BRAIN ANEURYSMS

DETECTION AND TREATMENT

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Raising Awareness. Ending Fear.™

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OUR MISSION

Provide information about and raise awareness of the symptoms and risk factors of brain aneurysms to prevent ruptures and subsequent death and disability.

Work with medical communities to provide support networks for patients and families.

Advance research to improve patients' outcomes and save lives.

Discovering that you have a brain aneurysm is a frightening and sometimes isolating experience. We prepared this booklet to provide you and your loved ones with accurate, timely information about brain aneurysm detection and treatment. Our goal is to help reduce the anxiety and isolation you may be feeling so that you can focus on your treatment and recovery. You will also find additional information on our website at: bafound.org.

The incidence of brain aneurysms is higher than most people realize. About six million people in the United States — or one in every 50 people in this country — have an unruptured brain aneurysm. The annual rate of ruptured aneurysms in the United States is about eight to 10 in every 100,000 people, or about 30,000 people a year. Every 18 minutes, a brain aneurysm ruptures.

Fortunately today there are a number of effective treatments, including surgical and minimally invasive options, for patients with brain aneurysms. Research is also under way, some funded by the Brain Aneurysm Foundation, to better understand the underlying causes of brain aneurysms, find new treatments, and improve existing treatments.

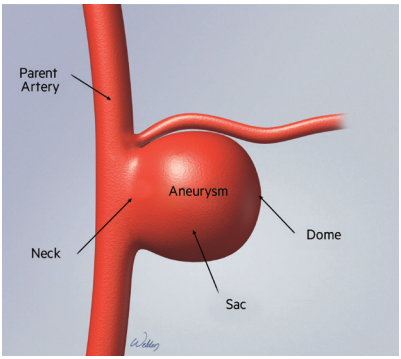
BRAIN ANEURYSMS

A brain aneurysm is a weak, bulging area in an artery in the brain, analogous to a thin balloon or a weak spot on a tire's inner tube. Because its walls may be weak and thin, an aneurysm is at risk of rupturing. If an aneurysm ruptures, blood spills into the space between the skull and the brain, a serious type of stroke known as a subarachnoid hemorrhage (SAH).

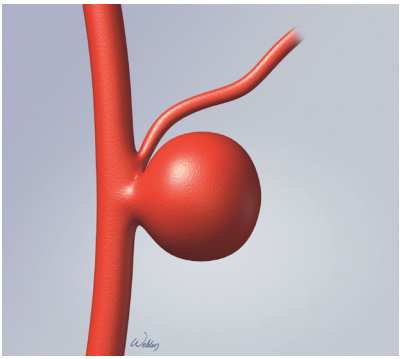
Types

Saccular aneurysms, also called "berry" aneurysms because they look like berries, are the most common type of brain aneurysm. Saccular aneurysms have a "neck" that connects the aneurysm to its main ("parent") artery and a larger, rounded area called the dome. These aneurysms bulge on only one side of the artery wall.

A less common type is a fusiform aneurysm, in which the artery is widened on both sides. Fusiform aneurysms do not have a defined neck.



Anatomy of a brain aneurysm



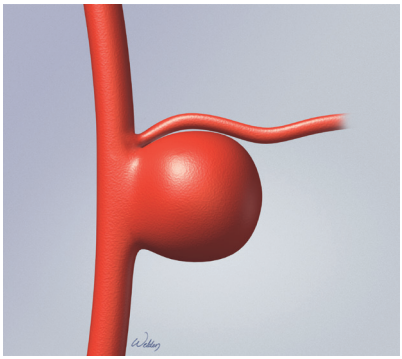
Berry aneurysm

Causes/Risk Factors

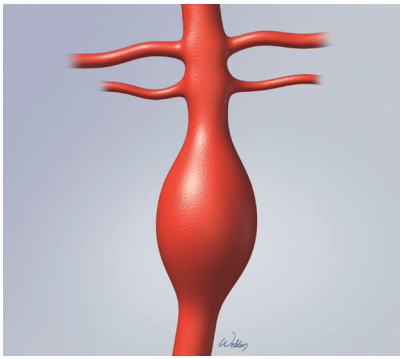
Brain aneurysms develop silently. Some people may have inherited a tendency for weak blood vessels, which may lead to the development of aneurysms. Aneurysms in children are rare, and most aneurysms probably develop as a result of wear and tear on the arteries throughout a person's lifetime. Occasionally, severe head trauma or infection may lead to the development of an aneurysm.

