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BRAIN (CEREBRAL) ANEURYSM

Hemavathy., Girija Bhaskaran and Subasri C

Sree Balaji College of Nursing, No7, works Road, Chennai Tamilnadu, India

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ABSTRACT

Intracranial aneurysms are relatively common, with a prevalence of approximately 4%. Un-ruptured aneurysms may cause symptoms mainly due to a mass effect, but the real danger is when an aneurysm ruptures, leading to a subarachnoid haemorrhage. Most aneurysms are asymptomatic and will not rupture, but they grow unpredictably and even small aneurysms carry a risk of rupture. Intracranial aneurysms are diagnosed and monitored with imaging including intra-arterial digital subtraction angiography, computed tomography angiography, magnetic resonance angiography, and recently transcranial Doppler ultrasonography has been proposed as a potential modality. Treatment options include observation, endovascular coiling, and surgical clipping. This paper will review the epidemiology, pathogenesis, clinical presentation, diagnosis, natural history, and management of un-ruptured saccular intracranial aneurysms.

INTRODUCTION

Aneurysms of the cerebral vasculature are relatively common. A recent systematic review collecting data from many countries reported a prevalence of 0.4% and 3.6% in retrospective and prospective autopsy studies, respectively, and 3.7% and 6.0% in retrospective and prospective angiographic studies, respectively. The angiographic studies likely overestimate the true prevalence due to a selection bias, whereas the retrospective autopsy studies likely underestimate the true prevalence due to an inability to review the original material. Eighty-five percent of saccular aneurysms of the cerebral vasculature occur in the circle of Willis. Multiple aneurysms are seen in 30% of patients. Most are small and asymptomatic. When an intracranial aneurysm ruptures, it may bleed into the brain parenchyma resulting in a parenchymal haemorrhage, or more often, it will bleed into the subarachnoid space, resulting in a subarachnoid haemorrhage (SAH). A SAH is a catastrophic event with a mortality rate of 25% to 50%. Permanent disability occurs in nearly 50% of the survivors, thus, only approximately one-third of patients who suffer a SAH have a positive outcome.

Facts of Brain Aneurysm

Four major blood vessels supply blood to the brain. They join together at the Circle of Willis at the base of the brain. Smaller arteries leave the circle and branch out to supply brain cells with oxygen and nutrients.

Artery junction points may become weak, causing a ballooning of the blood vessel wall to potentially form a small sac or aneurysm.

Cerebral aneurysms are common, but most are asymptomatic and are found incidentally at autopsy.

Aneurysms can leak or rupture causing symptoms from severe headache to stroke-like symptoms, or death. The health care practitioner needs to maintain a high incidence of suspicion to make the diagnosis, since many patients may have an initial small leak of blood causing symptoms hours or days before a catastrophic bleed occurs.

Diagnosis of a brain aneurysm may require CT scans, lumbar puncture, or angiography.

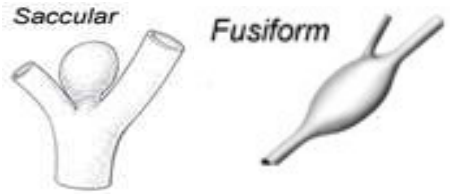
Treatment to repair the aneurysm may involve neurosurgery to put a clip across the weak blood vessel wall. Instead of surgery, some patients may be treated by an interventional radiologist or neurologist who may use a coil to fill the aneurysm to prevent bleeding.

Types of Brain Aneurysms

A brain aneurysm, also referred to as a cerebral aneurysm or intracranial aneurysm (IA), is a weak bulging spot on the wall of a brain artery very much like a thin balloon or weak spot on an inner tube. Pediatric Aneurysms are those that occur in children (<18 Years Old) but are considered rare. Not all brain aneurysms rupture. Doctors are now able to detect un-ruptured brain aneurysms with an increased frequency because of the growing availability of non-invasive imaging methods such as

Corresponding author:* **Hemavathy
Sree Balaji College of Nursing, No7, works Road, Chennai Tamilnadu, India

MRI/MRA. An un-ruptured brain aneurysm may or may not cause symptoms. The two types of aneurysms are:

