CASE 1
Embolization of a Ruptured Basilar Tip Aneurysm

Timo Krings

1.1 Case Description

1.1.1 Clinical Presentation

A 54-year-old man presents with sudden acute onset of headache, nausea, and vomiting. When he arrives in the emergency department, he has a decreased level of consciousness and is not fully oriented. Emergency computed tomography (CT) is performed.

1.1.2 Radiologic Studies

Computed Tomography (CT)

CT demonstrated a basal subarachnoid hemorrhage (SAH) with a nearly symmetric distribution, a small blood clot in the fourth ventricle, and no evidence of intraparenchymal hemorrhage. Enlargement of the ventricles (especially the temporal horns) was noted. Within the prepontine cistern, a focal round area without subarachnoid blood was seen (▶ Fig. 1.1). Computed tomography angiography (CTA) confirmed the suspicion of a single basilar tip aneurysm, and angiography with the intention to treat was performed during the same session.

Digital Subtraction Angiography (DSA)

Injection of the left vertebral artery demonstrated a basilar tip aneurysm. Three-dimensional rotational angiography revealed an irregular shape with a cranial daughter aneurysm (or bleb), which was regarded as the probable point of rupture. The aneurysm size was 12 × 10 × 9 mm. The neck of the aneurysm was considered to be moderately wide (5 mm). A cranial fusion–type basilar apex was present, and the most proximal portions of both P1 segments were incorporated in the neck. No focal vasospasm was seen (▶ Fig. 1.2).

1.1.3 Diagnosis

Diagnosis was made of ruptured aneurysm of the basilar tip.

1.1.4 Treatment

Equipment

- Standard 6F access (puncture needle, 6F vascular sheath).
- A 6F multipurpose catheter (Guider Soft Tip; Boston Scientific, Natick, MA) with continuous flush and a 0.035-in hydrophilic guidewire (Terumo, Somerset, NJ).
- A 45-degree angled microcatheter with a 1.7F tip and a 0.0165-in inner lumen (Excelsior SL 10; Boston Scientific) with a 0.014-in guidewire (Synchro 14; Boston Scientific).
- Coil selection: For framing, GDC 10 soft 360-degree coils, 1 mm × 20 cm, 10 mm × 20 cm, and 9 mm × 20 cm; for subsequent filling and finishing, GDC 10 soft 2D SR coils, 7 mm × 10 cm and 5 mm × 8 cm, and two coils, 4 mm × 8 cm (Boston Scientific).
- Contrast material.
- Heparin.

Description

The 6F multipurpose catheter was placed in the distal vertebral artery. Control injections demonstrated good flow and no vasospasm surrounding the guiding catheter. Following a roadmap in the working projection, the microcatheter was advanced via the micro-guidewire and carefully placed in the lower one-third of the aneurysm. Here, the first coils were deployed, with care taken not to advance the coils into the cranial daughter aneurysm. With the first three complex-shaped coils, a stable frame for subsequent filling of the aneurysm could be established. Control runs demonstrated no protrusion of coils into the parent vessels and good framing of the aneurysm neck. Subsequently, the microcatheter was advanced as far distally into the aneurysm as possible to continue coiling from the dome to the neck with two-dimensional coils, which allowed dense packing of the aneurysm with only two coil loops (of smaller, soft coils) protruding into the daughter aneurysm. If protrusion beyond the frame was noted caudally, the coils were repositioned. A control run demonstrated complete exclusion from the aneurysm and a dense coil mesh (▶ Fig. 1.3).