There are a number of risk factors that contribute to the formation of aneurysms. Two of the most significant are, fortunately, ones that can be controlled: cigarette smoking and high blood pressure (hypertension)

Others are: age (over 40), drug use (particularly cocaine), excessive alcohol use, gender (women have a higher risk), and race (people of color have a higher risk).



Wide neck berry aneurysm



Fusiform aneurysm

Familial Aneurysms

In most cases, brain aneurysms are not hereditary, and there is generally only a single case in a family. Occasionally, however, an individual with a brain aneurysm will have other family members who are affected. When two or more first-degree relatives (parent, child, or sibling) have proven aneurysms, these are called "familial aneurysms."

Individuals in these families may be at higher risk of developing aneurysms than the general population. Therefore aneurysm screening with an imaging study of the brain arteries is usually recommended, particularly for first-degree relatives.

If an aneurysm is found, the specialist will work with you to determine if the aneurysm should be treated and, if so, what type of treatment to have. If no aneurysm is detected, a repeat screening may be performed in the future.

Data from a large study of familial aneurysms (the Familial Intracranial Aneurysm Study) indicate that there is a 20 percent incidence of aneurysms in first-degree relatives of patients with a familial aneurysm. Family members most likely to have aneurysms were women or individuals who had a history of smoking and/or high blood pressure.

Pediatric Aneurysms

Aneurysms in children under 18 years of age are rare. In contrast to adults, brain aneurysms in children occur more often in males than in females (by a 1:8 to 1 ratio). This suggests that the formation of pediatric brain aneurysms is different than that of adults.

Pediatric brain aneurysms are not as well understood as brain aneurysms in adults. However, it has been observed that approximately 20 percent of aneurysms in children are so-called giant aneurysms (larger than 2.5 cm in diameter), and that children are four times more likely to present with subarachnoid hemorrhage (SAH) than without SAH. Fortunately, with improvements in brain imaging techniques, increasing numbers of children with brain aneurysms are being diagnosed before their aneurysm ruptures.

Although they can occur with no known cause, aneurysms in children are commonly associated with severe head trauma, connective tissue disorders, or infection. A tendency to develop aneurysms can sometimes run in families (see “Familial Aneurysms,” page 7) or can occur as part of a genetic disorder, such as Marfan syndrome, Ehlers-Danlos syndrome, or autosomal dominant polycystic kidney disease.

As with adults, the treatment options for pediatric patients include open surgery (clipping), endovascular therapies (such as coiling), or careful observation. The decision about treatment, or even whether to treat, is based on a careful analysis of the risks and benefits. It is important that children who have been diagnosed with an aneurysm diligently maintain long-term follow-up with their medical team.

Unruptured Aneurysms

Most aneurysms are quite small and cause no symptoms unless they rupture. Unruptured aneurysms may be found by chance on tests performed for other problems such as headaches or carotid artery disease.

Rarely, unruptured aneurysms may become large and press on nerves in the brain, causing symptoms such as blurred or double vision, a drooping eyelid, a dilated pupil, weakness or numbness, or pain above and behind the eye. If you experience these symptoms seek prompt medical attention. Unruptured aneurysms rarely cause chronic headaches.

Unruptured aneurysms can also be discovered at the time a ruptured aneurysm is diagnosed. This is not uncommon, as one in five people diagnosed with an aneurysm has more than one.

Ruptured Aneurysms

An aneurysm that has bled is called a ruptured aneurysm. When an aneurysm ruptures, the blood from the aneurysm usually goes into the spinal fluid in the space surrounding the brain (called the subarachnoid space); this type of bleeding is called a subarachnoid hemorrhage.

A ruptured aneurysm usually causes a sudden severe headache, often described as the "worst headache of my life." Other signs of rupture are nausea and vomiting, blurred or double vision, a stiff neck, and/or loss of consciousness. Should these symptoms occur, seek immediate medical attention.