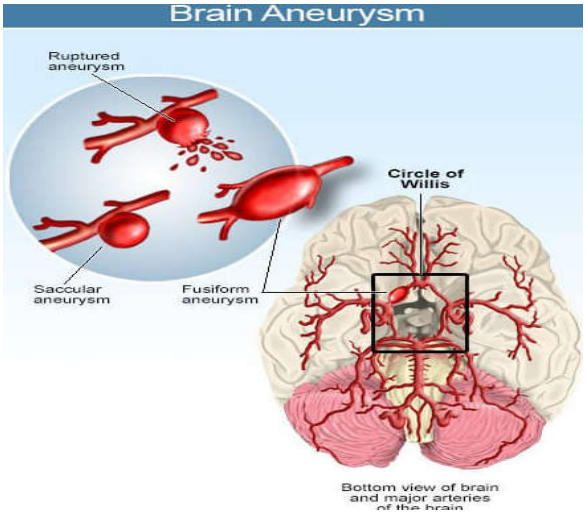


Causes of Brain Aneurysm

The Circle of Willis is the junction of the four major arteries, two carotid arteries and two vertebral arteries, that supply the brain with nutrition (especially oxygen and glucose). This loop of arteries is located at the base of the brain and sends out smaller branch arteries to all parts of the brain. The junctions where these arteries come together may develop weak spots. These weak spots can balloon out and fill with blood, creating the outpouchings of blood vessels known as aneurysms. These sac-like areas may leak or rupture, spilling blood into surrounding brain tissue.

Aneurysms have a variety of causes including high blood pressure and atherosclerosis, trauma, heredity, and abnormal blood flow at the junction where arteries come together.

There are other rare causes of aneurysms. Mycotic aneurysms are caused by infections of the artery wall. Tumours and trauma can also cause aneurysms to form. Drug abuse, especially cocaine, can cause the artery walls to inflame and weaken.



Picture of a brain aneurysm

Brain aneurysms are a common occurrence. At autopsy, incidental aneurysms that have never caused any symptoms or issues are found in more than 1% of people. Most aneurysms remain small and are never diagnosed. Some, however, may gradually become larger and exert pressure on surrounding brain tissue and nerves and may be diagnosed because of stroke-like symptoms. The greater concern is a brain aneurysm that leaks or ruptures, and potentially causes stroke or death. Blood may leak into one of the membranes (meninges) that covers the brain and spinal canal and is known as a subarachnoid haemorrhage.

(sub= beneath + arachnoid=one of the brain coverings + haemorrhage =bleeding).

Risk Factors

There are many risk factors for the development of intracranial aneurysms, both inherited and acquired. Females are more prone to aneurysm rupture, with SAH 1.6 times more common in women. The prevalence of aneurysms is increased in certain genetic diseases; the classic example is autosomal dominant polycystic kidney disease (ADPKD), but other diseases such as Ehlers-Danlos syndrome, neurofibromatosis, and a1-antitrypsin deficiency also demonstrate a link. In ADPKD, 10% to 15% of patients develop intracranial aneurysms. Marfan's Syndrome was once thought to be linked to intracranial aneurysm formation, but recent evidence suggests that this may not be true. Aneurysms also run in families in the absence of an identified genetic disorder, with a prevalence of 7% to 20% in first or second degree relatives of patients who have suffered a SAH.

- Increasing age
- Hypertension
- Smoking
- Alcohol abuse
- Oestrogen deficiency
- Hypercholesterolemia
- Carotid artery stenosis

Symptoms and Signs

A brain aneurysm is a bulging area within the wall of an artery that supplies the brain. In most cases, brain aneurysms do not produce symptoms. In some cases, the aneurysm may cause symptoms by pushing on other areas of the brain. Depending on the size of the aneurysm and the area involved, these symptoms can include

- Headache
- Speech changes.
- Numbness, or weakness of one side of the face,
- A dilated pupil, or
- Change in vision.

When a brain aneurysm ruptures, there is bleeding within the brain. Symptoms of a ruptured brain aneurysm come on suddenly and include a severe, sudden headache that is different from other headaches an individual has experienced.

Diagnosing & Image Finding

The diagnosis of brain aneurysm begins with a high index of suspicion by the health care practitioner. The history of the headache, an acute onset of the headache, associated with a stiff neck and an ill-appearing patient on physical examination, typically lead the health care practitioner to consider the diagnosis and order a CT (computerized tomography) scan of the head. If the CT scan is performed within 72 hours of the onset of the headache, it will detect 93% to 100% of all aneurysms. In the few cases that are not recognized by CT, the health care practitioner may consider performing a lumbar puncture (LP, or spinal tap) to identify blood in the cerebrospinal fluid that runs in the subarachnoid space. Some hospitals will consider CT angiography of the brain instead of the LP.

If the CT or the LP reveals the presence of blood, angiography is performed to identify where the aneurysm is located and to plan treatment. Angiography, where a catheter is threaded into the arteries of the brain and dye is injected while pictures are taken, can demonstrate the anatomy of the arteries and uncover

the presence and location of an aneurysm. CT angiography or MR angiography may be performed without threading catheters into the brain as is the case with a formal angiogram. There is some controversy as to which type of angiogram is best to assess the patient, and the kind chosen depends upon the patient's situation and condition.

