

Aneurysm Embolization: Coiling, Stenting, & Flow Diversion

Overview

Coil embolization is a minimally invasive procedure to treat an aneurysm by filling it with material that closes off the sac and reduces the risk of bleeding. It is performed from "within" the artery (endovascular) through a steerable catheter inserted into the blood stream at the groin and guided to the brain. Tiny coils, glue, or mesh stents are used to promote clotting and close off the aneurysm.

What is aneurysm coiling?

The goal of endovascular coiling is to isolate an aneurysm from the normal circulation without blocking off any small arteries nearby or narrowing the main vessel. Endovascular describes the minimally invasive technique of accessing the aneurysm from within the bloodstream, specifically during angiography. The bloodstream is entered through the femoral artery in the upper leg. A flexible catheter is advanced from the femoral artery to one of four arteries in the neck that lead to the brain. The doctor steers the catheter through the blood vessels while injecting a special dye that makes them visible on an x-ray monitor. The result is a kind of roadmap of the arteries.

Once the catheter reaches the aneurysm, a very thin platinum wire is inserted. The wire coils up as it enters the aneurysm and is then detached. Multiple coils are packed inside the dome to block normal blood flow from entering. Over time, a clot forms inside the aneurysm, effectively removing the risk of aneurysm rupture. Coils remain inside the aneurysm permanently. Coils are made of platinum and other materials, and come in a variety of shapes, sizes, and coatings that promote clotting. Coils accomplish from the inside what a surgical clip would accomplish from the outside: they stop blood from flowing into the aneurysm but allow blood to flow freely through the normal arteries.

Aneurysms vary in their size and shape. Saccular aneurysms have a neck at their origin on the main artery and a dome that can expand like a balloon (Fig. 1). Other aneurysms, described as wide-necked or fusiform in shape, do not have a defined neck. Placing coils into these aneurysms may be complicated and require additional support from stents or balloons. Some aneurysms cannot be treated with coiling and must be surgically clipped.

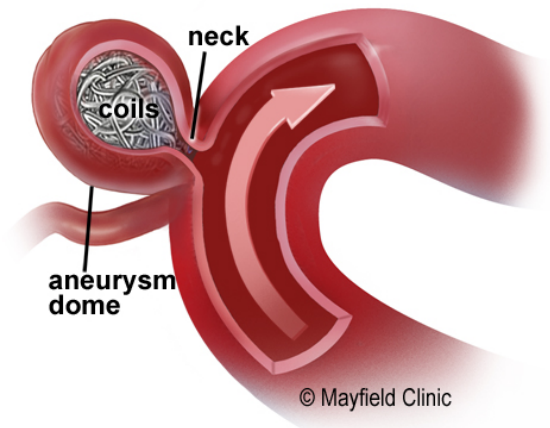


Figure 1. Most aneurysms resemble a balloon, with a narrow neck at the origin and a large expanding dome. During a coiling procedure, a catheter is inserted into the aneurysm and coils are packed inside the dome. Coils promote blood clotting, which closes off the aneurysm and eliminates the risk of rupture.

Who is a candidate?

The choice of aneurysm treatment (observation, surgical clipping or bypass, or endovascular coiling) must be weighed against the risk of rupture and the overall health of the patient.

Coiling may be an effective treatment for the following:

- **Ruptured aneurysms** burst open and release blood into the space between the brain and skull, called a subarachnoid hemorrhage (SAH). The risk of repeated bleeding is 22% within the first 14 days after the first bleed [1]. So timing of treatment is important - usually within 72 hours of the first bleed. Vasospasm (narrowing of an artery) is a common complication of SAH.
- **Unruptured aneurysms** may not cause symptoms and are typically detected during routine testing for another condition. The risk of aneurysm rupture is about 1% per year but may be higher or lower depending on the size and location of the aneurysm [2]. However, when rupture occurs, the risk of death is 40%, and the risk of disability is 80%.