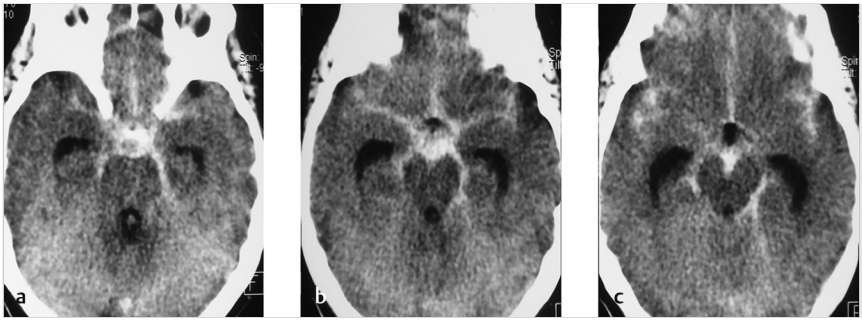


Fig. 1.1 (a–c) Unenhanced axial computed tomography (CT) reveals nearly symmetric hyperdensity within the basal cisterns, corresponding to diffuse subarachnoid hemorrhage (SAH). Prominent size of the temporal horns of the lateral ventricles is noted. Note the small round hypodense area within the hyperdense clot at the level of the prepontine cistern, which is suspicious for a basilar tip aneurysm.

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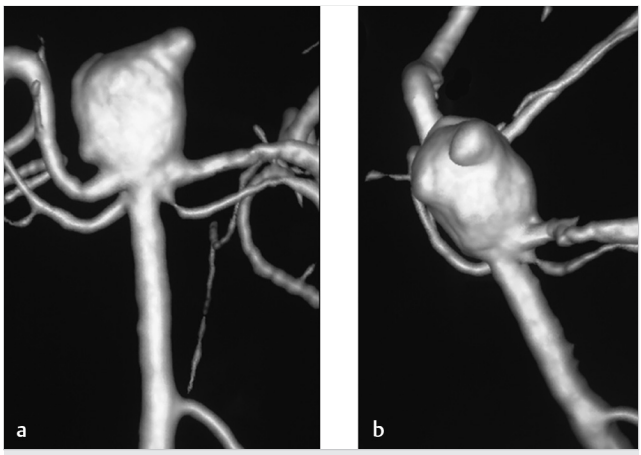


Fig. 1.2 Digital subtraction angiography (DSA) of the vertebral artery. Three-dimensional reconstruction in **(a)** anteroposterior (AP) and **(b)** oblique lateral views shows a basilar tip aneurysm with a rather wide neck. A daughter bleb is noted at the left posterior aspect of the aneurysm dome.

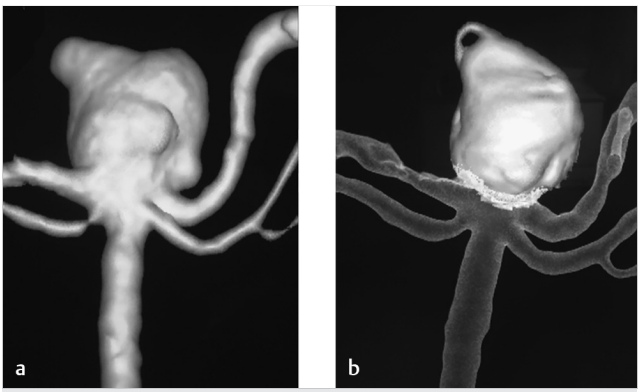


Fig. 1.3 Three-dimensional rotational angiography in posteroanterior (PA) view **(a)** before and **(b)** following coil embolization demonstrating the dense coil mesh. No contrast material is noted entering the aneurysm. Only a few loops are seen in the daughter bleb.

No thromboembolic complications were noted, and all distal vessels were well preserved. The procedure was carried out with the patient on heparin (5000 IE), which was not reversed following the procedure.

1.2 Discussion

1.2.1 Background

Saccular aneurysms are the most frequently encountered form of aneurysm. They arise at arterial bifurcations and resemble berry-like outpouchings of the vessel wall. Their etiology and pathophysiology are complex and poorly understood. Although genetic factors likely contribute to their development, other factors, such as aging, elevated blood pressure, blood shear stresses, and cigarette smoking, are also thought to contribute to the formation and/or rupture of aneurysms.

The average annual risk for SAH is 10 to 21 per 100,000 people, with higher incidence rates encountered in Finland and Japan. Risk factors for hemorrhage include female gender, advanced age, previous symptomatic aneurysm, larger size, and location in the posterior circulation.

