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Surgical Management of Aneurysmal Subarachnoid Hemorrhage: An Overview

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Abstract: **Aneurysmal subarachnoid hemorrhage (aSAH) makes up roughly 10.5 cases per 1000,000 of all strokes around the world. This review was aimed to discuss the surgical approaches for the treatment of aSAH, this paper also aims to overview the diagnostic procedures that could help in perfuming better surgical outcomes. An electronic search was conducted through MEDLINE, EMBASE, and the Cochrane Central Register of Controlled Trials, databases to identify all studies related to the surgical treatment option of Aneurysmal subarachnoid hemorrhage published up to December 2016. Aneurysmal SAH is a neurosurgical emergency with substantial morbidity and death. Effective management of patients with aSAH involves a multidisciplinary group consisting of neurosurgeons. Surgical clipping remains a conclusive treatment for ruptured cerebral aneurysms, and lots of methods have enhanced over the years to better technique, dissect, and protect both intricate and simple aneurysms following aSAH. Endovascular therapy is now a well-accepted option to surgical clipping for ruptured and non-ruptured intracranial aneurysms. The present advanced endovascular techniques for the treatment of aneurysmal SAH consist of coiling alone and coiling assisted by the balloon remodeling method. The use of freshly established self-expandable stents seems appealing, as their safety and effectiveness have actually been shown for the treatment of non-ruptured aneurysms.**

Keywords: **Aneurysmal subarachnoid hemorrhage (aSAH), neurosurgical.**

1. INTRODUCTION

Aneurysmal subarachnoid hemorrhage (aSAH) makes up roughly 10.5 cases per 1000,000 of all strokes around the world [(1)]. Regardless of advances in diagnostic tools, perioperative management, and conclusive surgical or endovascular interventions, aSAH stays a disastrous condition. Following aSAH, a minimum of 12% of patients die prior to receiving medical attention, [(2)] 46% die within 30 days, [(3)] and numerous survivors have significant morbidity and need long term assistance.1 Cognitive dysfunction is common among aSAH survivors, with approximately 50% showing deficits and unable to return to work [(4,5)]. Due to the fact that aSAH happens at a fairly young age and has such a poor prognosis, it is approximated that the loss of efficient years from SAH is a significant part of years lost from ischemic stroke [(6)]. Outcomes following ASAH are mainly figured out by the intensity of the preliminary bleed, early rebleeding, and delayed cerebral ischemia secondary to vasospasm. Intracranial aneurysm development and subsequent rupture is an intricate multifactorial process that is not well understood [(6)].

Intracranial saccular or berry aneurysms are acquired vascular sores consisting of thinned outpouchings of the arterial wall. They are most typically seen at the bifurcation of arteries in the proximal circle of Willis (**Figure1**) [(7)]. The approximated prevalence of unruptured intracranial aneurysms is 2%-- 3% in the general population, but might be greater in older patients, women, and patients with family history or certain genetic conditions [(8)]. Aneurysms can present in a variety of ways, from sudden death following subarachnoid hemorrhage to an incidental finding on cerebral imaging. Those that survive the preliminary bleed are at risk for a host of secondary insults consisting of rebleeding, hydrocephalus [(9)] and postponed ischemia deficits (DID) [(10)].

