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Introduction
Discovering that you have a brain aneurysm is a frightening and sometimes isolating experience. The incidence of brain aneurysms is higher than one might guess. Approximately 3-6 million or 1 in 50 people in the United States have unruptured brain aneurysms. The annual rate of subarachnoid hemorrhage due to ruptured aneurysms is about 8 to 10 in 100,000 people; this equals about 30,000 people a year. Today there are several promising ways to treat aneurysms giving hope to those who suffer from this illness.

This booklet is designed to provide information and answer questions often asked by brain aneurysm patients and their families.

What is a Brain Aneurysm?
A brain aneurysm is a weak, bulging spot on the side of a brain artery very much like a thin balloon or a weak spot on a tire inner tube. Saccular or “berry” (so called because they look like berries) aneurysms are the most common type of brain aneurysm. They have a neck which connects the aneurysm to the main blood vessel and a larger rounded portion called the dome; the berry aneurysm bulges on only one side of the artery wall. Fusiform aneurysms are less common and are defined by a widening of the brain artery on both sides. Fusiform aneurysms do not have a defined neck.

How do Brain Aneurysms develop?
Brain aneurysms form silently. There may be inherited tendencies for weak blood vessels which may lead to development of aneurysms. However, aneurysms in children are rare, and most aneurysms probably develop from wear and tear on the arteries during life. On occasion, severe head trauma or infection may lead to development of an aneurysm. There are a number of possible risk factors that contribute to the formation of aneurysms.
Two of the most significant risk factors are cigarette smoking and high blood pressure.

**Are there signs that a person has an aneurysm?**
Most aneurysms are very small and never cause any symptoms. Some people discover they have an aneurysm only when the aneurysm bursts (ruptures, bleeds, leaks, hemorrhages) and causes a severe headache or even loss of consciousness. Other aneurysms are discovered when they enlarge and press on nerves causing problems such as double vision.

**Ruptured Aneurysms**
Aneurysms which have bled are called ruptured aneurysms. When the aneurysm ruptures, the blood from the aneurysm usually goes into the spinal fluid in the space surrounding the brain (the subarachnoid space); this type of bleed is called a subarachnoid hemorrhage.

Rupture of an aneurysm usually causes a sudden severe headache described as the “worst headache of your life”. Other signs of subarachnoid hemorrhage are severe nausea and vomiting, stiff neck and even loss of consciousness.

The bleeding probably only lasts seconds, but there are many things that can happen because of the bleed. The blood can destroy or damage brain cells, cause pressure on the brain, or cause the blood vessels to narrow. This narrowing is called vasospasm (spasm). Vasospasm can cause a stroke if the arteries narrow to the point that not enough blood gets to the brain tissue. If there is a lot of blood in the spinal fluid, the normal movement of that spinal fluid can be slowed or blocked leading to pressure in the brain; this is called hydrocephalus.

**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. On occasion, unruptured aneurysms may grow large and press on brain nerves causing problems such as double vision, drooping eyelid, or pain.
behind the eye. Rarely do unruptured aneurysms cause chronic headaches. Unruptured aneurysms can also be discovered when a ruptured aneurysm is diagnosed. This is not uncommon as 1 in 5 people diagnosed with an aneurysm have more than one.

**How are aneurysms diagnosed?**

When a ruptured aneurysm is suspected, a head CT (computerized tomography) scan is ordered. A CT will show if there has been bleeding in the brain. However, a basic CT scan does not usually show the cause of the bleeding. If a contrast dye is injected into a blood vessel, the brain blood vessels will be highlighted and aneurysms can be seen using special imaging techniques. This technique is called a CTA (computerized tomography angiography).

A CTA may be sufficient to diagnose a ruptured aneurysm but sometimes an angiogram (arteriogram) is needed to better see the aneurysm and blood vessels. During an angiogram, an area of the groin is numbed and a catheter (small tube) is inserted into an artery. The catheter is then advanced through a large artery up into the brain arteries. Dye is injected through the catheter by a neuroradiologist. The dye then highlights the arteries, and pictures are taken using an x-ray. There is a slight risk of blood clots, dye reactions or stroke associated with angiograms. Unruptured aneurysms may also be diagnosed with CTA or angiography. Sometimes magnetic resonance imaging (MRI) along with magnetic resonance angiography (MRA) is used to screen patients for aneurysms. MRI and MRA scans are performed using a large magnet and computer. These scans do not expose the patient to any radiation.
Treatment Decisions