Although the bleeding resulting from a rupture probably lasts only seconds, there is much that can happen as a result. For instance, the blood can destroy or damage brain cells. It can also cause the arteries to narrow erratically, a condition called vasospasm, reducing blood flow to vital areas of the brain. Vasospasm can cause an ischemic stroke (also called a cerebral infarction) if the arteries narrow to the extent that not enough blood gets to the brain tissue.

If there is a lot of blood in the spinal fluid, it can slow or block the spinal fluid's normal movement. This may lead to the buildup of fluid in the cavities of the brain, causing pressure on brain tissue — a condition called hydrocephalus.

People who have suffered a ruptured aneurysm may have temporary or permanent deficits. These may include vision, speech, and perception problems; memory and thinking problems; fatigue; and/or issues with balance and coordination. You can learn more about these and how to cope with them in our Treatment Recovery Guide.

DIAGNOSIS

When a ruptured aneurysm is suspected, a head CT (computerized tomography) scan is performed. This is a painless, non-invasive X-ray exam. A CT scan will show if there has been bleeding in the brain. However, a basic CT scan does not usually show the cause of the bleeding. Using a technique called computerized tomography angiography (CTA), in which a contrast dye is injected into the bloodstream, the brain's blood vessels are highlighted and aneurysms can be seen using special imaging techniques.

Sometimes an angiogram is needed to provide a better view of the aneurysm and blood vessels. An angiogram may be done on an emergency basis after a subarachnoid hemorrhage is detected. For someone with an unruptured aneurysm, the angiogram is often performed as an outpatient procedure in an angiography suite of a hospital.

During an angiogram, an area of the groin is numbed and the doctor inserts a catheter into an artery in the groin. The catheter is then advanced to the appropriate area, and a contrast dye is injected through it. The dye highlights the arteries, and X-ray images are taken.

Sometimes magnetic resonance imaging (MRI) or magnetic resonance angiography (MRA) are used to screen patients for aneurysms. MRI and MRA, which use computer-generated radio waves and a powerful magnetic field, do not expose the patient to any ionizing radiation (X-rays).

CTA, MRA, or an angiogram may also be used to diagnose unruptured aneurysms.

TREATMENT OPTIONS

Options for treatment are:

- Open surgery (clipping)
- Endovascular therapy (coils, stents, liquid agents, flow diversion device)
- No treatment: observation, with control of risk factors and possible repeat imaging

Decisions regarding treatment are based on many factors, including:

- The patient's neurological condition, medical condition, and age
- The location, size, and shape of the aneurysm
- The availability of treatment options
- Whether the aneurysm is ruptured or unruptured
- The risk of aneurysm rupture
- Family history of aneurysm or subarachnoid hemorrhage

These and other factors help your doctor decide which type of treatment to recommend.

Usually doctors treat the aneurysm with the method that presents the lowest risk and highest chance for success. For example, aneurysms in the back part of the brain may be more safely treated with coils. Endovascular treatment may also be better for sick or older patients because it does not require long, deep anesthesia.

Open surgery may be better for healthy, young patients due to the known longevity of clipping. It may also be recommended for patients with aneurysms requiring treatment that are not safely treatable with an endovascular approach.

It is important to keep in mind that the primary goal of treatment is to prevent the aneurysm from bleeding or re-bleeding. Treatment does not usually improve symptoms except when large aneurysms are pressing on nerves.

Unruptured Aneurysms

The optimal management of unruptured aneurysms is the subject of considerable research. This is because the natural history of unruptured aneurysms — meaning, what happens if they are not treated? — is not well understood. In addition, the risks associated with the treatment of unruptured aneurysms are not known with certainty.

When deciding whether to treat an unruptured aneurysm, the risk of treatment is compared with the risk of leaving the aneurysm alone. Treatment may increase the likelihood of suffering a stroke, for example, and may also lead to problems with thinking or functioning, especially among elderly or ill patients.

Decisions about treatment must therefore be specific to each patient. Your doctor will take into account these factors:

- Large aneurysms are more likely to rupture
- Aneurysms located in certain areas of the brain may be more likely to rupture
- Patients who have had a previous aneurysm rupture are at greater risk of a future rupture of other unruptured aneurysms they may have
- Patients with a family history of aneurysms may be more likely to have an aneurysm rupture

Ruptured Aneurysms

Once an aneurysm has bled, there is a high risk that it will bleed again, especially within 48 to 72 hours after the first bleed. With each bleed, the chances for recovery lessen. For this reason, ruptured aneurysms are ideally treated as soon as possible.