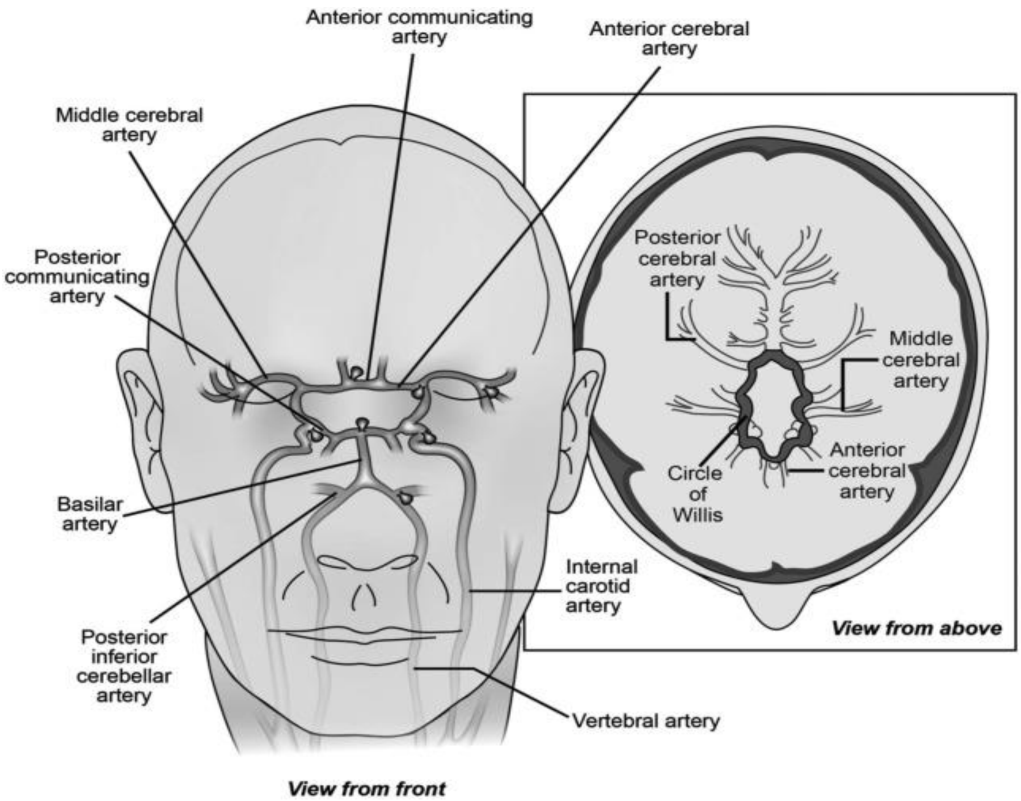

Figure 1: Common locations for intracranial saccular aneurysms [7]

Persistent hydrocephalus is a typical complication of aSAH. Between 8 and 67% of aSAH patients or 30% of those with External ventricular drain (EVD) eventually develop chronic hydrocephalus requiring long-term CSF diversion with a shunt [11,12]. Previous studies have actually attempted to show factors forecasting the need for shunt insertion after aSAH. Czorlich et al. [11] exposed that low initial GCS, high Hunt and Hess grade, presence of ICH, high Fisher CT grade, and high Graeb and LeRoux scores (IVH seriousness scores based on the amount of blood and size of each ventricle were connected with a greater rate of long-term CSF diversion [11].

Several research studies, particularly the International Subarachnoid Aneurysmal Trial (ISAT) [13], support the efficacy and safety of endovascular treatment. However, whether the very best approach is clipping or coiling, and where specific settings, is still a matter open to discussion in current clinical practice [13].

This review was aimed to discuss the surgical approaches for the treatment of Aneurysmal subarachnoid hemorrhage (aSAH), this paper also aims to overview the diagnostic procedures that could help in perfuming better surgical outcomes.

2. METHODOLOGY

n electronic search was conducted through MEDLINE, EMBASE, and the Cochrane Central Register of Controlled Trials, databases to identify all studies related to the surgical treatment option of Aneurysmal subarachnoid hemorrhage (aSAH) published up to December 2016. The search strategy included key words such as “subarachnoid hemorrhage,” OR “Aneurysmal subarachnoid hemorrhage” and “aneurysms,” and “aSAH,” and “surgical treatment”. This search was restricted to English language published studies involving human subjects only. Furthermore, we searched the references list of included studies to have more chance of finding relevant articles to our study.

3. RESULTS

Aneurysm rupture with resultant subarachnoid hemorrhage (SAH) is the most feared effect of unruptured intracranial aneurysms (UIA). SAH occurs at a rate of approximately 6 - 10/100,000 person-years, with burst aneurysms triggering around 85% [14]. The casualty rate for SAH is 30%-- 40%, although this may be enhancing in time [15]. Of those who survive SAH, 1 in 5 might be functionally dependent [15]. Even for those patients who obtain functional independence, a range of neurologic or mental sequelae can happen [14]. Unruptured aneurysms can typically remain asymptomatic (particularly those less than 10 mm) or can provide with symptoms consisting of headache, seizure, cranial nerve palsies, focal neurologic deficits related to mass effect, and cerebral ischemic events distal to the site of aneurysm due to emboli arising from the aneurysmal sac [16].