The prognosis following untreated aneurysmal SAH is poor; in a community-based study, the mortality rates were 12% before patients reached the hospital, 43% within the first week, and 56% at day 30 if the aneurysm was left untreated. In a meta-analysis of untreated ruptured aneurysms performed by Heros in 1990, significant morbidity and mortality after the first hemorrhage were estimated to be 50%, with a further mortality of 35% after the second bleed. The risk for rebleeding without treatment is approximately 1% per day for the first 9 days, increases to 4% at day 10, and then fluctuates at approximately 2 to 3% per day during days 11 through 15. The cumulative risk for rebleeding is approximately 20% in the first 2 weeks and 30 to 50% in 6 months.

Aneurysms typically arise at branch points on the parent artery. The branch point may be formed by the origin of a side branch from the parent artery (e.g., posterior communicating artery) or by subdivision of a main arterial trunk into two trunks (e.g., middle cerebral artery or terminal internal carotid artery bifurcation, tip of the basilar trunk). Sidewall aneurysms are rare and if present usually arise at a turn or curve in the artery and point in the direction that the blood would have flowed if the curve were not present. At both the branch points and the curves, local alterations in intravascular hemodynamics are present that exert high shear stress forces on those regions that receive the greatest force of the pulse wave. Therefore, the aneurysm dome typically points in the direction of the maximal hemodynamic thrust in the preaneurysmal segment of the parent artery. Aneurysms that are encountered on a straight, nonbranching segment of an intracranial artery should raise the suspicion of a dissecting process because saccular aneurysms are infrequently encountered at these sites. More than 90% of all saccular intracranial aneurysms are located at one of the following five sites: (1) internal carotid artery at the origin of the posterior communicating artery; (2) junction of the anterior cerebral and anterior communicating arteries; (3) proximal bifurcation of the middle cerebral artery; (4) terminal bifurcation of the basilar artery into the posterior cerebral arteries; and (5) terminal bifurcation of the carotid artery into the anterior cerebral and middle cerebral arteries. In the anterior circulation, other common sites of aneurysms are the origins of the ophthalmic, superior hypophyseal, and anterior choroidal arteries. In the posterior circulation, the origin of the posterior inferior cerebellar, anterior inferior cerebellar, and superior cerebellar arteries and the junction of the basilar and vertebral arteries are likely sites of aneurysm formation.

1.2.2 Noninvasive Imaging Workup

Physical Examination

- Patients typically report abrupt onset of the “worst headache of their life.” Loss of consciousness, meningismus, focal neurologic deficits, and nausea may be present.

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- Many patients report earlier, milder headaches over the days preceding the acute event, most likely representing small "sentinel bleeds" from an unstable aneurysm.
- On physical examination, patients are photophobic and demonstrate nuchal rigidity.
- Cerebrospinal fluid (CSF) analysis is necessary in patients whose CT is negative but in whom an SAH is strongly suspected.
- The rate of rebleeding is significantly higher in patients with poor overall clinical status than in those with good clinical status.

Computed Tomography (CT)/Computed Tomography Angiography (CTA)

- In the acute setting of patients with the "worst headache of their life," CT is the first method of choice to detect SAH and aneurysm, following CTA.
- The presence of additional intraparenchymal hemorrhage (with or without mass effect) and/or acute hydrocephalus should prompt emergency neurosurgical treatment in the appropriate clinical setting.
- In patients with large aneurysms, the aneurysm "ghost" can be seen within the subarachnoid blood as a focal area of SAH sparing.
- CTA has a high sensitivity and specificity, and in most instances, the treatment decision can be based on the three-dimensional reconstruction of CTA; however, if CTA is negative in the presence of a classic SAH, DSA is still necessary.

Magnetic Resonance Imaging (MRI)/Magnetic Resonance Angiography (MRA)

In the acute setting, MRI or MRA is rarely needed. Fluid-attenuated inversion recovery (FLAIR)–weighted sequences will demonstrate the subarachnoid blood with a slightly higher accuracy than that of CT as a high signal (unsuppressed CSF) within the subarachnoid spaces. In later stages following an SAH, pial hemosiderosis can be seen that is best detected by susceptibility or T2*-weighted sequences.