The surgical decision

The treatment decision for observation, surgical clipping or bypass, or endovascular coiling or flow diversion largely depends on the aneurysm's size, location, and neck geometry. The less invasive nature of coiling is likely to be favored in patients who are older, are in poor health, have serious medical conditions, or have aneurysms in certain locations. In patients younger than 40 years of age, the difference in the safety between coiling versus clipping is small. Therefore, the better long-term protection from bleeding may give patients with clipped aneurysms an advantage in life expectancy.

Comparing the long-term results of coiling versus clipping of aneurysms is an area of ongoing study. Clipping has proven its long-term effectiveness over several decades. Coiling is a relatively new technique (since 1990s) and its long-term protection against rebleeding is not known. The International Subarachnoid Aneurysm Trial (ISAT) explored this topic over a period of years (1994-2007) [3]. But because the study was limited to ruptured aneurysms and included a very select group of patients, its results cannot be applied to all aneurysm patients. Therefore, the best treatment option remains highly individualized. Discuss with your doctor the technique most appropriate for your specific case.

Who performs the procedure?

Coiling is performed by a neurosurgeon or neuroradiologist who has specialized training in endovascular surgery. Ask your doctor about their training, especially if your case is complex.

What happens before the procedure?

Preparation before surgery will vary, depending on whether the patient arrives at the emergency room with a ruptured aneurysm or whether the patient is considering coiling for an unruptured aneurysm.

A ruptured aneurysm is life threatening, and every patient is assessed for medical stability and treated as necessary. Once the patient has been stabilized, the medical team must find the source of the hemorrhage. This is typically accomplished with an angiogram or CT angiogram. The neurosurgeon and/or interventional radiologist then reviews the findings to determine whether the aneurysm should be treated with endovascular coiling or surgical clipping. The physician shares this recommendation with the patient and family.

A patient with an unruptured aneurysm has time to prepare for a scheduled surgery and will typically undergo tests (e.g., blood test, electrocardiogram, chest X-ray) several days before surgery. In the doctor's office, you will sign consent forms and complete paperwork regarding your medical history including allergies, medications, bleeding history, anesthesia reactions, and previous surgeries.

Discuss all medications (prescription, over-the-counter, herbal supplements) you are taking with your health care provider. Some medications need to be continued or stopped the day of surgery. Be sure to discuss all allergies to medications, jewelry (nickel), or shellfish (iodine) with your doctor.

Stop taking all non-steroidal anti-inflammatory medicines (Naprosyn, Advil, Motrin, Nuprin, Aleve, etc.) 1 week before surgery. Stop taking coumadin 1 week before surgery. Some blood thinning medications (aspirin, Plavix) are occasionally recommended prior to coiling. The doctor will give you specific instructions to either stop or start taking blood thinners. Additionally, stop smoking, chewing tobacco, and drinking alcohol 1 week before and 2 weeks after surgery as these activities can cause bleeding problems. No food or drink is permitted past midnight the night before surgery.

Patients are admitted to the hospital the morning of the procedure. An intravenous (IV) line is placed in the arm. An anesthesiologist will explain the effects of anesthesia and its risks.

What happens during the procedure?

Endovascular procedures are usually performed in the special procedures room or angiography suite in the radiology department. The procedure has six steps and generally takes 2 to 4 hours.

Step 1: prepare the patient

You will lie on your back on the x-ray table and be given anesthesia. The type of anesthesia varies depending on your medical condition, your ability to follow instructions from the surgical team, the complexity of your case, and your surgeon's preference. Some cases can be done with "twilight" sedation and others with a general anesthetic. Anti-clotting medication (heparin) is injected throughout the procedure to prevent blood clots from forming. Your head is positioned so that it will not move during the procedure.

Step 2: insert the catheter

The inner thigh and groin area are shaved and cleansed. A local numbing agent is given to minimize discomfort as the skin incision is made. The femoral artery is located and a hollow needle is inserted into the artery (Fig. 2). Next, a long tube made of flexible plastic called a catheter, is passed through the needle to enter the bloodstream. A special dye, called a contrast agent, is injected into the bloodstream through the catheter. The dye makes the blood vessels visible on the x-ray monitor (fluoroscope). Watching the monitor while injecting dye, the doctor carefully guides the catheter from the femoral artery in the leg, up the aorta, past the heart, and to one of four arteries in the neck that lead to the brain. You may feel brief discomfort when the catheter is inserted, but most catheter manipulation is painless.

