ABSTRACT

Development, Effects, and Treatment of Arachnoid Cysts

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I discuss arachnoid cysts, or excess fluid build up in the brain and spinal cord, and the treatments that are used to control or eliminate them. First, I talk about the causes and origin of arachnoid cysts in the central nervous system, and how frequently cysts are diagnosed. Next, I discuss the medical significance of cysts and their potential effects. Finally, I describe the current diagnostic procedures used to find arachnoid cysts, as well as current and developing technologies that are used to treat these cysts.

DEVELOPMENT, EFFECTS, AND TREATMENT OF ARACHNOID CYSTS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

Causes and Origins of Arachnoid Cysts

Cerebrospinal fluid is a naturally occurring substance found in the brain and spinal cord. This fluid functions as padding for the brain, as well as a way to absorb any mechanical shock from quick movement, which would otherwise cause damage to the brain. Any excess accumulation of fluid results in the formation of a cyst, which when formed in specific areas of the nervous system is called an arachnoid cyst. These types of cysts can occur in either the arachnoid mater, or middle layer, of the brain tissue, or in the spinal cord. They are found in approximately four percent of the population (Flaherty, 2000), and are usually congenital in origin, although research has encountered some cases in which the cysts have been acquired after birth due to factors such as a tumor, lesion, hemorrhage or inflammation (Martinez-Lage, Perez-Espejo, Almagro & Lopez-Guerrero, 2011).

In the case of congenital cyst formation, one malfunction that happens during embryonic development supposedly occurs during the development of the arachnoid layer. This development includes the initial flow of cerebrospinal fluid through the subarachnoid space, which is located just inside the arachnoid layer of neural tissue, followed by the shrinkage and closure upon full development of the arachnoid. The development of the arachnoid cyst can occur by the entrapment of cerebrospinal fluid either by abnormal splitting of the tissue in the arachnoid layer while it is developing down into the subarachnoid space, which causes certain areas

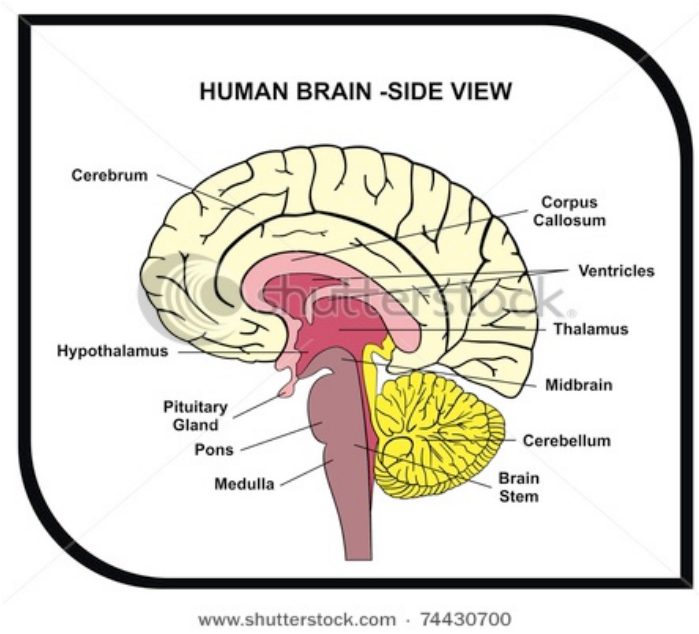
of cerebrospinal fluid to be closed off from the rest of the nervous system, or by abnormal flow of the cerebrospinal fluid during development.

Another malfunction that could result in congenital cyst formation in the brain occurs secondarily from a condition called hydrocephalus. Hydrocephalus is the accumulation of excess cerebrospinal fluid within the ventricles or the subarachnoid space of the brain, causing intracranial pressure that could lead to damage and consequent formation of a cyst. Excess fluid build up in the ventricles is called internal hydrocephalus, while excess fluid in the subarachnoid space is called external hydrocephalus. In these cases, the ventricles or subarachnoid spaces themselves put pressure on the brain by taking up more space than they are supposed to, while formation of the cyst creates even more intracranial pressure by taking up space of its own as it forms outside and separately from the ventricles. As with any condition involving an arachnoid cyst, the cyst may or may not communicate with the subarachnoid space. Therefore, if there is communication between the two, an existing cyst may expand due to fluid build up from hydrocephalus, or vice versa.