1.2.3 Invasive Imaging Workup

Diagnostic cerebral angiography combined with three-dimensional rotational angiography remains the gold standard for evaluating patients presenting with SAH and suspected for intracranial aneurysms. DSA and three-dimensional DSA have the highest temporal and spatial resolution and provide the most precise depiction of intracranial vessel morphology and hemodynamic analysis. It is therefore still needed in CTA-negative cases of SAH. If the quality of the noninvasive images is suboptimal, treatment decisions can be made after careful analysis of the angiography. For aneurysmal detection and pretherapeutic planning, three-dimensional rotational angiography is considered the gold standard. If not available, additional oblique views with magnification should be obtained for aneurysm detection and detailed pretherapeutic morphologic analysis. Analysis must include the location of the aneurysm, incorporation of vessels in the aneurysm neck, width of the neck, size of the aneurysm, presence and location of associated daughter aneurysms, vasospasm, and additional aneurysms. Should the studies prove negative for aneurysm, then address vasculitis, cranial dural arteriovenous fistulae, and sinus thrombosis as possible alternate etiologies for SAH.

1.2.4 Differential Diagnosis

- Although more than 80% of SAHs are caused by aneurysmal rupture, other sources of SAH include trauma (typically more peripheral and local and associated with other sequelae of trauma), arteriovenous malformation hemorrhage (classically associated with intraparenchymal bleed), and dural arteriovenous fistula with cortical venous reflux (especially a dural arteriovenous fistula within the posterior fossa, which can present with SAH).
- Perimesencephalic SAH: Patients are classically neurologically intact, with only slight nuchal rigidity and a small amount of subarachnoid blood layer within and adjacent to the perimesencephalic cistern.

1.2.5 Treatment Options

Conservative or Medical Management

- Given the high rate of rebleeding, conservative management of an acutely ruptured aneurysm is not recommended unless the patient's clinical condition precludes active intervention. Aneurysms should in principle be treated as soon as possible.
- In the time interval between arrival in the hospital and treatment, principles of general care include management of headache (paracetamol with or without codeine). Hypertension should not be treated aggressively because it may act as a compensatory mechanism for the increased intracranial pressure.

Surgical Treatment

- Whether to clip or to coil is extensively discussed in Case 2. In the present case of a patient with a large basilar tip aneurysm, the endovascular option is undoubtedly the therapy of choice in most centers.
- Treatment of hydrocephalus may be necessary in the acute setting together with extraventricular drainage.
- An indication for emergency surgical intervention is an aneurysm associated with a space-occupying hematoma in a patient with a decreased level of consciousness.

Endovascular Treatment

- Endovascular options are considered the method of first choice in ruptured aneurysms of the posterior circulation.
- The general principle of treating these aneurysms is endosaccular deployment of platinum spirals (coils), either with or without the assistance of devices such as balloons or stents (see Cases 5 and 6).
- In many cases, the bleb (daughter aneurysm) indicates the point of rupture and therefore a segment of the aneurysm sac that is weaker than the remainder. Coiling of this bleb needs

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to be done either very carefully or not at all. In the present case, we allowed only one loop of a single coil to enter the presumed point of rupture to avoid periprocedural repeated rupture. In cases in which the bleb is located proximal to or very close to the neck, surgery may be indicated rather than coil embolization.

1.2.6 Possible Complications

- Periprocedural hemorrhage.
- Thromboembolic complications.
- Recanalization of the aneurysm.

1.2.7 Published Literature on Treatment Options

Given the high risk for rebleeding with its associated mortality, there is no question that acutely ruptured aneurysms should be treated. Concerning the timing of treatment, in most centers an acute treatment is advocated. Even with an early and successful intervention, SAH is a devastating disease, and the risk for a poor outcome is high. Factors associated with a poor outcome are poor clinical status on admission, a large SAH, advanced age, location of the aneurysm in posterior circulation, and preexisting medical conditions. Neurologic complications due to hydrocephalus and vasospasm and systemic complications with infections, cardiac problems (arrhythmia, myocardial infarction), or pulmonary edema may all lead to a poor outcome.