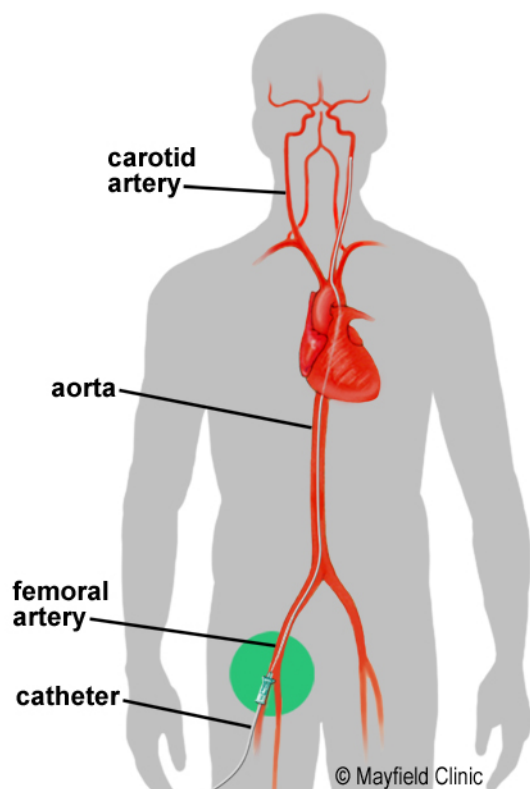


Figure 2. During an angiogram, a catheter is inserted into the femoral artery in the groin. It is then guided through the arterial system to the arteries in the brain.

Step 3: locate the aneurysm

When the catheter is placed correctly, the doctor injects the contrast dye while x-ray pictures are taken (Fig. 3). You may feel a hot, flush that lasts 5 to 20 seconds. Dye injections are repeated until the doctor can view all necessary arteries and take measurements of the aneurysm, especially its neck.

Step 4: insert the coils / stent

A second smaller catheter, about the size of a string of spaghetti, is advanced through the first catheter. This microcatheter travels through the arteries and into the aneurysm itself. Next, small platinum coils are advanced through the catheter until they emerge inside the aneurysm (Fig. 4). Contrast dye is injected to allow the doctor to see the position of the coils in the aneurysm as seen on the x-ray monitor. If the position is good, the doctor releases the coil from the guide wire. Coils are inserted, one after another, until the aneurysm is packed (Fig. 5). An inflatable balloon may be used to guide coils into the aneurysm.

Some aneurysms with a wide neck or unusual shape require a stent to help hold the coils in place (Fig 6). The stent is advanced through the catheter and positioned in the normal artery next to the aneurysm. A stent is a metal, chicken wire-like tube that conforms to the shape of the artery. The guide wire is passed through the stent to deliver coils into the aneurysm. The stent remains in the artery permanently holding the coils in place.

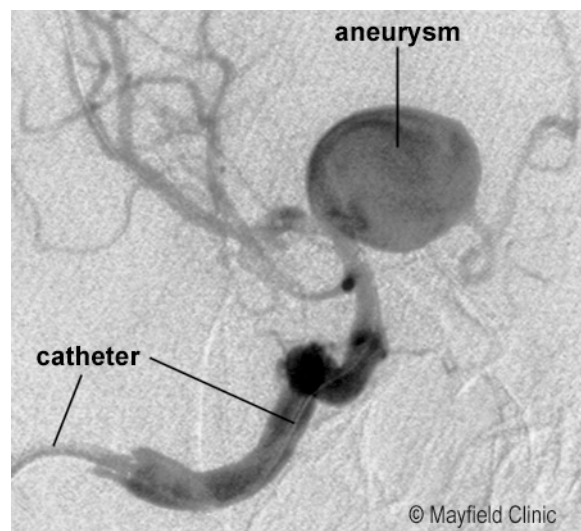


Figure 3. Angiogram shows a catheter in the internal carotid artery. A flush of dye shows blood filling an aneurysm.