Diagnosis of Aneurysmal subarachnoid hemorrhage (ASAH):

A variety of variables contribute to the delineation of suitable screening parameters for a disease. Aneurysm rupture with SAH is a devastating condition for which low-risk screening is available and which is potentially avoidable with intervention. The preliminary steps in the evaluation of a patient with presumed SAH needs to focus on airway assessment, early CT imaging, high blood pressure control, serial assessment of neurological function and preparation for angiography. The patient's medical status is assessed utilizing the Hunt and Hess Scale [17] and World Federation of Neurological Surgeons Scales [18] (**Table 1**).

Table 1: Clinical grading scales following subarachnoid hemorrhage. [17,18]

	Hunt and Hess scale [17]	**World Federation of Neurological Surgeons Scale** [18]	
Grade	**Symptoms**	**Glasgow Coma Scale**	**Motor deficits**
I	Asymptomatic or mild headache	15	Absent
II	Moderate to severe headache, nuchal rigidity, with or without cranial nerve deficits	14-13	Absent
III	Confusion, lethargy or mild focal symptoms	14-13	Present
IV	Stupor and/or hemiparesis	12-7	Present or absent
V	Comatose and/or extensor posturing	6-3	Present or absent

A non-contrast CT scan within 24 hours detects > 95% of subarachnoid hemorrhages [19]. Blood appears as a high-density signal in the cisterns surrounding the brainstem and the basal cisterns. CT might be falsely negative if the volume of blood is very little, if the hemorrhage occurred several days prior or if the hematocrit is exceptionally low. The quantity of subarachnoid blood is graded [20,21] and is an essential predictor of vasospasm risk (**Figure 2**) [22]. Early hydrocephalus is suggested by enhancement of the third ventricle and of the temporal horns of the lateral ventricles.

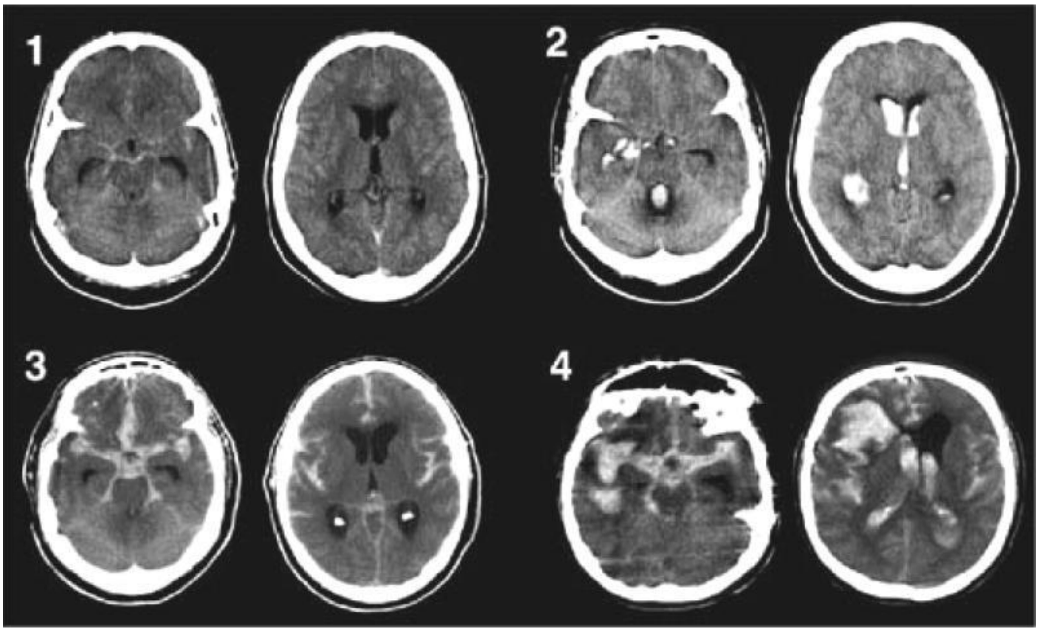

Figure 2: The Modified Fisher CT rating scale: Grade 1 (minimal or diffuse thin SAH without IVH),indicating low risk for symptomatic vasospasm; Grade 2 (minimal or thin SAH with IVH) and Grade 3 (thick cisternal clot without IVH), indicating intermediate risk for symptomatic vasospasm; and Grade 4 (cisternal clot with IVH), indicating high risk for symptomatic vasospasm.[22]

If CT is regular and suspicion of SAH stays strong, a back puncture (LP) must be carried out [(23)]. The existence of xanthochromia may be helpful in identifying a terrible back puncture from a true SAH specifically if it is detected by spectrophotometry [(24)]. Traditional catheter angiography remains the gold requirement for detection of intracranial aneurysms and should be carried out as soon as practical to facilitate early repair work of the ruptured aneurysm. CT angiography has just recently improved to the point where some centers utilize it as the primary test to indentify an aneurysm [(25)]. MRI techniques are rapidly advancing to this point.