Basilar apex aneurysms arise where the posterior cerebral arteries branch off from the tip of the basilar artery. At the aneurysm site, the blood flow changes from vertical to nearly horizontal, so these aneurysms project upward in the direction of the long axis of the basilar artery. A majority of patients with basilar tip aneurysms display a relatively short basilar artery (caudal fusion disposition), with the tip of the basilar artery near the caudal end of the interpeduncular fossa. The neck of the basilar aneurysm is preferentially located at the caudal part of the fusion. The largest and most important perforators to arise from the basilar tip are the posterior thalamoperforating arteries (retromammillary arteries). These originate from the basilar tip and P1 segment, enter the brain through the posterior perforated substance in the interpeduncular fossa medial to the cerebral peduncles, and ascend through the midbrain to the thalamus. On occasion, a single P1 perforator may supply both the thalami. Typically, the caudal portions of P1 supply their own sides, whereas the cranial segments of P1 may supply bilateral territories. In patients with caudal fusions of the basilar artery, the posterior communicating artery flows caudally and is likely to supply diencephalic–mesencephalic territories. In patients with cranial fusion of the basilar artery, there is likely to be a basilar contribution to supply this area. The risks from occlusion of these vital perforating vessels include visual loss, weakness, memory deficits, autonomic and endocrine imbalance, abnormal movements, diplopia, and decreased level of consciousness. Given the risk for surgical perforator occlusion, especially in larger aneurysms, endovascular approaches have been widely adopted to treat basilar apex aneurysms.

The aim of endovascular treatment with platinum coils is to permanently occlude the aneurysm lumen based on the following assumptions: Immediately after the coils are deployed in the aneurysm, thrombocytes adhere to the coil loops because of changes in hemodynamics and flow velocity followed by fibrous organization of the primary thrombus over the course of the following days. According to the theory, mechanical stability is further increased over the next weeks by collagenous extracellular matrix and granulation tissue between the coil loops that may then create a foundation for neoendothelial sprouting from healthy vessel walls. Although these theoretical considerations seem appealing, experimental results are not always consistent; the newly developed thrombus, which mainly consists of erythrocytes captured within thin fibrin strings, may not be able to withstand the arterial blood pressure and the presence of fibrinolytic agents in the circulating blood. Moreover, physiologic thrombus retraction, the physical effects of the so-called water hammer effect on the coil material, and the possible presence of old thrombus within the aneurysm dome into which coil loops may be shifted, can lead to a delayed aneurysm regrowth. Despite the potential for delayed recanalization of the aneurysm, the rebleeding rates of sufficiently coiled aneurysms are low, and endovascular treatment of cerebral aneurysms is an established option in the management of ruptured aneurysms.

Pearls and Pitfalls

- The average annual risk for SAH is 10 to 21 per 100,000 people per year.
- Untreated ruptured aneurysms have a poor prognosis. Rebleeding is associated with a high mortality rate and occurs more frequently in patients with poor clinical grades and within the first 48 hours following acute SAH. Early treatment is therefore recommended.
- Aneurysms are classically found at branching points of the large basal intradural arteries.
- “Thunderclap” headaches are the most common presenting symptom and should lead to prompt CT and (if negative) CSF analysis.
- DSA should be employed if CTA is negative in the setting of a classic SAH.
- Coiling of basilar tip aneurysms is safe and effective in preventing recurrent hemorrhage. Follow-up controls are mandatory to detect reopening, especially in large aneurysms.

Further Readings

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CASE 2
Embolization of a Ruptured Anterior Communicating Artery Aneurysm

Timo Krings

2.1 Case Description

2.1.1 Clinical Presentation

A 51-year-old man has an acute onset of headache without loss of consciousness and without focal neurologic deficits. On arrival in the emergency department, he exhibits photophobia and nuchal rigidity. Emergency computed tomography (CT) demonstrates a diffuse symmetric subarachnoid hemorrhage (SAH) and no evidence of hydrocephalus. Computed tomography angiography (CTA) reveals a multilobulated anterior communicating artery aneurysm. Angiography is performed.