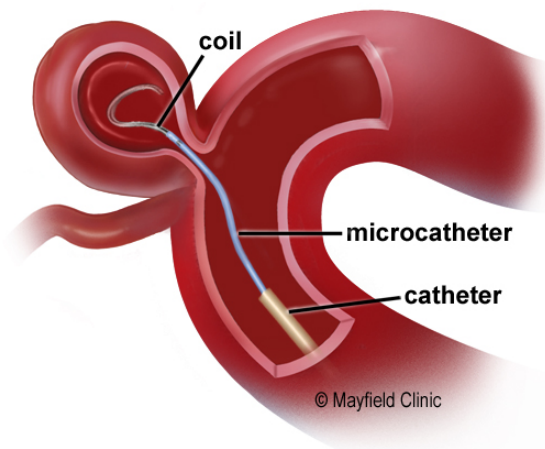


Figure 4. A microcatheter is advanced through a catheter and into the aneurysm to deliver coils into the dome.

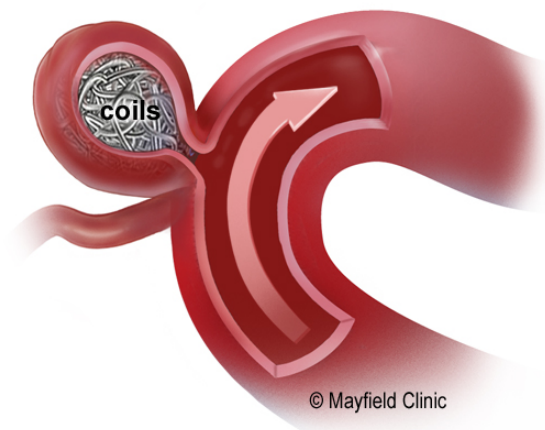


Figure 5. Coils are inserted until the aneurysm is packed. The arrow indicates blood flow through the artery, but not through the aneurysm.

Other devices:

- **Flow-diversion stent.** A tightly woven mesh tube is placed inside the parent artery across the aneurysm (Fig. 7). Because blood cannot easily get through the spaces of the tight mesh stent, the blood flows inside the flow-diverter and continues down the artery without going into the aneurysm. Without the pulsating blood flow, the aneurysm will eventually clot off and shrink in 6 weeks to 6 months.
- **Intrasaccular flow disruptor.** A tightly woven mesh basket is placed inside the sac of the aneurysm (Fig. 8). It creates a bridge across the wide neck of the aneurysm, preventing blood from getting through the spaces of the tight mesh. The blood flow continues down the artery without going into the aneurysm.

Step 5: check the coils / stent

By injecting contrast agent, the doctor inspects the coils to ensure that blood is no longer flowing into the aneurysm (Fig. 9). This technique also verifies that the coils are inside the aneurysm and not narrowing the main artery.

Step 6: remove the catheter

Once the coils have been placed, the catheter is removed. Pressure is applied to the groin area for about 10 to 15 minutes so that the artery won't bleed. A bandage is tightly applied to the incision.

Sometimes an angio-seal may be used to close the puncture site in the artery. It seals the opening by sandwiching an anchor inside the artery with a collagen sponge outside the artery. A suture holds the sandwich together. In about 60 to 90 days, the body absorbs the anchor and sponge naturally.

What happens after the procedure?

You are transferred to the neuroscience intensive care unit (NSICU) for observation and monitoring as the anesthesia or sedation wears off. Pain medication is given as needed. Nausea and headache can occur after the procedure, but medication is available to control these symptoms.