Another cause of arachnoid cyst formation occurs during the development of the spinal cord. The cyst forms from the dura mater (or the outermost layer of neural tissue) present in the spinal cord. This type of cyst is almost always extradural and does not communicate with the surrounding dura mater. However, in rare cases communicating cysts will occur in this area. Like brain cysts, these cysts can also form either congenitally or from lesions suffered after birth. However, spinal cord arachnoid cysts occur with a much lower frequency than brain

arachnoid cysts when considering congenital cysts, and acquired spinal cord cysts are also much more rare (Gul, Bahadir, Kalayci & Acikgoz, 2010).

There are several different theories on the origin of congenital spinal cord arachnoid cysts. One of these theories states that the cyst could arise from the septum posticum, which is a barrier in the posterior arachnoid space in the spinal cord that divides this space in two (Khosla & Wippold II, 2002). This hypothesis could adequately explain most cysts that occur in the spinal cord, as they generally form on the dorsal side (the side toward the back) of the cord at the mid-thoracic level, which is at about the mid-back. The explanation is possible because the septum posticum stretches from the cervical portion of the posterior arachnoid space to the lower thoracic portion. However, this theory does not sufficiently explain cysts that form in the anterior arachnoid space. A second theory that also tries to explain these anterior cysts states that the cysts could arise from an open area in the spinal cord that provides little resistance for the movement of fluid that could result in abnormal flow of cerebrospinal fluid. The existence of low resistance of fluid in this area can be caused by dilation of the arachnoid space, which sometimes results from constantly high hydrostatic pressure of the cerebrospinal fluid present. The theory combines this potentially abnormal flow of cerebrospinal fluid (which is one known cause of arachnoid cyst development in the brain) with the idea that several adhesions, or fibrous connections between tissues and organs resulting from injury, could have compounded the abnormality to cause the formation of the arachnoid cyst (Martinez-Lage, Perez-Espejo, Almagro & Lopez-Guerrero, 2011).



Structures in the brain

Arachnoid cysts could also occur after birth due to some form of damage to the brain or spinal cord. One type of damage stems from inflammation of tissue surrounding the existing cerebrospinal fluid, resulting in the infiltration of fluid into the inflamed tissue through adhesions, or irregular tissue connections, that form from the arachnoid tissue. This tissue inflammation could follow several different injuries to the brain or spinal cord tissue, including a tumor, trauma, and a disease such as meningitis. Other potential diseases that seem to have caused arachnoid cyst formation in the past have been generalized, and have simply been classified as mesenchymal in origin, meaning that the diseases originated from embryonic cells.

The major location of congenital arachnoid cyst formation in the brain is the middle part of the brain, as opposed to the anterior and posterior portions of the brain, called the middle fossa (Martinez-Lage, Perez-Espejo, Almagro & Lopez-

Guerrero, 2011). More specifically, the cysts tend to occur along the Sylvian fissure or the lateral sulcus, which separates the frontal and parietal lobes from the temporal lobes on both sides of the brain. This fissure is one of the earliest to develop in the brain, as it forms in about the fourth month of embryonic life. About fifty percent of all arachnoid cysts develop along this fissure. Most of the remaining arachnoid cysts occur of relatively equal frequency in the quadrigeminal cistern, cerebellopontine angle, retrocerebellar area, sellar area, and suprasellar area. Respectively, these areas of the brain are located between the corpus callosum and the cerebellum near the third ventricle, between the cerebellum and the pons, behind and slightly below the cerebellum, surrounding the sides of the pituitary gland, and above the pituitary (see Structures in the brain). Each of these locations accounts for about ten percent of arachnoid cysts that occur (see Locations of arachnoid cyst developement).

Locations of arachnoid cyst developement

Location of cyst	Central Sulcus	Quadrigeminal Cistern	Cerebello-pontine Angle	Retro-cerebellar Area	Sellar Area	Supra-sellar Area	All Other
Percent of cysts at location	50%	10%	10%	10%	10%	10%	~1%