Options for treatment are:

- Open surgery (clipping treatment, craniotomy)
- Endovascular therapy (coils, pipeline flow diversion device, liquid embolics, stents, etc.)
- No treatment/observation, with control of risk factors

Decisions regarding treatment are based on many factors including:

- Neurological condition
- Medical condition
- Age
- Aneurysm location
- Aneurysm size and shape
- Risk for aneurysm rupture
- Availability of treatment options
- Ruptured vs. unruptured aneurysm

These factors help the cerebrovascular physician decide which type of treatment is best for the patient. For example, aneurysms in the back part of the brain may be more safely treated with coils. Endovascular treatment may 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. Usually doctors treat the aneurysm with the method that presents the lowest risk and highest chance for success.

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

Once an aneurysm has bled, it is at high risk to bleed again, especially within 48 to 72 hours after the first bleed. With each bleed, the chances for recovery lessen. Thus, ideally, ruptured aneurysms are treated as soon as possible. However, if a patient is in a coma, has major medical problems or is quite elderly, treatment may worsen their condition.
In these situations, treatment is often withheld until the patient becomes more stable.

Sometimes, unruptured aneurysms are treated at the same time as the ruptured aneurysm. However, some unruptured aneurysms are not at a high risk of bleeding and may be treated at another time. Separating treatments can minimize risks and complications for the patient.

The best management of unruptured aneurysms is somewhat controversial and is the subject of considerable research. This is because the natural history of unruptured aneurysms is not well understood. For example, what happens if they are not treated? In addition, the risks associated with current treatment of unruptured aneurysms is not clear. When deciding whether to treat an aneurysm, the risk of intervention must be compared against the risk of leaving the aneurysm alone. These decisions must be specific to each patient. Some considerations that aid the decision of whether to treat are:

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

The risks associated with treatment should always be considered. Treatment may increase the likelihood of suffering a stroke. Treatment can also lead to problems with thinking or functioning, especially among elderly or ill patients.

For all brain aneurysm patients, including those treated conservatively and those managed with either surgery or endovascular treatment, risk factors should be controlled.
These risk factors include:

- Cigarette smoking: patients should not smoke, and should be assisted in smoking cessation if they are a cigarette smoker.
- Hypertension: all patients should know their blood pressure and if elevated, be treated with appropriate medications to reduce the blood pressure (called anti-hypertensive medications).

**Surgery**

**What is the risk of surgery?**

The patient’s condition, the size and location of the aneurysm, and other factors determine the risk of surgery. Overall the risk of death or stroke from surgery after rupture of an aneurysm is relatively small (usually under five percent for the procedure). The risk may be somewhat higher with large aneurysms. There are potential consequences of a hemorrhage that may produce a stroke days after an aneurysm is treated. Surgery poses the lowest risk when it is performed before an aneurysm ruptures.

**Is there a need for blood replacement during surgery?**

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, or have family members donate if that is your preference.

**Clipping Treatment**

Surgical clipping of brain aneurysms has been available longer than endovascular therapy, and continues to have excellent long-term results. In recent years titanium clips have generally been used. They are MRI compatible and they will not set off alarms at airports or metal detectors. A team of doctors, led by a neurosurgeon, performs the clipping procedure. This is considered 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.

This surgery is done under general anesthesia, so patients meet with an anesthesiologist before the procedure and are asked questions pertaining to their medical history. An anesthesiologist remains in the operating room throughout the procedure.
The neurosurgeon performing the microsurgery 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 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 the tiny titanium clip which resembles a small clothespin. With the clip in place, the aneurysm is totally sealed off, and no more blood can enter the aneurysm. The bone plate is then secured into place and the wound is closed.

The microsurgical procedure is meticulous and exact to get the best results. After the surgery, you will wake up on the operating table 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 actually remember of the operating day, and how well you feel the next day. The image below shows an angiogram taken after surgery with the aneurysm completely obliterated.
Aneurysms which are quite large or involve a large part 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.

**What happens after surgery?**
In most cases you stay at least one night in the Neurological Intensive Care Unit (NICU). The stay in the NICU is longer for a ruptured aneurysm to closely monitor for the development of vasospasm.

Once transferred to a hospital room outside of the NICU, most people are up within a few days to a week. Patients leave the hospital within a few days for unruptured aneurysm surgery, and usually within two weeks after a hemorrhage. If complications arise, the process is longer. If all goes well, recuperation at home takes about a month to six weeks. Your doctor will clearly define your limitations for you before you leave the hospital.