2.1.2 Radiologic Studies

Digital Subtraction Angiography

After injection into the right internal carotid artery (ICA), the anterior communicating artery aneurysm was identified pointing anteriorly and inferiorly with at least three lobules, each measuring ~4 mm. The neck of the aneurysm measured 3.8 mm. A rather acute angle between the ICA termination and A1 was present (▶ Fig. 2.1).

2.1.3 Diagnosis

The patient was diagnosed with a ruptured aneurysm of the anterior communicating artery.

2.1.4 Treatment

Equipment

- Standard 6-Fr access (puncture needle, 6-Fr vascular sheath).
- A 6-Fr multipurpose catheter (Envoy; Cordis, Warren, NJ) with continuous flush and a 0.035-in hydrophilic guidewire (Terumo, Somerset, NJ).
- A 45-degree angled microcatheter with a 1.7-Fr tip and a 0.0165-in inner lumen (Excelsior SL 10; Boston Scientific, Natick, MA) with a 0.014-in guidewire (Synchro 14; Boston Scientific).
- Coil selection: for framing of the distal (bilobed) portion, GDC 360-degree soft coil 5 mm × 9 cm (Boston Scientific) and subsequent filling with DeltaPaq coil 3 × 8 (Micrus, San Jose, CA); for the proximal portion, MicruSphere 3 mm × 5.4 cm (Micrus) and subsequent filling with DeltaPaq coil 2 mm × 2 cm (Micrus).
- Contrast material.
- Heparin.

Description

The 6-Fr multipurpose catheter was advanced into the right distal ICA. Over a **J**-shaped micro-guidewire, the acutely angulated A1 segment was catheterized by retracting the **J**-shaped guidewire from the M1 segment to hook up into the A1 segment and then slowly advancing both the microcatheter and the guidewire. To navigate the microcatheter around the acute curve, the guidewire was subsequently placed into the right distal A2 segment. Once the microcatheter was within the A1 segment, the guidewire was retracted and navigated into the aneurysm. The slack was removed from the system, and the catheter was slowly navigated into the distal lobulated part of the aneurysm. The first two coils were aimed at framing the distal part of the aneurysm. This part was then filled with DeltaPaq coils, which allowed good filling of the distal part of the aneurysm. The catheter was then gently retracted, and the second part of the aneurysm was coiled. Given its rounder shape, a MicruSphere coil was chosen for framing, followed by DeltaPaq coils for subsequent filling. The final result demonstrated complete occlusion of the aneurysm and no missing branches (▶ Fig. 2.2). The patient had an uneventful recovery.

2.2 Discussion

2.2.1 Background

For ruptured aneurysms, two major treatment options are available: neurosurgical clip ligation and endovascular coil

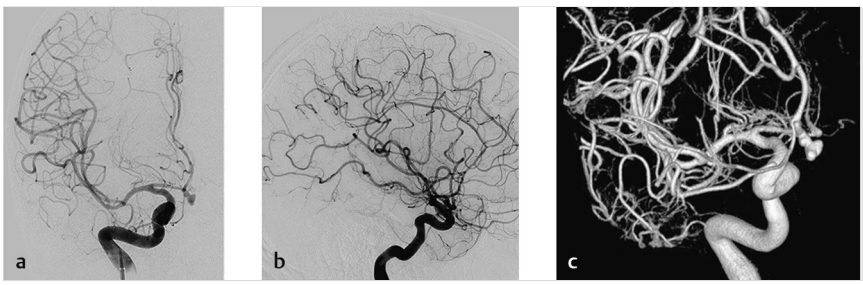


Fig. 2.1 Digital subtraction angiography (DSA). Right internal carotid artery (ICA) angiogram in **(a)** anteroposterior (AP) and **(b)** lateral views and **(c)** 3D reconstruction reveals a lobulated outpouching at the anterior communicating artery pointing anteroinferiorly, representing a ruptured aneurysm.