Other locations at which arachnoid cysts form with very low frequencies are among the cerebrum, at the fissure between the left and right hemispheres of the brain, and in the ventricles (Martinez-Lage, Perez-Espejo, Almagro & Lopez-Guerrero, 2011). Some of these rare occurrences of arachnoid cysts seem to result

from arachnoid cells that were displaced during fetal development or from abnormal flow of cerebrospinal fluid during development, which may cause cerebrospinal fluid to become trapped near blood vessels or other important structures. The misplaced fluid could then cause a buildup of pressure and malfunction of adjacent structures as the excess fluid pressurizes and blocks these structures. Some of these different misplaced locations may also lead to the development of hydrocephalus along with the arachnoid cyst. Certain locations of the cyst, such as the suprasellar and quadrigeminal cysts, were shown to cause hydrocephalus one hundred percent of the time, while other locations were variable, such as posterior cysts, caused hydrocephalus less than half of the time (Martinez-Lage, Perez-Espejo, Almagro & Lopez-Guerrero, 2011). Therefore, arachnoid cysts and hydrocephalus do not always occur together, but the existence of one condition predisposes the affected person to acquiring the other.

As previously stated, the existence of a cyst in certain locations seems to lead to hydrocephalus at a very high rate. In the case of spinal cord arachnoid cysts, the major location of development is in the mid-thoracic level and occurs dorsally with respect to the spinal cord. This location accounts for almost all spinal cord arachnoid cysts. The rare exceptions probably result from traumatic injury after birth. A good example of the typical location and appearance of these spinal cord cysts is seen in a case involving an eight-year-old boy, in which the cyst was found after the boy experienced increasing pain in his lower back and legs. The pain in the back was from the pressure of the cyst itself and the pain in the leg was a result of

compression of the sensory nerves that received painful stimuli from the legs (Woon, Shah & Cartmill, 2008).

CHAPTER 2

Medical Significance and Effects of Cysts

Arachnoid cysts can have many different effects and cause many different symptoms depending on their location. All of these effects and symptoms are caused by compression of certain neurologic structures in the brain, or from the mass effect imposed by the cyst in either the brain or spinal cord. One major secondary effect of arachnoid cysts that is also directly related to discrepancy in cerebrospinal fluid buildup is hydrocephalus, or extra fluid in the ventricles of the brain, causing them to be enlarged. This condition is caused by blockage by the cyst of flow of cerebrospinal fluid at the foramina of Monro, a small hole between the third ventricle and the lateral ventricle in the brain (Paraskevopoulos et. al., 2011). The blockage causes buildup of cerebrospinal fluid in the ventricle behind the obstruction, and the buildup then causes the ventricles to expand.

There are many symptoms that can be caused from compression of different structures by an arachnoid cyst. Compression by the cyst of the optic chiasm, located behind the eyes, causes vision impairment ranging from partial to full loss of vision depending on the force of the compression on the chiasm. Similarly, compression of part of the pituitary gland could cause serious effects on the output of hormones, impairing the endocrine function of the gland. This type of obstruction could cause impairment of one of many hormones excreted by the pituitary gland, causing many different symptoms to be expressed. The symptoms present could

result from decreased secretion of growth hormone (GH), adrenocorticotropic hormone (ACTH), the sex hormones estrogen and testosterone, or thyroid-stimulating hormone (TSH), all of which are regulated and secreted by the pituitary gland. A decreased secretion of growth hormone would cause several problems if not treated early enough. Stunted growth of bones and a short stature, as well as a possible delay in puberty would be potential consequences of low growth hormone secretion. Alternatively, a decrease in adrenocorticotropic hormone secretion would decrease the release of glucocorticoids by the pituitary gland including cortisol, which mobilizes blood sugar for energy and causes the metabolism of fat, protein and carbohydrates. Therefore, a decrease in ACTH would cause a slow breakdown of these essential nutrients and decreased energy due to low availability of sugar that can be utilized. Mineralocorticoid secretion, which includes aldosterone, would also be decreased with a decrease in ACTH. Aldosterone acts on the kidney, making its collecting ducts more permeable to allow retention of body fluids. Because of this action, a decrease in the secretion of aldosterone would cause excess fluid loss and result in dehydration. A decrease in either of the sex hormones would present symptoms if the affected individual were either a male who experienced a decrease in testosterone production, or a female who experienced a decrease in estrogen production. Both of these situations would cause the affected person to exhibit bodily characteristics normally expressed by the opposite gender. Finally, a decrease in secretion of thyroid stimulating hormone, which helps regulate metabolism and aids in physical development, could result in cretinism. Cretinism is the condition of severely stunted mental and physical growth, and it

would occur if hypothyroidism caused by the lack of adrenocorticotropin were to go untreated for a long period of time.