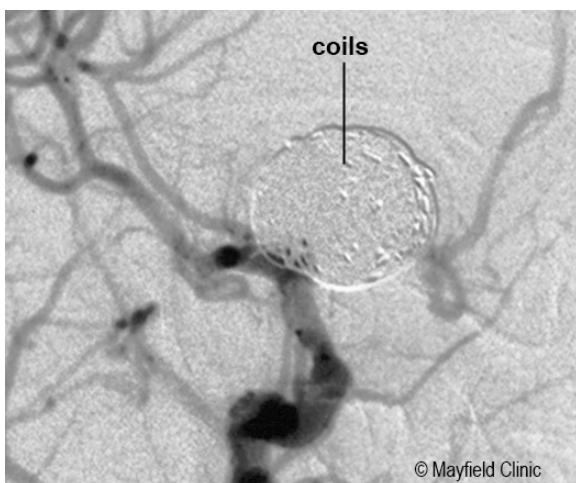


Figure 9. Angiogram shows coils filling the aneurysm.

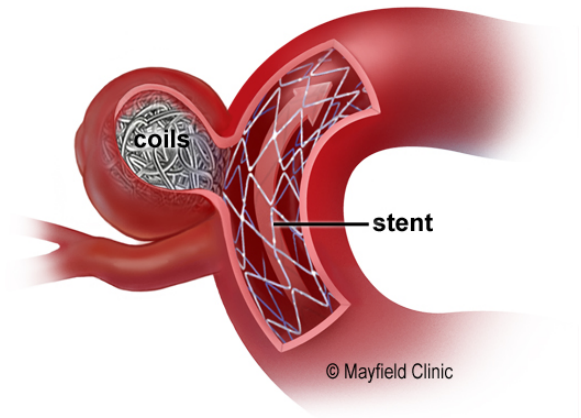


Figure 6. A stent is used for aneurysms with a wide neck to help hold the coils in place. Arrow shows blood flow through the artery.

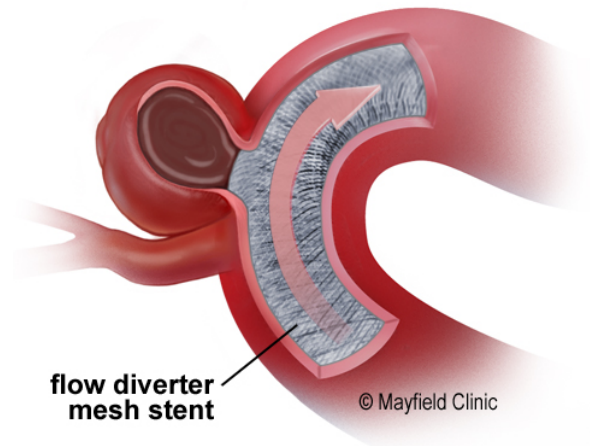


Figure 7. A flow-diverter mesh stent is placed inside the artery to reduce blood flow from entering the aneurysm. The aneurysm will eventually clot off and shrink.

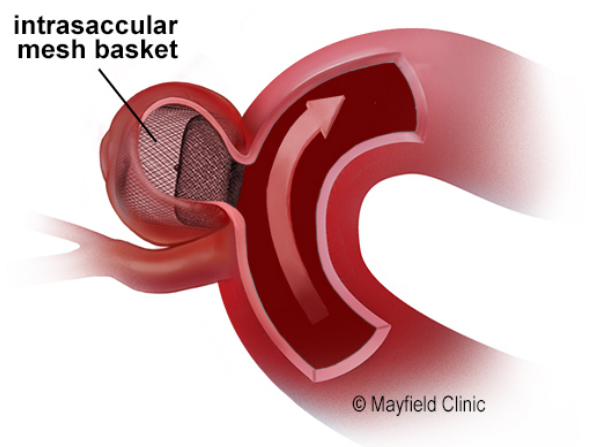


Figure 8. A mesh basket is placed inside the aneurysm sac to disrupt blood flow from entering.

You must remain flat on your back for the next 6 hours, keeping the bandaged leg as straight as possible. If an angio-seal was used, you must remain flat on your back for only 2 hours. You may feel a pea-size lump in your groin or mild tenderness at this site. Notify the nurse if any pain, swelling, or bleeding occurs at the incision site.