However, for patients who are in a coma, have major medical problems, or are quite elderly, treatment may worsen their condition. In these situations, treatment is often withheld until the patient becomes more stable.

Sometimes, if also present, unruptured aneurysms are treated at the same time as the ruptured aneurysm. However, unruptured aneurysms are not at a high risk of bleeding right away. They may be treated at another time, following recovery from the subarachnoid hemorrhage, or may be followed. Separating treatments can minimize risks and complications for the patient.

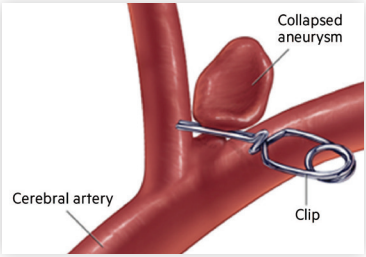
For *all* brain aneurysm patients — whether or not their aneurysm has ruptured — risk factors should be controlled. First-degree relatives of patients with familial aneurysms should also control their risk factors.

- Cigarette smoking: you should not smoke, and you should be provided with assistance in smoking cessation if you are a current cigarette smoker.
- High blood pressure: you should know your blood pressure, and if it is elevated, be treated with medications (anti-hypertensive medications) to reduce it.

SURGICAL TREATMENT: CLIPPING

Surgery poses the lowest risk when it is performed before an aneurysm ruptures. The patient's condition, the size and location of the aneurysm, and other factors determine the risk of surgery. Your doctor will discuss the risks and benefits of surgery with you and your family and answer any questions you may have.

Clipping is an open surgical procedure to seal off the aneurysm neck and, thus, prevent blood from entering the aneurysm, which obliterates it. Clipping of brain aneurysms has been available longer than endovascular therapy, and has excellent long-term results. In recent years, titanium clips have generally been used. These are MRI compatible and they will not set off alarms at metal detectors.



The Procedure

A patient undergoing aneurysm surgery seldom requires blood replacement. If necessary, blood from the blood bank is used. You can also donate your own blood before the procedure, or have family members donate if you prefer.

This surgery is done under general anesthesia, so patients meet with an anesthesiologist before the procedure and are asked questions about their medical history.

A team of doctors, led by a neurosurgeon, performs the clipping procedure. This is an open surgery, which means the skull is cut and microsurgery is performed. Part of the preparation for this surgery may include shaving a section of the hair on your head.

The neurosurgeon makes an incision behind the hairline or on the back of the head, depending on the location of the aneurysm. From there a section of bone, or bone plate, is removed (craniotomy) from the skull to expose the brain tissue.

The neurosurgeon approaches the aneurysm in the opening between the skull and the brain, but does not go through brain tissue. Under a microscope, the aneurysm is carefully separated from the normal blood vessels and the brain, so the neurosurgeon can see it and properly treat it.

The aneurysm is then clipped with a device that resembles a tiny clothespin. With the clip in place, the aneurysm is totally sealed off, and no more blood can enter it. The bone plate is then secured into place and the wound is closed. Aneurysms that are quite large or involve a large section of the blood vessel may require special procedures, such as putting clips on either side of the aneurysm or making a bypass around the aneurysm.

After the surgery, you will wake up somewhat cold and slightly dizzy, and amazed that it is all over. You will need to do breathing exercises. You may experience nausea and a sore throat.

What will surprise you is how little you remember of the day of the operation, and how well you feel the next day.

After Treatment

In most cases you will stay at least one night in the Neurological/Neurosurgical Intensive Care Unit (NICU). The stay in the NICU will be longer for patients with a ruptured aneurysm to closely monitor for the development of vasospasm.

Once transferred to a hospital room outside of the NICU, most patients are up within a few days to a week. Patients treated for an unruptured aneurysm will leave the hospital within a few days, while patients treated for a ruptured aneurysm will usually leave the hospital within two weeks. However, if complications arise, the stay will be longer.

If all goes well, recuperation at home takes about a month to six weeks. Your doctor will clearly define your limitations before you leave the hospital.