Other significant effects caused by compression of surrounding structures by arachnoid cysts in the brain include impaired memory or conversion of short to long term memory, difficulty controlling smooth movements, and difficulty balancing. The memory problem would result from a cyst that is partially compressing the cerebrum. A cyst in this location could also cause other impairments such as reasoning ability, logic, speech, language abilities, and thinking in general. Obviously a cyst that is compressing this portion of the brain would cause some of the more significant problems that would affect everyday life, considering that the cerebrum is the main command center in the brain for reasoning and communication. Conversely, someone with a cyst compressing the hippocampus in the brain would be able to learn and remember things immediately, but if asked to recall them a couple hours later they would be unable to do so, because the conversion of short to long term memory takes place in the hippocampus. At the same time, a cyst affecting the hippocampus may also affect the cerebellum, which is located next to it in the hindbrain. The cerebellum controls balance and refined movements, and compression of this structure would cause the patient to have difficulty with balance, with the degree of the balance issues varying according to the amount of pressure being placed on the cerebellum. Simultaneously, a cyst in this location would cause problems with refining certain movements, making the movements uncoordinated and shaky. This shaky movement would occur because the cerebellum also controls the coordination and refinement of movements that are

started by the cerebrum. This symptom could cause a doctor to misdiagnose the cyst as Parkinson's disease, which is also characterized by slow, uncoordinated movements, if there are no other major symptoms caused by the cyst.

There are many other signs and symptoms that could be caused by cysts in the brain. One symptom could be a larger than normal head if the cyst is slowly increasing in size. Increased intracranial pressure would result from the cyst taking up space in the brain that should be occupied by other structures. Headaches, nausea, and vomiting could all occur from the increase in intracranial pressure (John's Hopkins). Optic disk swelling, or Papilledema, could occur if the cyst is near the optic disk, causing impairment in vision that could be manifested as tunnel vision. Sleepiness or a coma could result from the increased intracranial pressure in general, or from compression of the pineal gland that controls sleep-wake cycles. Irritability could result from a cyst compressing the frontal lobe of the brain, and hydrocephalus, or swelling of the ventricles, could result if the flow of cerebrospinal fluid is obstructed, especially in the third ventricle (Paraskevopoulos et. al., 2011).

Different symptoms could also be seen if the cyst is located in the spinal cord. Compression of nerves in the spinal cord could cause pain or loss of sensation in the areas of the body that the compressed nerves innervate. These symptoms could easily be misdiagnosed as a degenerated vertebral disc, which would cause the superior and inferior vertebrae to pinch down on the nerves between them. Partial compression of the motor nerves in these areas could also cause muscle spasms from irregular stimulation of the nerves due to compression or restricted movement from impairment of the motor nerves by the compression. Difficulty eating is

another symptom of a spinal cord cyst that would result if the cyst also causes compression of the nerves that control peristalsis in the esophagus or other parts of the digestive tract (John's Hopkins). Peristalsis allows food to continue moving through the digestive tract, and the cessation of these movements would cause the food to rely on other mechanical forces, such as gravity or being pushed by other food, to continue its movement through the digestive tract.

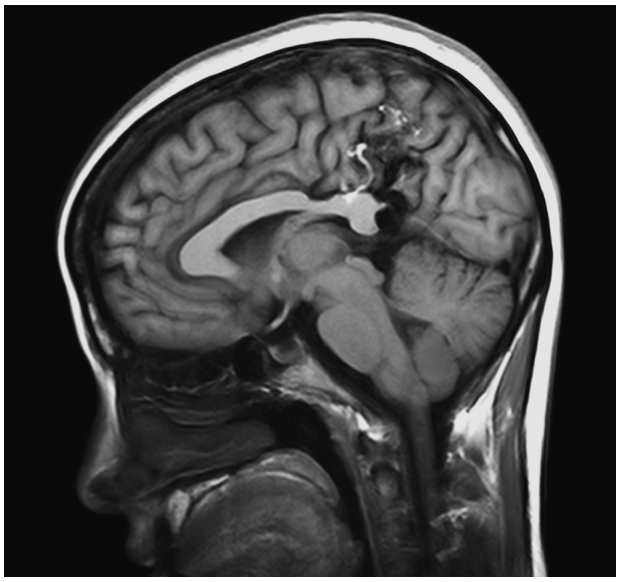
Overall, the symptoms that arachnoid cysts can cause vary significantly. The symptoms present will always depend on the location and size of cyst. Many cysts will cause increased intracranial pressure, as well as secondary symptoms from affected surrounding structures. Finally, the symptoms caused by the cyst must all be considered in order to diagnose the cyst, as well as to know its location. It is very easy to misdiagnose a cyst as a type of failure in the surrounding structure because the cyst is putting additional pressure on the structure and subsequently causing it to fail.