A patient who suffered a ruptured aneurysm typically remains in the NSICU for 14 to 21 days. During that time, he or she is monitored carefully for signs of vasospasm, a narrowing (spasm) of an artery that can occur 3 to 14 days after a subarachnoid hemorrhage. Signs of vasospasm include arm or leg weakness, confusion, sleepiness, or restlessness.

A patient who underwent coiling for an unruptured aneurysm is usually released from the hospital the next day. You will be given detailed discharge instructions to follow at home for 2 weeks. In general, you can expect:

Restrictions

- Don't lift anything heavier than 5 pounds for the next 3 days. No strenuous activity.
- Don't drink alcohol. It thins the blood and increases the risk of bleeding. Also, don't mix alcohol with pain medicines.
- Don't smoke or use nicotine products: vape, dip, or chew. Smoking is a major risk for aneurysm formation and rupture.
- Don't drive until your surgeon says it's OK.

Incision Care

- You may shower the day after surgery. Remove the bandage before showering. Gently wash the site with soap and water every day. Don't scrub or pick at the Dermabond skin glue covering the incision. Pat dry and leave open to air.
- A pea-size lump in your groin or mild tenderness and bruising at the puncture site is normal. If bleeding occurs at the site, lie down and apply firm pressure.

Medications

- Mild headache can develop after the procedure. Drink plenty of water over the next few days. this will help flush out the contrast dye.
- Take aspirin and/or Plavix as prescribed for one month. Don't take additional blood thinners during this time without doctor's approval. This includes nonsteroidal anti-inflammatory drugs (Advil, Aleve) and supplements.
- You may take acetaminophen (Tylenol).

When to Call Your Doctor

- Fever over 101.5° F or if the incision begins to separate or show signs of infection, such as redness, swelling, pain, or colored drainage.
- Go to an emergency room if you have a large swelling or sudden pain at the puncture site, or loss of sensation, numbness, or swelling of leg.

- Call 911 if you have a sudden severe headache, popping or snapping sensation in head, nausea and vomiting, or a stiff neck (signs of an aneurysm rupture).

Follow up appointments

A follow-up appointment with the surgeon is made 4 weeks after the procedure. A follow-up angiogram is taken 3 to 6 months after the procedure. The study is done to check the coils and the aneurysm.

What are the risks?

No procedure is without risk. General complications related to an invasive procedure include infection, allergic reactions, stroke, seizure, and bleeding. Complications related to an endovascular procedure include:

- **Blood clots** (thromboembolism): clots can form inside the guiding catheter, on the coils or stents, or in the parent vessels. Clots can break loose and travel downstream to block a smaller artery, potentially causing a stroke. Blood clots occur in 8% of cases, but stroke only occurs in 3%. Giving heparin during the procedure reduces clot formation.
- **Aneurysm rupture**: caused by puncture of the aneurysm with the catheter, guidewire, or the coils. This occurs in about 5% of ruptured aneurysms that have an already weakened wall, but is less common in unruptured aneurysms.
- **Vasospasm**: an abnormal narrowing or constriction of an artery resulting from irritation by blood in the subarachnoid space or from catheter manipulation during an endovascular procedure. Vasospasm can be treated with drugs (triple-H therapy, nimodipine, papaverine) and angioplasty.
- **Coil position**: after placement, some coils may protrude out of the aneurysm neck and narrow the parent artery. A stent or temporary balloon may be inflated to push the coils back into the aneurysm. It is rare for a coil to move out of the aneurysm after the procedure is complete.
- **Incomplete occlusion**: occurs when coils do not completely fill the aneurysm, leaving a residual neck. Blood can enter the residual neck and cause the aneurysm to regrow (recur).

Aneurysm rebleeding after coiling is higher immediately after the procedure (1.9% within 30 days). Between 30 days and 1 year, the rebleeding rate is 0.6% [3].

What are the results?

The long-term success of endovascular coiling to treat aneurysms is about 80 to 85%. Aneurysm recurrence after coiling occurs in 20% of patients [3]. Recurrence happens if coils do not completely block off the aneurysm or if the coils become compacted within the aneurysm (Fig. 9). A recurrence may not be significant enough to require

additional treatment. If a major portion of the aneurysm remains unfilled, additional coils or a surgical clip can be placed to stop the growth. Overall, 5-10% of patients will undergo a second treatment to place additional coils, usually within the first year.