Angiography fails to show the reason for non-traumatic subarachnoid hemorrhage in roughly 15% to 20% of cases [(26)]. Intraoperative fluorescent angiography has actually been a current addition to the neurosurgical armamentarium to assess intraoperative blood flow dynamics, aneurysm sac obliteration, and vessel patency. Angiography using fluorescein salt has been utilized by some groups [(27)] in the treatment of cerebral aneurysms; nevertheless, the nearinfrared color indocyanine green (ICG) has emerged as the preferred representative for microsurgical use [(28,29)] secondary to remarkable contrast of vessels throughout primary and subsequent dye applications. ICG has been assessed in several research studies of aneurysm clipping, [(28,29)] and combination of ICG near-infrared video innovation into the surgical microscope [(30)] has significantly facilitated its application. ICG use is noninvasive, safe, easy, and offers the cosmetic surgeon with rapid feedback after clip application. ICG supplies high resolution imaging of vessel anatomy, arterial and venous blood flow, and incomplete aneurysm clipping. Raabe and coworkers [(31)] demonstrated that ICG angiography associated with intraoperative or postoperative DS angiography in 90% of cases, and it supplied significant information in 9% of cases, a number of which caused clip repositioning. This method is also special because it can picture perforating arteries with excellent resolution [(32)].

External ventricular drain (EVD) procedure in aSAH:

Insertion of an external ventricular drain (EVD) is perhaps among the most typical and essential lifesaving treatments come across in the neurologic intensive care unit [(33)]. Numerous kinds of obtained brain injury, such as intracranial hemorrhage with intraventricular extension, subarachnoid hemorrhage, distressing brain injury, and bacterial meningitis, may gain from EVD insertion. A lot of these conditions are related to intracranial high blood pressure or raised intracranial pressure (ICP) above 20 mmHg due to blockage of cerebrospinal fluid (CSF) outflow [(33)].

CSF production approximates 0.2 - 0.4 mL/min or 500-- 600 mL a day (34). CSF is circulated along the ventricular system into the subarachnoid space and after that taken in into the venous system within the arachnoid granulations that line the convexity of the brain. A balance typically exists between its production and absorption. Disturbance of this balance, that is, caused by intraventricular blood, results in intracranial high blood pressure with intense non-communicating hydrocephalus, the condition wherein there is an excess of fluid in all or part of the CSF area in the brain [(35)]. Insertion of an EVD in this situation would assistant in the reduction of intracranial hypertension by diverting CSF and intraventricular blood, permit instillation of medications, and allow constant intracranial pressure monitoring to assist guide brain targeted resuscitation in these critically ill patients [(35)].

External ventricular drain (EVD) insertion:

A freehand pass method utilizing surface landmarks is frequently used by surgeons to position an EVD [(36)]. The right frontal cerebral hemisphere is the favored site of entry given its nondominance for language function in > 90% of patients [(36,37)]. The patient is kept with head of bed raised at 45 degrees in the supine position. Hair is gotten rid of using clippers and the scalp is prepared in a sterile fashion [(37)]. A burr hole is put at Kocher's indicate avoid the remarkable sagittal sinus and frontal cortex motor strip [(36)]. This point is located by drawing one line in the midline from the nasion to a point 10 cm back and another from the previous indicate a site 3 cm lateral to it, along the ipsilateral midpupillary line. After instillation of local anesthesia, a direct skin incision is made down to the periosteum and the bone is scraped. A twist drill is used to permeate the cranium in the trajectory determined for ventricular cannulation, and the pia and dura are pierced with a scalpel. The ventricular catheter is primed and passed no greater than 7 cm, intending in a coronal airplane towards the medical canthus of the ipsilateral eye and in the anteroposterior aircraft toward a point 1.5 cm anterior to the ipsilateral tragus, towards the ipsilateral Foramen of Monro. Once CSF flow is pictured after elimination of catheter stylet, it can be transduced to acquire an opening intracranial pressure. It is then tunneled through the skin away from the point of entry through a different incision, sutured firmly in place, and then linked to an external drainage system [(37)]. Issues such as hemorrhage and unintentional placement into brain tissue is reported in 10 - 40% of cases [(38)]. As a result, technical advances utilizing computed tomography (CT), ultrasound, endoscopy, and stereotactic neuronavigation have been developed to enhance the precision and efficiency of ventriculostomy placement [(36,38)].