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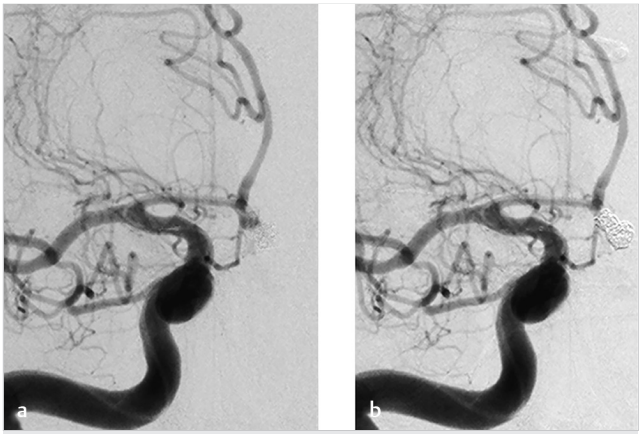


Fig. 2.2 Right internal carotid artery (ICA) angiogram in the working projection following embolization of **(a)** the distal and **(b)** proximal compartments. No filling of the aneurysm sac with contrast is seen after the coiling.

treatment. Following its first clinical use in 1990, coil embolization was primarily reserved for those aneurysms that were difficult to access surgically and for patients with poor clinical grades. Since publication of the results of the International Subarachnoid Aneurysm Trial (ISAT), however, the endovascular treatment of cerebral aneurysms has gained more acceptance and is now regarded in most centers as the technique of choice for the treatment of ruptured aneurysms. The ISAT demonstrated that patients with aneurysms rated by both the neurosurgeon and the interventional neuroradiologist as possible candidates for their respective therapies had a better outcome concerning morbidity, dependency, and mortality when they underwent endovascular treatment. Approximately 10,000 patients with acute SAH were screened; of those, slightly more than 20% ($n = 2143$) were included in the study as eligible for both treatment options and were randomized to either surgery or coiling. The rate of death or dependency was 23.7% in the endovascular group and 30.6% in the surgical group at 1 year, resulting in relative and absolute risk reductions for death or dependency after endovascular treatment of 22.6% (95% confidence interval [CI], 8.9–34.2%) and 6.9% (95% CI, 2.5–11.3%), respectively. The study concluded that outcome in terms of survival free of disability at 1 year was better with endovascular options. The recently published long-term results (mean follow-up, 9 years; range, 6–14 years) confirm the positive trend for endovascular treatment options, with a significantly decreased risk of death at 5 years in the endovascular group (relative risk, 0.77; 95% CI, 0.61–0.98; $p = 0.03$). However, the proportions of survivors at 5 years who were independent did not differ between the two groups: 83% (626 of 755) in the endovascular group and 82% (584 of 713) in the neurosurgical group. The risk of rebleeding was higher in the endovascular group (11 vs. 2 rebleeds); however, it was still very low, with a cumulative risk of rebleeding after 6 years of ~1%.

2.2.2 Noninvasive and Invasive Imaging Workup

- Imaging workup (CT, CTA, or DSA) must detail imaging features that are important in deciding whether to treat by neurosurgical or endovascular approaches and, if an endovascular approach is chosen, what kinds of devices and techniques to employ for the procedure.
- Brain:
  - Hydrocephalus.
  - Intraparenchymal blood, mass effect, and midline shift.
  - Fisher's grade of SAH and blood distribution.
  - Edema/swelling.
- Arterial access:
  - Tortuosity of vessels at the neck.
  - Calcifications or stenoses of major arteries supplying brain.
  - Arterial variations.
- Aneurysm morphology:
  - Size, configuration, and direction of the aneurysm dome; presence or absence and location of aneurysm blebs (daughter aneurysms).
  - Neck morphology, including width of the aneurysm neck, incorporation of parent vessel, perforator or branching vessel into the neck of the aneurysm.
  - Calcifications of the aneurysm neck or its dome.
  - Location of adjacent perforating arteries and presence of local or global vasospasm.
  - Other aneurysms.

