HIGH SCHOOL EDITION
Journal of Student Research
Volume 12 Issue 4 (2023)

Mind Over Matter: An Exploration of Treatment Planning for Cerebral Aneurysms

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ABSTRACT

Cerebral aneurysms are a condition that remain asymptomatic until a possibly fatal rupture. Diagnostic procedures such as CT scans, MRIs, and lumbar punctures were reviewed and discussed. Treatment options – surgical, endovascular, and therapeutic – were also discussed and detailed. A case study was presented on a male who had a cerebral aneurysm. Age was reviewed as a crucial aspect to consider when deciding between treatment options as it affects a patient's medical condition. Lifestyle was also an aspect to consider as it reveals hidden risks specific to the patient. Finally, the seriousness of the aneurysm itself was discussed as the location, size, and shape affect the risk level and urgency of rupture and treatment. The factors were discussed in terms of the patient and the choice of treatment was also reviewed.

Cerebral aneurysms are a dilation of an artery in the brain. This is usually the result of weakness in the muscle lining of the artery. These bulges, which can vary in size and location, are often symptomless unless they rupture. After a rupture, the artery will bleed into the brain, an event known as a subarachnoid hemorrhage. Such a hemorrhage may lead to stroke, coma, and in many cases of a cerebral aneurysm – death. Cerebral aneurysms range from 1 millimeter in diameter to over 25 millimeters (2023). Those over the diameter of 25 millimeters are considered giant aneurysms and are at a higher risk of rupture. However, prior to the rupture of an aneurysm, the location may result in pressure on certain nerves that may cause slight symptoms such as headaches, dull pains behind the eyes, and double vision (2023, March 7). In the United States, there are an estimated 6.7 million cases of cerebral aneurysms – approximately one in every 50 people. Of these cases, there is an annual rupture report rate of 30,000 per year, one rupture every eighteen minutes. The rupture of cerebral aneurysms is responsible for 500,000 deaths per year worldwide (2023, June 2). Once diagnosed, however, there are many treatment options for a patient to decide between. To select the best treatment, the patient should consider many factors about themselves and the aneurysm.

For a cerebral aneurysm to be treated, it must be detected by screening. Regular screening for cerebral aneurysms is not highly recommended by medical professionals. However, many screening techniques are employed to detect and confirm the presence of a cerebral aneurysm when the patient is undergoing testing. CT scans and angiograms provide 2-dimensional images of the brain and arteries containing dyed blood. A lumbar puncture may be used to detect the presence of red blood cells in the cerebrospinal fluid. If a cerebral aneurysm has ruptured, there will be red blood cells that leak into the cerebrospinal fluid from the rupture. An MRI or MRI angiography may be conducted to show the size and location of an aneurysm. These scans use both 2-dimensional and 3-dimensional images of the brain to detect bleeding and image the arteries. A cerebral angiogram is used when all other testing does not yield sufficient results. It uses a catheter to dye the arteries and X-ray imaging to detect the presence of an aneurysm. However, most aneurysms can be detected by a CT or MRI.

Once an aneurysm is detected, there are many treatments to lower or eliminate the risk of rupture. One such treatment is surgical clipping. In this surgical procedure, a neurosurgeon will remove a piece of the skull, locate the

aneurysm, and place a metal clip at the base of the dilation. The procedure is highly effective, and the aneurysm usually does not return. However, the risks, which are extremely low, include bleeding into the brain and loss of blood flow to the brain (2023, March 7). Another treatment possibility is endovascular treatment. In this operation, a neurosurgeon inserts a catheter through the wrist or the groin and maneuvers it to the location of the aneurysm. Then, a springy metal web, called a coil, is placed inside the aneurysm. Many coils are used to completely fill the aneurysm (2020, September 4). Sometimes, the addition of a stent is used to hold the coils in place. The operation prevents further blood flow into the aneurysm and causes the blood to clot, which destroys the aneurysm. However, risks include bleeding into the brain and the return of the aneurysm (2020). A newer version of endovascular treatment is flow diversion; an operation that uses a catheter to place a stent and divert blood flow away from the aneurysm while also prompting new cell growth naturally blocking the aneurysm. This operation is used for aneurysms too large for coiling. Finally, medical therapy can be used as a treatment option to prevent further aneurysm growth. Patients will work with a medical professional to set a smoking cessation plan or blood pressure control. Each treatment comes with its own risks and benefits, but many of the patient's personal factors should be considered as well when deciding on a treatment plan.