ENDOVASCULAR TREATMENT

Endovascular simply means within the blood vessel. Instead of open surgery, the aneurysm is accessed via a catheter inserted in an artery (usually in the groin) and treated by inserting various devices (coils, stents, balloons, flow diversion devices) or liquid agents that prevent blood from flowing into the aneurysm. Endovascular treatment is also referred to as embolization.

The goal of endovascular therapy is the same as surgical treatment: to prevent rupture by safely sealing off the aneurysm from its parent artery.

Available since about 1990, endovascular treatment was initially used to treat aneurysms that could not be treated with surgery. The field has developed rapidly so that now endovascular treatment is used as the primary treatment method at many medical centers. Your doctor will discuss the risks and benefits of endovascular treatment with you and your family and answer any questions you may have.

Coiling Procedure

Endovascular treatment of aneurysms is most often performed in an angiography suite by a specialized team of doctors, nurses, and technologists. An interventional neuroradiologist or neurosurgeon trained in interventional neuroradiology is the primary doctor during the procedure.

Prior to the procedure, you will undergo some pre-admission testing (for example, blood tests, an EKG, and chest X-ray). You may also be put on medications to prevent small clots during the procedure. During the procedure, you will be under general anesthesia.

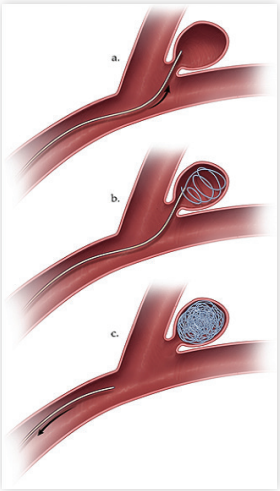
At the time of the procedure, your groin is scrubbed and shaved, usually on both sides. Sterile drapes and cloths are placed over your body, leaving the groin area exposed. A small skin incision, measuring approximately 6 mm (a dime is 18 mm), is made over the artery and a needle is used to puncture the blood vessel.

A sheath (thin tube) is then placed in the artery, which provides continual access to the artery. Using X-ray visualization and high-speed filming techniques that provide a continuous view of the normal blood vessels and aneurysm, the doctor inserts a catheter, led by a guide wire, and advances it to the site of the aneurysm. Through the catheter, a smaller microcatheter is advanced into the aneurysm opening and the coil system is introduced.

The coil system consists of different materials, most commonly platinum and sometimes other gel-like and suture-like materials. The coils are soft and pliable, and are available in several sizes and shapes to fit correctly inside an aneurysm.

While inside the catheter, the coil is straight, but when the coil exits the catheter, it takes on a spiral shape, conforming to the shape of the aneurysm. The coil (or coils, as sometimes more than one is needed) prevents blood from flowing into the aneurysm. This causes the blood inside the aneurysm to clot, which destroys the aneurysm.

Coil



After Treatment

You will be monitored in a recovery area after the procedure. Although rare, there is a risk of blood clots or a stroke associated with endovascular therapy. Drugs to prevent clotting may be used. The length of stay in the hospital varies for each patient. Patients treated for unruptured aneurysms can often go home within 24 hours. Patients with ruptured aneurysms remain in the hospital longer.

Follow-up imaging will need to be done to assess for the stability of the coil or other device and to make sure the aneurysm does not grow back. Your doctor will tell you when and how often you will need follow-up studies. It is very important to adhere to your follow-up schedule.

ADVANCES IN ENDOVASCULAR TREATMENT

For years, coils have been the mainstay of endovascular treatment of brain aneurysms. In recent years, devices that improve the results of endovascular coiling have been developed, making endovascular treatment available to increasing numbers of patients.

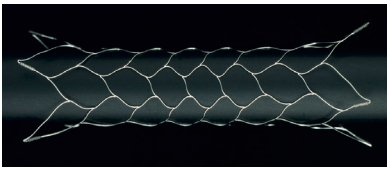
In addition, new endovascular treatment options have been introduced. Today, for example, aneurysms can also be treated with liquid agents. There is also an entirely new form of endovascular treatment that diverts blood past the aneurysm.

