.6% of the total 827 aneurysms treated in this series, which is probably due to the limited availability of remodeling balloons during the study span. We believe this makes the results of this series, as well as that of Henkes et al, speculative for extrapolation to general practice.

A literature review and meta-analysis conducted by Shapiro et al[12] did not show a higher incidence of

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thromboembolic events or iatrogenic rupture with the use of adjunctive balloon remodeling compared with unassisted coiling. Additionally, higher occlusion rates on initial and subsequent follow-up angiograms were reported in the literature, which met the inclusion criteria for meta-analysis defined by the investigators.

Our series clearly shows that balloon remodeling does not impose additional risk to the patient, even in the small, distal, anterior circulation vessels. We have observed thromboembolic complications in 15 patients (1.9%) and hemorrhagic complications in 14 patients (1.7%), with an overall complication rate of 3.6%. The thrombi were resolved completely, with no clinical consequence in five patients. Balloon inflation aided in the control of bleeding in 11 of 14 patients in whom an intraoperative perforation occurred. Therefore, the overall mortality rate due to procedural complications was 1.4% in this series. There was only one complication evidently related to the use of a HyperForm balloon in this series, which was dissection of the superior trunk of the middle cerebral artery due to balloon inflation resulting in vessel occlusion and neurologic deficit at discharge. This patient experienced a full recovery in 6 months.

These results are comparable to those reported by Gallas et al,[13] consisting of a multicenter study including 705 ruptured aneurysms (the balloon use rate was 6%) with a procedural mortality rate of 1.4% and an overall morbidity rate of 8.6%; Henkes et al[10] reported a procedural mortality rate of 1.4% and a procedural morbidity rate of 5.3%. Also comparable to the previous large series are the results reported by Murayama et al[14] of their group of 916 aneurysms, approximately half of which were ruptured. These investigators reported a procedural complication rate of 8.4%, including an intraprocedural perforation rate of 2.3% and a thromboemboli rate of 4.4%. The majority of these series documented that balloon remodeling does not complicate the procedure by increasing risks.

CONCLUSION

The super-compliant HyperForm remodeling balloon can be safely and very effectively used to treat ruptured aneurysms with minimal concern of increasing the complication rate. It not only increases the feasibility of endovascular treatment but also the safety of the procedure, especially in acute ruptured aneurysms. ■

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