Though the symptoms may suggest a brain aneurysm, other diagnoses may need to be considered. Migraine headache, meningitis, tumour, and stroke all may cause neurologic symptoms. Based on the patient's presentation, the health care practitioner will need to decide which tests and studies to use in addition to brain imaging to establish the correct diagnosis.

Pathogenesis

There are four main types of intracranial aneurysms: saccular, fusiform, dissecting, and micotic type. The saccular type accounts for 90% of intracranial aneurysms, thus, it will be the focus of this review. Saccular aneurysms are a result of aberrations to the normal arterial structure, which consists of the tunica intima adjacent to the lumen of the vessel, the tunica media (the muscular middle layer), and the tunica adventitia (the outer layer composed mainly of connective tissue). The internal elastic lamina delimits the tunica intima from the tunica media, and the external elastic lamina delimits the tunica media from the tunica adventitia. Saccular aneurysms occur when there is collagen deficiency in the internal elastic lamina and breakdown of the tunica media. An outpouching, consisting of only tunica intima and adventitia, protrudes through the defect in the internal elastic lamina and tunica media to produce the aneurismal sac. The impaired integrity of the wall may be due to congenital weakness or absence of the tunica media or adventitia, degenerative alterations of the internal elastic lamina (from hypertension, turbulent flow, or atherosclerotic deposits in the wall), or both of these factors combined. Low collagen and elevated plasma elastase has been observed in patients with aneurysms, suggesting that vascular re-modelling involving collagen and elastin plays an important role.

Eighty-five percent of saccular aneurysms arise from the arteries of the circle of Willis. The most frequent location is the anterior communicating artery (35%), followed by the internal carotid artery (30%-including the carotid artery itself, the posterior communicating artery, and the ophthalmic artery), the middle cerebral artery (22%), and finally, the posterior circulation sites, most commonly the basilar artery tip.

Treatment for brain aneurysm

Treatment for a symptomatic aneurysm is to repair the blood vessels. Clipping and coiling are two treatment options.

Clipping: A neurosurgeon can operate on the brain by cutting open the skull, identifying the damaged blood vessel and putting a clip across the aneurysm. This prevents blood from entering the aneurysm and causing further growth or blood leakage.

Coiling: An interventional neurologist, neurosurgeon, or interventional radiologist can thread a tube through the arteries, as with an angiogram, identify the aneurysm, and fill it with coils of platinum wire or with latex. This prevents further blood from entering the aneurysm and resolves the problem.

Both these options have the risk of damaging the blood vessel and causing more bleeding, damaging nearby brain tissue, and causing the surrounding blood vessels to go into spasm; depriving brain tissue of blood supply and causing a stroke.

Prior, during, and after surgery, attention is paid to protect the brain and its blood vessels from potential further damage. Vitals signs are monitored frequently, and heart monitors are used to watch for abnormal heart rhythms. Medications may be used to control high blood pressure and prevent blood vessel spasm, seizure, agitation, and pain.

Outcome of Brain Aneurysm

A brain aneurysm may remain unchanged for the rest of your life, may grow slowly, may grow rapidly, or may rupture and bleed. In some instances, brain aneurysms can shrink or even disappear. This is more likely with smaller aneurysms than with larger aneurysms. Over time, un-ruptured aneurysms become more stable and less likely to rupture or bleed.If you have a brain aneurysm, it is not possible to know for sure exactly which path it will follow over the course of the next few years, or over the course of your whole life.

There are several factors associated with a higher chance of brain aneurysm rupture:

- Increase in size
- Seizures
- Smoking
- Untreated hypertension
- Previous rupture without treatment
- Alcohol use

Future directions for the treatment of Brain Aneurysm

For those who survive an initial aneurysm rupture, blood vessel spasm (vasospasm) may be the villain in causing continued brain damage. Experiments to develop new drugs to control vasospasm are ongoing. Molecules that can cause spasm are being identified, and antibodies may be able to be produced to blunt their effect.

Studies are also looking at the possibility that brain aneurysms may be hereditary, and perhaps screening of high-risk populations may be possible in the future.

Clinical Presentation

The symptoms of SAH result from blood spilling into the cerebrospinal fluid (CSF) and the subsequent increased intracranial pressure and breakdown of blood products. Characteristic symptoms include: "the worst headache of my life," nausea and vomiting, loss of consciousness, neck stiffness, and seizures. The clinical manifestations of un-ruptured aneurysms, however, are much subtler. Only 10-15% of intracranial aneurysms are symptomatic, with the majority being identified incidentally during evaluation for other conditions. When present, the symptoms are primarily due to the mass effect of a large aneurysm, or possibly from minimal leakage of blood which irritates the meninges, though not enough to be classified as a haemorrhage. These symptoms

include headache, unilateral third cranial nerve palsy (from a posterior communicating artery aneurysm), bilateral temporal hemianopsia (from an anterior communication artery aneurysm impinging on the optic chiasm) ischemic cerebrovascular disease, poorly defined spells, and seizures. These symptoms may be a warning sign of an impending rupture, as 10% to 43% of patients with SAH report experiencing a sentinel headache in the 2 months preceding the rupture.