For aneurysms treated with a flow diversion stent, complete closure of the aneurysm occurs between 6 weeks to 6 months after the procedure. You will need to be on two antiplatelet (blood thinner) medicines for several weeks to prevent clots from sticking to the stent.

Because the risk of aneurysm recurrence after endovascular coiling is higher than surgical clipping, all patients with coiled aneurysms are advised to return after 6, 12, and 24 months for a diagnostic angiogram to monitor for a residual or recurring aneurysm. A patient whose aneurysm ruptured should be checked earlier at 3 months. Angiography is an invasive procedure, however the risk for complications with angiographic monitoring of coiled aneurysms is low [4].

A patient whose coiled aneurysm recurred and was retreated should be checked once a year for 3 more years (years 3, 4, and 5) with MRA.

Recovery

Most patients treated with coils for an unruptured aneurysm can expect to live normal and productive lives. They typically can work and enjoy activities, including exercise, as before. Part of their healthcare regimen is to return for follow-up angiograms as prescribed.

Patients treated with coils for a ruptured aneurysm face challenges ranging from minor to serious, depending on the severity of the rupture. Short-term memory loss and headaches are common after a ruptured aneurysm. Some of these deficits may disappear over time with healing and therapy. Family members and friends can play an important role in helping the patient recover physically and emotionally. A daily planner and reminder notes placed at strategic locations in the household are helpful tools for those coping with short-term memory loss. Patients and family members also can benefit from participating in a support group.

Sources & links

If you have more questions, please contact New England Neurological Associates at 978-687-2321.

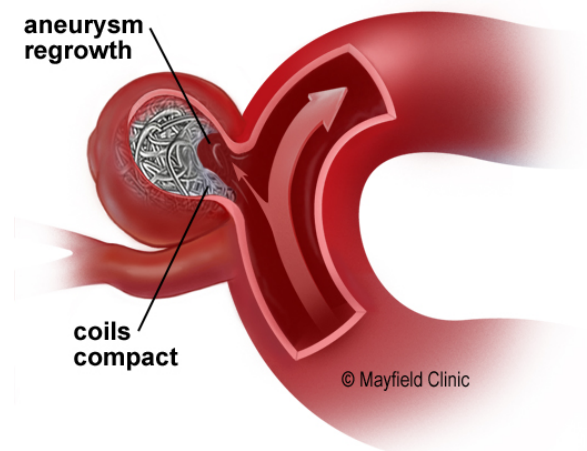


Figure 10. Sometimes the coils compact inside the aneurysm from the impact of the blood pressure and may need to be retreated.

Sources

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2. Wiebers et al. Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment. *Lancet* 362:103-10, 2003.
3. Molyneux AJ, et al. International subarachnoid aneurysm trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms. *Lancet* 366(9488):809-17, 2005.
4. Ringer AJ, et al. Does angiographic surveillance pose a risk in the management of coiled intracranial aneurysms? *Neurosurgery* 63(5):845-49, 2008.

Links

Brain Aneurysm Foundation www.bafound.org
www.brainaneurysm.com

Glossary

aneurysm: a bulge or weakening of an artery wall.

angiogram: a type of X-ray that takes pictures of blood vessels with the help of contrast dye injected via a catheter.

catheter: a long tube made of soft, flexible plastic that can be threaded through arteries.

embolization: the insertion of material, coils, or glue into an aneurysm so that blood can no longer flow through it.

heparin: an anti-clotting medication.

subarachnoid hemorrhage (SAH): bleeding into the space surrounding the brain; a stroke.

vasospasm: abnormal narrowing or constriction of arteries resulting from irritation by blood in the subarachnoid space.



updated > 1.2020

reviewed by > Andrew Ringer, MD and Craig Kilburg, MD, Mayfield Clinic, Cincinnati, Ohio

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