**Endovascular Therapy**
Available since about 1990, endovascular treatment (such as coil embolization) is a relatively new therapy to treat aneurysms that could not be treated with surgery. The endovascular field has developed rapidly to the point that embolization is now used as the primary means for treatment at many centers. In 2002, ISAT (International Subarachnoid Hemorrhage Trial) found patients with ruptured brain aneurysms did better clinically in the short term after endovascular treatment compared to surgery. However, long-term follow-up has suggested that endovascular treatment may not be as good as surgery at eliminating aneurysms and preventing rebleeding. Endovascular therapy is a rapidly evolving field with continual improvements in techniques and devices.

Endovascular means within the blood vessel. Thus, instead of open surgery, the aneurysm is treated by inserting various devices such as coils, stents, balloons or gels through a large artery.

**What is the goal of this treatment?**
The goal of endovascular therapy is the same as surgical treatment: to prevent aneurysm rupture by safely sealing off the aneurysm from
the parent artery (the artery on which the aneurysm has formed). Endovascular treatment prevents blood flow into the aneurysm.

**Who performs the procedure?**
Endovascular treatment of aneurysms, also referred to as embolization, is most often performed in the angiography suite by a specialized team of physicians, nurses and technologists. An interventional neuroradiologist or neurosurgeon trained in interventional neuroradiology is the primary doctor in the procedure.

**How are you prepared for the procedure?**
If you were rushed into treatment because of a rupture, doctors will discuss this treatment option with you and your family and answer any questions. If you are coming in for treatment, as a result of aneurysm detection before rupture, the doctor will have explained the procedure and the risks and benefits. Should it be decided that treatment of the aneurysm is indicated, you will have some pre-admission testing (blood tests, EKG, chest X-ray, etc.). You may be put on medicines to prevent small clots during the procedure.

**How is the coiling procedure performed?**
At the time of the procedure, your groin is scrubbed and shaved, usually on both sides, to facilitate sterile access to the underlying femoral arteries. 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 vessel. A sheath (hollow thin tube) is then placed in the artery, which provides constant access to the artery. The catheter (hollow plastic tube) is then placed in the groin artery, and the catheter along with what is called a guiding wire, is advanced into the artery for treatment of the aneurysm. Once that artery is selected, the wire is removed and a contrast dye is then injected into the bloodstream to provide a clear view of the normal blood vessels as well as the aneurysm.

The entire process is done using continual X-ray visualization and high-speed radiographic filming techniques. The doctor takes measurements and views of the aneurysm. Once the angiogram has detected the presence, size and location of the aneurysm, a smaller “microcatheter” is then placed inside the initial catheter. The microcatheter is then successfully navigated into the aneurysm opening, and the coil system is introduced.

The coil systems consist of different materials, most commonly platinum, and sometimes other gel-like and suture-like materials. The coils are soft and pliable. The coils 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.

Depending on the anatomy, shape, size and location of the aneurysm, the doctor may employ other devices to aid in the coiling. Sometimes, a stent (a small wire mesh tube) is necessary to keep the coils inside the aneurysm.
In other cases a balloon is temporarily inserted to keep the coils inside the aneurysm. Your doctor will discuss these procedures with you.

The goal of the procedure is to pack off the aneurysm and prevent blood from entering the aneurysm dome. It may take several coils to pack off the aneurysm.

**Post-Embolization Care**
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.

**Important:** Follow-up imaging will need to be done to assess for 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.

**Other Procedures**
**Adjuncts to Endovascular Embolization/Coiling**
Recent technological advances have led to the development of adjunctive devices and techniques to improve the results with endovascular embolization/coiling. These are devices that help coils stay inside the aneurysm sac which can be particularly helpful for aneurysms with wide necks or large aneurysms that in the past were difficult to treat with embolization/coiling.
One such adjunctive device is an intracranial stent. A stent is a metal mesh device in the shape of a pipe or tube which is placed inside the parent artery at the site of the aneurysm to cover the neck of the aneurysm. This helps to keep coils placed in the aneurysm sac to stay inside the sac.

The stents are usually made of nitinol, a high grade metal alloy of nickel and titanium. If you have a stent placed, you will need to be on one or more antiplatelet medicines such as aspirin, clopidogrel, ticlodipine, or others for several weeks. Your provider will review this with you.