Stents

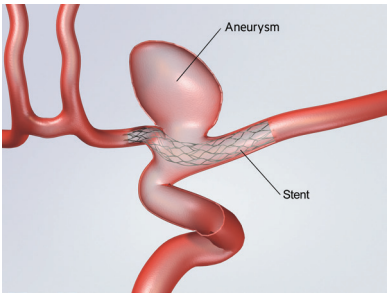
Devices called stents are sometimes used in coiling. A stent is a small wire mesh tube that is placed inside the parent artery at the site of the aneurysm to cover the neck of the aneurysm, which helps keep the coil(s) inside the aneurysm sac. These devices can be particularly helpful for aneurysms with wide necks, or for large aneurysms that in the past were difficult to treat with an endovascular approach.

The stents are usually made of nitinol, a high-grade metal alloy of nickel and titanium. The stent is placed in the same manner as the coils (via a catheter in an artery in the groin) at the time of the coiling procedure or sometimes as a separate treatment.

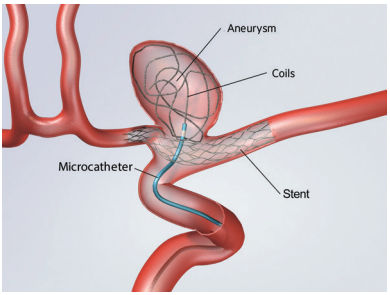
If you have a stent placed, you will need to be on one or more antiplatelet (mild blood thinner) medicines such as aspirin, clopidogrel, or others for several weeks. Your doctor will review this with you



Stent



Aneurysm with stent in place.



Coils put in place after stent.

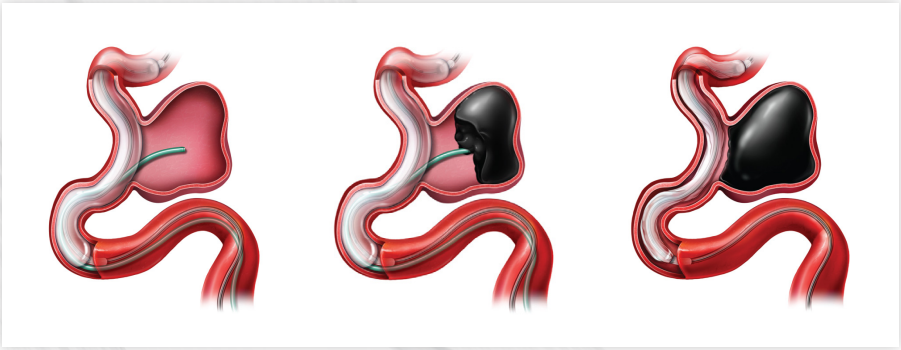
In some cases, a balloon is temporarily inserted to keep coils inside the aneurysm.

Balloon

Liquid Agents

The liquid agent that is currently available for aneurysm treatment in the United States is Onyx HD 500, which solidifies on contact with blood.

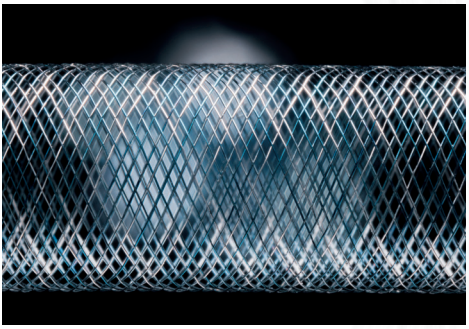
Using an endovascular approach like that used in coiling (via a catheter in an artery in the groin), the doctor injects Onyx HD 500 via a microcatheter into the aneurysm sac, where it solidifies, causing clotting and obliteration of the aneurysm. During the procedure, a balloon is placed across the neck of the aneurysm and inflated temporarily to prevent the Onyx HD 500 from leaking outside the aneurysm sac.



Onyx HD 500 inserted.

Flow Diversion Device

In 2011, the Food and Drug Administration (FDA) approved a new endovascular device called the Pipeline™ Embolization Device (PED).



Pipeline™ Embokization Devie (PED)

The PED is a flexible mesh tube made of platinum and nickel-cobalt alloy. Using an endovascular approach like that used in coiling (via a catheter in an artery in the groin), the doctor places the device in the artery from which the aneurysm protrudes (the parent artery), covering the neck of the aneurysm. The device directs blood flow past the aneurysm, which causes clotting and prevents it from expanding or rupturing. This may also cause the aneurysm to shrink over time.