There are currently three imaging modalities widely used in the diagnosis of intracranial aneurysms: intra-arterial digital subtraction angiography (IADSA), computed tomography angiography (CTA) and magnetic resonance angiography (MRA). IADSA is similar to conventional angiography in that a catheter is advanced in the arterial system to the point of interest, and radio-opaque contrast material is injected while images are acquired. The contrast fills the lumen of the arteries; thus, the vessel anatomy is visualized on the image. In conventional angiography, serial x-ray films are captured, while in IADSA, serial digital images are obtained and stored on a computer. An initial image acquired before contrast injection is subtracted from the post-contrast images. The resultant image displays dark vessels against a blank background. This technique allows greater contrast resolution (the areas with contrast are more obvious), but decreased spatial resolution (because digitally acquired images have a lower resolution than films) when compared with conventional angiography.

Comparison of Sensitivity and Specificity of CTA, MRA, and TCD in the diagnosis of intracranial aneurysms.

Method	Sensitivity	Specificity
CTA	90	86
MRA	87	95
TCD	82	95

In light of the ISUIA data, observation is a viable option in many cases. If this management is selected, it is important for the treating physician to be aware that aneurysms may grow unpredictably, so it is necessary to serially monitor the aneurysm and watch for new-onset symptoms related to the aneurysm. Serial monitoring can be accomplished non-invasively

The procedure is guided by fluoroscopy, and when the catheter has reached the aneurysm, several soft platinum coils are deployed in the lumen of the lesion. These coils completely fill the lumen and induce the formation of a thrombus to occlude the aneurysm, preventing future rupture. A wide neck and large size of the aneurysm make the procedure more difficult with poorer results. This procedure appears to be safe relative to surgical treatment, and it is able to treat lesions that are difficult to approach surgically, but there are questions regarding the durability of the endovascular technique. In most studies, complete occlusion is achieved in 80% to 90% of patients. At post-treatment follow-up, however, small neck remnants are common, and some degree of thrombus recanalization is observed in 50% of all patients and up to 90% of patients with giant aneurysms. Both neck remnants and recanalization are associated with a risk of rupture, and 20% of patients may require more than one coiling procedure. Contrast enhanced transcranial Doppler sonography has been shown by a small study to be sensitive and specific (100% and 97%, respectively) in the detection of clinically relevant residual flow in the follow-up of coil-embolized aneurysms. IADSA is effective in visualizing treatment failures with residual necks or complete recanalization, but 3D MR appears to be more effective in evaluating "partial treatments" (such as incomplete recanalization, which may prove to be useful in detecting treatment failures before they have the potential to haemorrhage.

Surgical clipping has been used for the treatment of intracranial aneurysms for longer than 40 years. This procedure involves placing a surgical clip at the junction of the healthy artery and the neck of the aneurysm. This treatment is very effective, demonstrated by annual risks of rupture following clipping reported from 0% to 0.9% (4,28). The disadvantage is the invasive nature of the procedure, which is associated with a higher risk of complications, and as with any surgery, elderly patients are less able to tolerate the trauma of the procedure.

The morbidity, mortality, and re-bleeding rate of intervention for intracranial aneurysms

Outcome	Intravascular Coiling (%)	Surgical Clipping (%)
Mortality	1.0-1.1	2.6-3.8
Morbidity	3.7-4.0	10.9-12.1
Rebleeding	2.6	0-0.9

CONCLUSION

Intracranial aneurysms are relatively common, occurring in approximately 4% of the population. Most of these aneurysms are asymptomatic, and they carry a small but real risk of rupture, resulting in a subarachnoid haemorrhage. IADSA is the gold-standard for diagnosis of intracranial aneurysms, but CTA, MRA, and transcranial Doppler sonography are also effective diagnostic tests. These non-invasive imaging modalities are more appropriate for serially monitoring aneurysms because of the risks associated with invasive angiography. The natural history of intracranial aneurysms is still being explored, but our current understanding suggests that the annual risk of rupture is 1% or less. Large, irregularly shaped lesions arising from the posterior circulation are at an increased risk for rupture. The management strategies consist of observation, intravascular coiling, and surgical clipping.

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