**Treatment Description**

At the time of the embolization/coiling procedure, or sometimes as a separate treatment, a microcatheter and wire are navigated from the access site (usually the femoral artery in the groin) using x-ray visualization up to the site of the aneurysm in the brain. The stent can then be placed at the site of the aneurysm.

Then coils are placed in the aneurysm sac and would be performed as described in the coiling description. Once the procedure is completed, the patient is transferred to the recovery room and then the intensive care unit for monitoring and care.

**Liquid Embolics**

Coils have been the mainstay of endovascular embolization of cerebral aneurysms. Recently there has been the technological development of liquid agents, a surgical glue, for embolization of cerebral aneurysms. Currently, the liquid agent that is available in the United States, is Onyx HD 500 (ethylene vinyl alcohol copolymer dissolved in dimethyl sulfoxide). Onyx HD 500 is a liquid that solidifies when in contact with blood, thus, in the treatment of
cerebral aneurysms, Onyx HD 500 is injected via a microcatheter inside of the aneurysm sac, and it solidifies inside the aneurysm sac. A balloon is placed across the neck of the aneurysm and is inflated temporarily to prevent the Onyx HD 500 from leaking outside of the aneurysm sac.

**Treatment Description**
A microcatheter and wire are navigated from the access site (usually the femoral artery in the groin) using x-ray visualization up to the aneurysm in the brain and placed inside the aneurysm sac. A balloon is navigated from the access site up to the parent artery and placed so that it covers the neck of the aneurysm. The balloon is then inflated to block the aneurysm neck. Then dimethyl sulfoxide is injected to fill up the inside of the microcatheter, followed by the Onyx HD 500 which pushes the mixture out into the aneurysm sac. Once in contact with blood, this mixture solidifies and fills up the aneurysm sac. The balloon is deflated periodically to allow restoration of blood flow in the parent artery. Once the aneurysm is filled up with Onyx HD 500, the procedure is completed. Once the procedure is completed, the patient is transferred to the recovery room and then intensive care unit for monitoring and care.

**Flow Diversion Device: Pipeline™ Embolization Device (PED)**
In April 2011, the Food and Drug Administration (FDA) approved a new endovascular device called the Pipeline™ Embolization Device (PED). This device is an alternative to open surgery as well as an option to using coils or liquid embolic agents to treat the aneurysm. It is a cylindrical braided flexible mesh tube made of platinum and nickel-cobalt alloy wire mesh which is placed within an artery to block off large, giant, or wide-necked aneurysms in the internal carotid artery, a major blood vessel supplying blood to the front of the brain. The device can also reduce the likelihood that an aneurysm will rupture.
The physician places the PED across the opening (the “neck”) of the brain aneurysm, in order to redirect blood flow away from the aneurysm causing the blood that remains in the aneurysm to form a blood clot. This clot prevents rupture of the aneurysm and may also cause the aneurysm to shrink in size over time.

This is a new option in the management of brain aneurysms, and your physician will determine if this is a good treatment option for your situation.

**Familial Aneurysms**

*Are aneurysms hereditary?*

In most cases, brain aneurysms are not hereditary and there is generally a single case in a family. Occasionally, however, a family will have other family members affected. Familial aneurysms are those in which two or more first degree blood relatives (parent, child or sibling) have proven aneurysms. Research has shown members of these families may be at higher risk to develop aneurysms than the general population. Therefore, screening for aneurysms in other family members, particularly the first degree relatives of those affected, is usually recommended. MRI/MRA or CT/CTA are usually used for screening. An aneurysm specialist can suggest the best type of screening. If an aneurysm is found, the specialist will work with you to determine if the aneurysm should be treated, and if so, what type treatment should be used. If no aneurysm is detected, then a repeat screening may be performed at some point in the future.

Cigarette smoking and high blood pressure may increase the risk of aneurysm formation in the setting of familial aneurysm. It is important for members of such families to avoid cigarette smoking, and to know their blood pressure and use appropriate medications to lower the blood pressure if it is elevated.

A large study of familial aneurysms is called the Familial Intracranial Aneurysm study. Data from this study indicate that there is a 20% incidence of aneurysms in first degree relatives of patients with a familial aneurysm. Family members who were most likely to have aneurysms were female, over 30 years of age, with a history of smoking and/or high blood pressure.
The Brain Aneurysm Foundation is the world's only nonprofit organization solely dedicated to providing critical awareness, education, support and research funding to reduce the incidence of brain aneurysm ruptures.

For more information visit www.bafound.org

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