2.2.3 Treatment Options

Surgical Treatment

- Microsurgical clip ligation is considered a durable treatment for ruptured intracranial aneurysms; its success is based on surgical accessibility.
- Surgical access to the middle cerebral artery, the ICA termination, and the posterior communicating artery is relatively easily obtained. Access to the anterior communicating artery allows, in addition to clip ligation, fenestration of the lamina terminalis, which may reduce the number of cases of shunt-dependent hydrocephalus. Access to the posterior circulation, or the supraophthalmic ICA, is considered more challenging.
- Anterior communicating artery aneurysms that are pointing caudally and anteriorly are considered to be more readily accessible than those pointing cranially and posteriorly.
- Surgery during the acute phase of SAH in a patient with an edematous brain may require more brain retraction, especially if the aneurysm has a deep location.

Endovascular Treatment

- Endovascular coil embolization is an established alternative to surgical treatment options.
- Its success is mainly based on aneurysm morphology (size of the aneurysm, neck-to-dome ratio, perforators at the neck) and arterial access (tortuosity of vessels).

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2.2.4 Possible Complications

Possible complications include the following (see also Cases 12, 13, 14, 22 and 24):

- Thromboembolic complications.
- Periprocedural rupture.
- Unproven long-term stability.

Published Literature on Treatment Options

The percentage of patients harboring a residual neck or body remnant of the aneurysm after coil treatment ranges between 5 and 20%, and 15 to 35% of patients will in time demonstrate recanalization of the aneurysm. Consequently, the risk of rebleeding is higher after coiling than after clipping. As late rebleeding occurs more often in patients treated by coil embolization (0.152%/y in ISAT, up to 0.3%/y in the literature vs. 0.03% for surgery), the question arises whether in younger patients with a longer life expectancy the superiority of the initial postinterventional results may be offset by the rate of late rebleeding. In addition, the ISAT subgroup analysis of patients younger than 40 years demonstrated that the difference between poor outcome rates of coiled versus clipped aneurysms was very small in this age group. This led to the conclusion in a recently published study by Mitchell et al that in the younger age group, clip ligation may be favored over coil placement. This notion is further supported by experimental results that demonstrated stable aneurysm occlusion, with neoendothelium covering the former aneurysm neck in clipped aneurysms, whereas in coiled aneurysms no stable occlusion was visualized. However, over the past years, endovascular methods have improved considerably, with new coils and device-assisted coiling, whereas there has been very little change in neurosurgical techniques. It is therefore likely that the rate of recurrent SAH will decrease, while the safety of the endovascular treatments will increase. This was confirmed by Schaafsma et al in a study of recurrent SAH within the first 8 years after treatment in 283 coiled patients with a total follow-up of 1,778 patient-years; the cumulative incidence was 0.4% (95% CI, –0.4 to 1.2) after coiling versus 2.6% (95% CI, 1.2–4.0) after clipping. The rates of rebleeding after adequate coiling of aneurysms are therefore equal to those after clipping.

The results of ISAT, including the long-term results, indicate the superiority of endovascular treatment options for those aneurysms deemed suitable for both surgery and endovascular approaches. The results can therefore not be generalized to all ruptured aneurysms and all neurosurgical/endovascular teams. Instead, the results of ISAT must be extrapolated to individual patients after all the different factors that may play a role in the treatment decision have been considered, including the etiology of the aneurysm, the age and clinical status of the patient, the respective neurosurgical and endovascular experience and skills available, the anatomy and location of the aneurysm with regard to feasibility of the endovascular or surgical approach, and the equipment and material available and the comfort with which the treating team may use them. Finally, factors such as the health care environment and the patient's or family's wishes may play a role in the treatment decision.

Pearls and Pitfalls

- Endovascular treatment should be favored over surgical treatment if both the neurosurgeon and the interventionalist agree that the aneurysm is suitable for treatment with both methods.
- The imaging workup must provide the details needed for the treatment decision.
- An anterior communicating artery aneurysm may not be visualized on angiography because of flow competition phenomenon from the contralateral A1 segment. In these instances, compression of the contralateral ICA during contrast injection or bilateral ICA injections may be helpful.

Further Readings

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