To investigate the extent and effect of certain factors on treatment decisions, a case study was conducted. The case is a 77-year-old male. He is 5 feet and 4 inches tall and weighs 180 pounds. At the time of the initial visit, the patient was on hydrochlorothiazide (12.5 mg), losartan (100 mg), bisoprolol (5 mg), levothyroxine (50 mcg), and allopurinol (300 mg). He does not have any known allergies. The patient leads a simple lifestyle. He lives in an apartment complex with his wife and enjoys watching television. He will also attend a senior day care program 5 days a week and takes walks around the apartment complex on occasion. His diet consists of carbohydrates, vegetables, and some meats. He does not smoke or drink currently but quit smoking 20 years ago. The patient has a long history of hypertension. He also underwent a surgical procedure to remove his left thyroid in 2014. The patient arrived at his primary care office complaining of double vision. A CT scan was conducted at the primary care office and a preliminary diagnostic was formed. The primary care physician referred the patient to a neurologist. Within a month, a diagnostic MRI angiogram was conducted, and a 2-millimeter aneurysm was found at the base of the brain near the spinal cord. The aneurysm appeared to be smooth, see Figure 1. This was sufficient for the neurologist to confirm the diagnosis of a cerebral aneurysm. The neurologist referred the patient to a neurosurgeon at Tufts Medical Center who recommended that the patient move forward with endovascular coiling. An angiogram was conducted to see the internal structure of the aneurysm. The patient remained in the hospital for 6 hours while in the supine position. Three months after the initial diagnosis, the patient underwent endovascular coiling and was admitted to the ICU for mandatory monitoring over a 24-hour period. After this time, the patient was moved to a normal hospital room for four days. The patient was also prescribed prasugrel (100 mg) to prevent clotting around the coil. In the first two days, the patient was not given, by mistake, bisoprolol for his hypertension. As a result, the patient had hypertension with arrhythmia. He was unable to stand up and remained in the hospital bed. After five days, the patient was released from the hospital and returned home without further complications. A nurse visited him in his apartment every day to follow up for one week. One year after the coiling procedure, the patient visited the neurosurgeon's office as an annual follow up. An MRI was conducted, and the neurosurgeon concluded that the aneurysm had shrunk to one-fifth of its original size. Then, the patient switched from prasugrel to mini aspirin (81 mg).

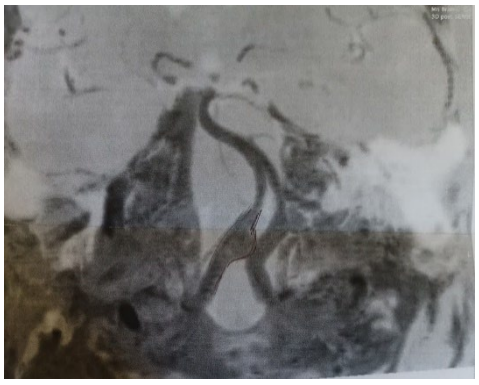

Figure 1

One of the largest looming factors to be considered when deciding upon cerebral aneurysm treatment is the patient's age. In the presented case study, the patient is 77 years old. Although the relationship between age and aneurysm rupture rate is unclear, the elderly have an increased prevalence of pre-existing health concerns and increased risk of larger aneurysms (2021, December). As the age of the patient increases, brain frailty also increases. Brain frailty has been shown to increase with the increase of white matter in the brain. Hence, with the

added delicacy of the brain, an elderly patient may benefit more by a conservative treatment approach rather than one that is more invasive.

These treatments should prioritize reduced exposure to anesthesia and a shorter procedure time. Similarly, procedures that emphasize cerebral homeostasis over vulnerability would help the frail elderly reduce risk. A study was conducted with 214 patients with a mean age of 68 years. Those with severe white matter lesions showed a poorer outcome to the surgical clipping procedure. They were also more susceptible to ischemia, hemorrhage, epilepsy, and a lengthened hospital stay due to the procedure (2020). Inevitably, with age, the patient will have more pre-existing medical conditions and difficulties. These conditions aid in the prediction of remaining life years after hospitalization. As shown by countless previous studies, elderly patients show a higher prevalence of congestive heart failure, chronic obstructive pulmonary disease, diabetes, hypertension, and many other conditions and failures. These medical conditions increase the risk of procedure and decrease the life expectancy after surgery. A retrospective study conducted by Silva et al. of patients over 65 who underwent surgical clipping found that elderly patients had higher perioperative mortality rates than those under 65. Those older than 65 also had higher risk of peri-interventional stroke, cardiac dysfunction, and acute renal failure after the procedure (2018). Additionally, elderly patients have seen infrequent positive outcomes with subarachnoid hemorrhage. Even those who have high cognitive function and healthy white matter experience a lower rate of favorable outcomes than those who are not elderly. Catapano et al. conducted a study on aneurysmal subarachnoid hemorrhages based on age and neurological grade. Those over 65 scored worse than those between 60 and 65 regardless of neurological grade. The patient's age in the case study is considered elderly. Hence, they selected a non-invasive procedure that was completed in a shorter amount of time and reduced exposure to anesthesia. The elderly, by their age and the associated medical challenges, are more vulnerable than those not elderly to invasive treatments and subarachnoid hemorrhages.