CHAPTER 3

Current Medical Treatments for Arachnoid Cysts

Arachnoid cysts can be detected by a couple of different technologies, one of which is a Magnetic Resonance Imaging system, or MRI. MRIs reflect the density of different areas of the brain, and cerebrospinal fluid, or CSF, has a very distinct appearance in MRI images. Due to this distinct appearance, any location of excess CSF (as in the case of a cyst or enlarged ventricles) can be seen on this imaging. An MRI is one of the main ways to confirm the existence of a cyst, and the resulting images are also useful for a doctor to know the place in the brain or spinal cord that they will need to locate when they operate on the patient.

MRI is a technique that is conducted in a machine containing a magnetic field and uses radio waves to produce images that can be printed out and viewed when held up to a light source. In order to produce the images, the radio waves that are emitted by the machine produce an energy change in the nuclei of water molecules in the brain that can then be detected and turned into a digital image by a computer (Kalapurayil, 2009). In this way, an MRI does not produce the ionizing radiation that is produced by other imaging techniques such as x-rays or computed tomography (CT) scans, and is therefore a much safer technology ("Mri of the," 2011).

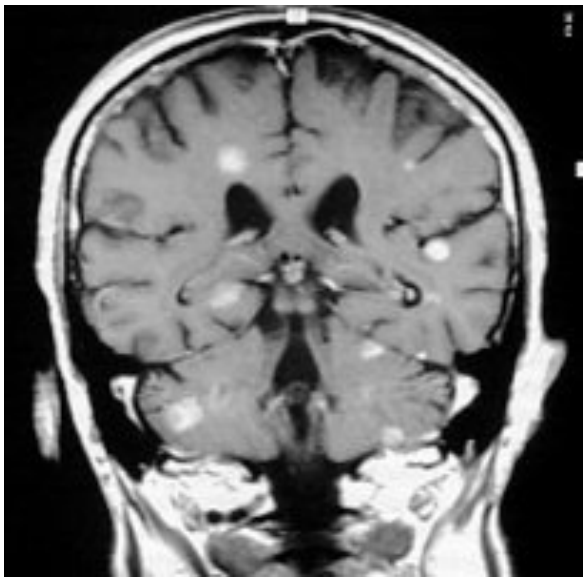


MRI image

First, the strong magnetic field that is produced by the MRI causes the water molecules in the brain to all align in the same direction, thereby creating an orderly and constant arrangement of the nuclei. The machine then emits radio waves that increase the energy content of each of the nuclei. The nuclei then return to their original energy state, and they emit a resonance wave in the process ("The science behind," 2012). These resonance waves have different strengths of vibration that are detected by the MRI. The MRI machine uses these different intensities in vibration along with the different number of nuclei that are detected throughout the brain, which reflects the density of water in the different areas of the brain, to transmit this information to advanced computer processing that can then create a three-dimensional image ("Mri of the," 2011). Finally, this image can be printed out and viewed using a conventional light source. The final image created by an MRI is

incredibly detailed, and MRI is the most useful technique to use for advanced diagnoses in the brain or spinal cord (see MRI image).

Another technology similar to MRI is a CAT or computed axial tomography scan. CAT scans use two-dimensional x-ray images taken quickly in sequence in order to give a virtual three-dimensional picture when the images are considered as a whole (see CAT scan image). This 'slicing' technique is the same as the technique used by MRIs. However, MRIs are generally preferred over CAT scans because CAT scans use radiation to create the images and MRIs do not. Instead, MRIs use magnetic



CAT scan image

resonance to detect the nuclei of atoms in the brain, and their densities are reflected as different shades on the black/white scale. Once an arachnoid cyst is confirmed and located by an MRI or CAT scan, the neurosurgeon is able to talk with the patient about different potential treatments for the cyst.