Endovascular techniques for treatment of aSAH, (Clipping & Coiling):

Endovascular methods for the treatment of intracranial aneurysms with conservation of the moms and dad artery, also called constructive treatments, include basic coil embolization, coil embolization with balloon renovation or stent support, and balloon-assisted liquid polymer embolization (**Figure 3A, B, and C**) [39]. Using covered stents (or stent grafts) has actually been proposed as a choice for big, fusiform, or wide-necked aneurysms, mainly located in the carotid and vertebral arteries, where the risk of occluding functionally important side branches is reasonably low (**see Figure 2D**) [39]. The long-lasting patency of stent grafts placed in reasonably little vessels, such as the internal carotid artery, is another possible disadvantage of this technique and stays currently unknown [40]. Stents with a tight mesh or stents covered with semipermeable membranes (collectively called flow diverters) may represent an enhancement over conventional stent grafts in terms of moms and dad artery and side branches patency. These stents might broaden the signs of stent grafting to intracranial lesions, although their use in burst aneurysms needs to be thoroughly evaluated. Moms and dad artery occlusion, also referred to as deconstructive therapy, remains a valid alternative option for nonsurgical prospects whose aneurysms are not open to constructive treatment techniques. The clinical condition of patients, the aneurysm place and morphology (in particular the diameter of the neck and its relation to the parent artery), and the existence of branches occurring from the sac or the neck are important factors to consider when selecting the most suitable treatment strategy. The aneurysm neck, in particular its size and relation to the moms and dad artery and possible side branches, is the crucial feature in figuring out if coil embolization is an appropriate treatment alternative. Requirement coil embolization is thought about feasible for aneurysms with a small neck (< 4mm) a dome-to-neck ratio equal or greater than two, and in the absence of essential branches occurring from the sac or the neck [41]. Coil embolization is attained mostly with platinum coils. Although a careful analysis of the aneurysm morphology is essential to preparing efficient treatment, aneurysms with a seemingly undesirable setup can periodically respond well to easy coiling (**Figure 4**) [39]. Advances made in platinum coil technology have attempted to attend to incomplete aneurysm occlusion, which increases the risk of coil compaction and aneurysm recanalization. Reported rates of recanalization are roughly 21% to 28.6% but can be as high as 60% for giant aneurysms [42,43]. Just recently developed hybrid, or biologically active, coils are chemically pretreated to enhance their thrombogenicity20 in an effort to try decreasing the recanalization rate [43].