In addition to the increased risk levels for treatment and hemorrhage as age increases, the patient's lifestyle also affects treatment planning. Chronic inflammation, hemodynamic stress, and vascular wall remodeling are factors that can be controlled by diet and affect the formation of cerebral aneurysms (2019). Anna Czekajło conducted a study that suggested an insufficient intake of antioxidants, hyperhomocysteinemia, hypertension, and alcohol consumption may also increase the risk of cerebral aneurysm development. The patient in the case study has a history of chronic hypertension. This should be considered when weighing treatment options as it increases the risk level of rupture if the aneurysm were to be left untreated for extended periods. A balanced diet of grains, vegetables, fruit, fish, and spices are beneficial to keeping cerebral aneurysms and their rupture at bay (2019). Another study used Mendelian randomization to observe the relationship between lifestyle choices and the risks of cerebral aneurysms and subarachnoid hemorrhage. The study found that smoking increased a person’s risk of cerebral aneurysms by 0.9% -- nearly double any other increase by lifestyle exposures (2021, November 3). The patient presented in the case study had a history of smoking up to 20 years prior to the diagnosis. Although the patient is not currently a smoker, the patient’s history should be considered as there will be lingering effects of earlier lifestyle choices, especially those that were long-term.

Additionally, the same study reported that a higher BMI also is associated with a higher risk of cerebral aneurysm and rupture. Although BMI is considered a flawed measurement, an unusually high weight due to high fat content results in higher likelihood of clotting and weaker artery lining. The patient in the case study had a BMI measurement of 30.9, placing him in the ‘obese’ category. This is a risk factor for his aneurysm treatment as the patient may respond differently to anesthetics and the procedure itself. Also, if there are clots present, the neurosurgeon would have to work around them to access the aneurysm. This would increase the time needed to perform the operation and increase exposure to anesthesia. Choices made in a patient’s lifestyle, such as substance exposure and diet, before or during a cerebral aneurysm will affect the risk level of treatments and hemorrhage.

An aspect of a cerebral aneurysm that is not by choice of the patient is the seriousness of the aneurysm. Aneurysm seriousness is not a definitive quantity. It is, however, determined by a measurement of several distinct factors including aneurysm size, shape, and location. An aneurysm's size affects the likelihood of rupture. If an aneurysm is over 3mm in diameter, it has a higher risk of rupture than an aneurysm that is under 3 mm (2022, April 3).

Like a balloon, the larger an aneurysm expands, the thinner its walls become and the more likely it will rupture. There is a limited amount of tissue that can stretch to cover the added surface area of an aneurysm. After a certain point, the stretched tissue will not be able to remain intact. At this point, the artery wall will rip, and the aneurysm will rupture. The patient presented in the case study had an aneurysm of 2mm. This size was not considered high risk and allowed the patient some more time to decide on a treatment plan.

Also, the shape of the aneurysm also dictates its seriousness. If a second aneurysm begins to form in contingence to the first, the risk of both aneurysms rupturing is increased. A typical aneurysm shape is similar to that of a dome. However, when two aneurysms form on top of each other they create a mushroom shape. This mushroom shape decreases the thickness of the aneurysm walls and furthers the likelihood of rupturing. An investigation on the size, location, and shape of aneurysms revealed that irregular aneurysms had a rupture rate of about five times stronger association than factors related to lifestyle (2016). Regardless of aneurysm size or location, those with an irregular shape, one that was not a simple smooth dome, had a far stronger chance of rupture. In the case study, the aneurysm was a smooth dome. Hence, the size and shape of his aneurysm yielded a lower risk of rupture.

Another risk factor that should be considered when determining the likelihood of rupture and treatment of an aneurysm is the location. Aneurysms that are on the posterior or anterior communicating arteries are at a higher risk of rupture (2023, March 8). These arteries are used as backup for blood supply to the brain in the case of a blockage in one of the carotid arteries. Hence, the blood volume in these arteries is higher than other arteries in the brain. This increased blood volume and pressure also increases the chance of rupture. The patient observed in the case study had an aneurysm on an artery located centrally in the brain. However, this artery was not a main artery and had a lower blood volume and flow rate. The patient's aneurysm size, shape, and location were considered minimal risk. However, if too much time were to pass before treatment, the aneurysm may grow to a size that yields a certain risk for rupture. The diagnostic scans will be useful in visualizing the location, size, and shape of an aneurysm. The seriousness of an aneurysm provides crucial details for risk assessment and should be heavily considered regardless of the patient's background when planning for treatment.

Considering the patient's age, lifestyle habits, and the seriousness of the aneurysm, the patient should be aware of the risk that may come along with certain treatment plans for his cerebral aneurysm. Unavoidably, with age, a patient will experience more medical difficulties both psychologically and physiologically. The patient may be frailer or have conditions that increase risk of treatment and rupture such as hypertension. Regardless of age, a patient's lifestyle also has considerable effect on risk levels. Exposure to certain substances, especially smoking, as well as an unbalanced diet contribute to the formation and chance of rupture of a cerebral aneurysm. Outside of the patient's control, however, the seriousness of a cerebral aneurysm also yields a substantial effect on the levels of risk under treatment. When an aneurysm is present on the communicating arteries, either posterior or anterior, is considered large, or has an irregular shape, it is far more likely to rupture. Scans should be thoroughly analyzed to determine the seriousness of the aneurysm and the information, combined with the patient's history, should be utilized to decide upon a treatment plan. The patient presented in the case study, after thoroughly weighing the risks given his history and case, decided upon endovascular coiling. The operation was successful, and the patient remains clear of cerebral aneurysms.

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