The PED can be useful for the treatment of very large or wide-necked aneurysms, which often cannot be effectively treated with coiling. Investigations are currently under way at many medical centers to determine whether the PED may also be safe and effective to use in other types of aneurysms.

GLOSSARY OF TERMS

Angiogram (also called arteriogram)
An X-ray study using an injected contrast dye to see the arteries and look for an aneurysm.

Artery
A thick-walled blood vessel through which blood flows from the heart to any organ of the body, including the brain.

Brain aneurysm
A weak, bulging area on the wall of an artery in the brain; also called an intracranial or cerebral aneurysm.

Catheter
A flexible tube for insertion into a vessel, body cavity, or duct; used for an angiogram of the brain arteries and in the endovascular treatment of brain aneurysms to provide access to the aneurysm site.

Cerebral aneurysm
See brain aneurysm.

Clipping
The surgical method for treating an aneurysm. The surgeon exposes the aneurysm with a craniotomy and places a metal clip across the base of the aneurysm so that blood cannot enter it.

Coiling
An endovascular treatment for aneurysms. The aneurysm is filled with a tiny platinum coil (or coils), causing the blood within it to clot and the aneurysm to be destroyed.

Craniotomy
Any operation in which the skull is opened, including the surgical procedure for clipping an aneurysm.

CT
Short for CT scan, or computed tomography scan. CT is a fast, painless, non-invasive diagnostic tool that uses X-rays to produce cross-section images of the body.

CTA
(computerized tomography angiography) – In this procedure, a contrast dye is injected into the bloodstream prior to CT scanning. This process produces detailed images of blood flow in the brain's arteries.

Endovascular
Within the blood vessels/vascular system.

Endovascular embolization
A procedure to treat abnormal blood vessels in the brain and other parts of the body by cutting off their blood supply.

Familial aneurysms
When an individual with an aneurysm has two or more first-degree blood relatives (a parent, child, or sibling) with proven aneurysms. Those family members are at higher risk of an aneurysm than people in the general population.

Fusiform aneurysm
An irregular-shaped widening of a brain vessel that does not have a discrete neck or pouch.

Hemorrhagic stroke
A stroke caused by a ruptured blood vessel and characterized by bleeding within or surrounding the brain.

Hydrocephalus
A condition in which too much fluid builds up within the fluid-filled spaces inside the brain (ventricles), putting pressure on the brain tissue. This may occur after aneurysm rupture.

Microcatheter
A very narrow catheter used to deliver devices and agents in the endovascular treatment of cerebral aneurysms.

MRI
Short for magnetic resonance imaging. MRI is a painless, non-invasive procedure that uses radio waves and a powerful magnetic field to produce detailed images of the brain and other parts of the body.

MRA
Short for magnetic resonance angiography. MRA is a painless, non-invasive procedure that uses radio waves and a powerful magnetic field to produce detailed images of blood vessels. Sometimes an injected contrast dye is used.

Parent artery
The artery in the brain on which the aneurysm has formed.

Saccular aneurysm
The most common type of brain aneurysm. Saccular aneurysms have a "neck" that connects the aneurysm to the parent artery and a larger, rounded area called the dome. Also called "berry" aneurysms.

Stent
A tubular device made of wire mesh that is used in the endovascular treatment of aneurysms. Also called an intracranial stent.

Stroke
A disability caused by injury to the brain. Most strokes are caused by loss of blood flow to a portion of the brain (called an ischemic stroke or cerebral infarction) or by injury related to bleeding within the brain tissue (an intracerebral hemorrhage) or into the space around the brain (subarachnoid hemorrhage).

Subarachnoid hemorrhage (SAH)
Bleeding into the space around the brain (the subarachnoid space).

Vasospasm
A potential delayed complication of a ruptured aneurysm in which blood vessels in the brain spasm, or narrow, limiting blood flow to vital areas of the brain. This can result in stroke or brain tissue damage.

NOTES

The content of this booklet was reviewed by members of the Brain Aneurysm Foundation Medical Advisory Board, September 2017.

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