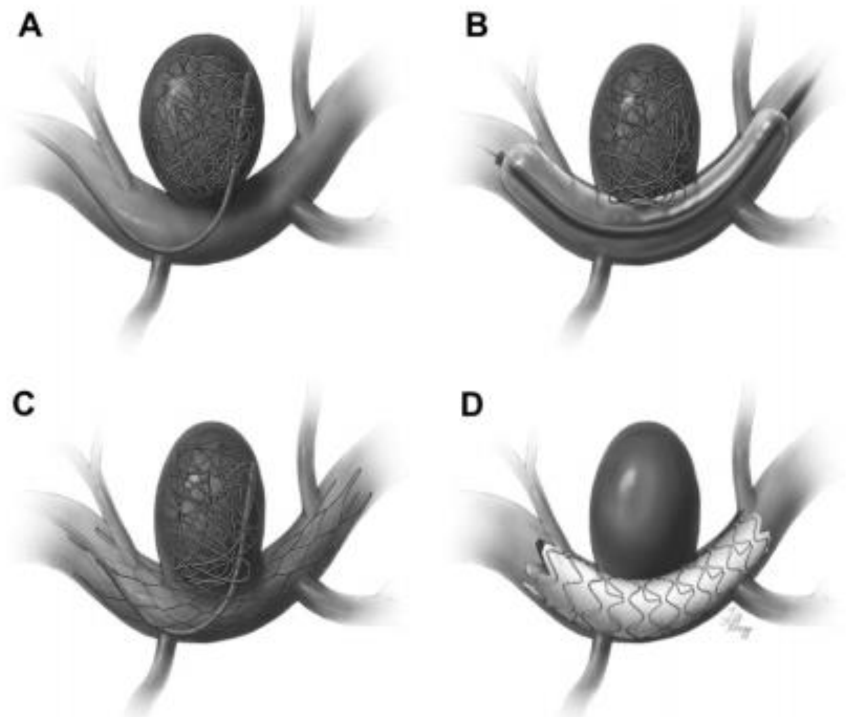

Figure 3: Endovascular treatment of intracranial aneurysms: constructive techniques. (A) Coil embolization: the microcatheter was placed within the aneurysmal cavity, which was progressively filled (packed). Standard coil embolization requires a favorable aneurysm geometry, particularly in regard to the sac-to-neck ratio. (B) Balloon remodeling: inflation of a compliant microballoon across the aneurysm neck concomitantly to coil deployment allows treating lesions with unfavorable sac-to-neck ratio. l. (C) Stent-assisted coiling. (D) Stent graft/flow diverters [39]

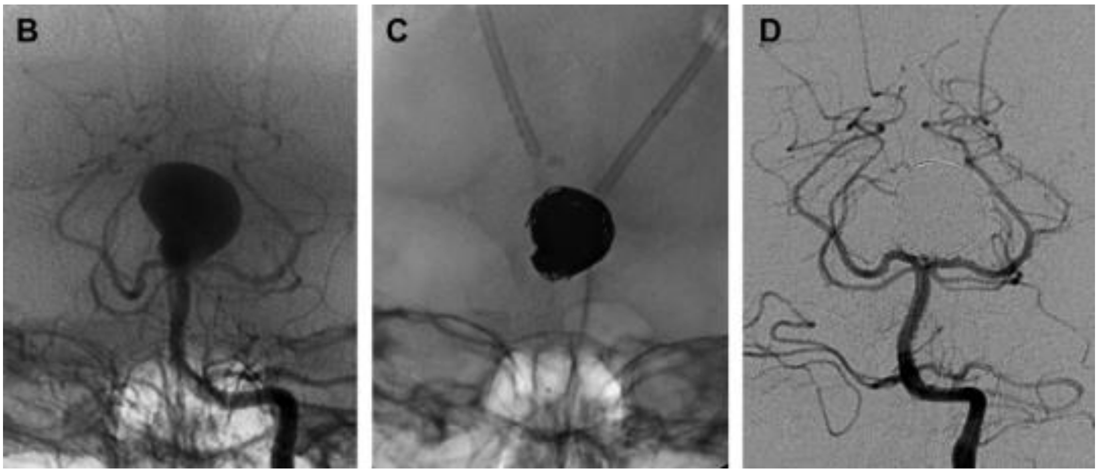

Figure 4: Head CT documenting diffuse SAH and IVH. The patient was transferred to the authors' institution for further management. (B) DSA, transfacial view, showing a large basilar tip aneurysm. (C) Nonsubtracted image of the pack of microcoils (bare platinum coils). (D) DSA, transfacial view after treatment. Mild irregularity is observed at the neck, but there is no residual opacification of the aneurysmal cavity. (39)

4. CONCLUSION

Aneurysmal SAH is a neurosurgical emergency with substantial morbidity and death. Effective management of patients with aSAH involves a multidisciplinary group consisting of neurosurgeons. Surgical clipping remains a conclusive treatment for ruptured cerebral aneurysms, and lots of methods have enhanced over the years to better technique, dissect, and protect both intricate and simple aneurysms following aSAH. Endovascular therapy is now a well-accepted option to surgical clipping for ruptured and non-ruptured intracranial aneurysms. The present advanced endovascular techniques for the treatment of aneurysmal SAH consist of coiling alone and coiling assisted by the balloon remodeling method. The use of freshly established self-expandable stents seems appealing, as their safety and effectiveness have actually been shown for the treatment of non-ruptured aneurysms.

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