Treatment of arachnoid cysts can involve several different methods. The method of treatment is chosen based on the location of the cyst and the preference of treatment by the doctor and patient. Each treatment has shown good long-term results, even though some of the treatments may not reduce the size of the cyst in some patients to the extent that they do in others. Treatments may either be used individually or concurrently with other treatments, again depending on the location and size of the cyst and the preference of the patient when they are given the potential options and outcomes of each different surgery. Current potential treatments for cysts include cystoperitoneal (CP) shunts, ventriculoperitoneal (VP) shunts, ventriculoatrial shunts, ventriculopleural shunts, endoscopic fenestration, CP and VP shunts with concurrent open or endoscopic fenestration, open cyst fenestration with a cystocisternostomy, marsupialization, and Burr hole drainage (Shim, 2009).

All shunting procedures involve a mechanical pump attached to a tube that is used to drain excess fluid out of the cyst and into other regions of the body. The most popular of these shunting procedures is a cystoperitoneal shunt. This particular type of shunt originates in the cyst itself and drains the excess fluid from the cyst into the peritoneal cavity near the patient's waist. The fluid is then in an area of much less pressure and can be handled by the body more easily through absorption and excretion.

Another similar type of treatment is a ventricularperitoneal shunt. The only difference in this type of shunt and a cystoperitoneal shunt is that a ventriculoperitoneal shunt originates in the ventricles of the brain rather than in the

cyst itself. Therefore, the shunt drains the extra fluid that accumulates in the ventricles in order to compensate for the space being occupied by a cyst, as long as the cyst is not growing. This type of shunt is particularly used for patients who also have hydrocephalus, or extra fluid build up in the ventricles of the brain, as well as the cyst (Shim, 2009). In this situation, this type of shunt would drain the excess ventricular fluid so that the pressure would be relieved. The cyst would need to not be growing in this case because the fluid would not actually be draining from the cyst itself. However, if the cyst were in communication with the neighboring ventricles then it would not matter whether the shunt originated in the cyst or the ventricles.

The shunting technique is one of the older treatments for cysts. Shunts are a simple form of drainage that allows for the movement of fluid to be regulated in the desired direction. When complete removal of the cyst is not an option, shunting is the most commonly used treatment. For cysts present in the suprasellar and quadrigeminal regions of the brain, such as the one seen in the figure below, an endoscopic ventriculocystostomy is the most common type of treatment (see Large quadrigeminal cyst) (Shim, 2009). This technique involves removing the whole cyst with potential reduction in the size of either of the ventricles as well. This is the most desired form of treatment for any cyst because it permanently removes the cyst. However, in certain cases for cysts located in these regions, a VP or CP shunt has been inserted and the cyst has been fenestrated either endoscopically or microsurgically (Shim, 2009). The endoscopic fenestration technique involves locating the cyst with a camera inserted through a small incision,

followed by poking a hole in the cyst to allow the fluid to be in communication with the surrounding ventricles. A very recent technique has also become available to cauterize the edges of the fenestration, which stops the fenestration from closing in the future. The microsurgical technique uses a larger incision that allows the doctor to reach cysts that cannot be reached endoscopically, but the result is the same as the doctor pokes a hole in the cyst to allow communication. The main advantage of the endoscopic technique is that the doctor can make a smaller incision in the head to avoid larger scars.

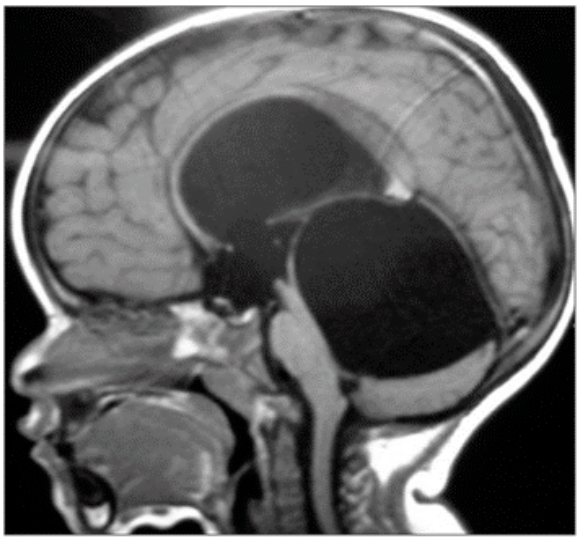


Fig 1. SagitTal T1 MRI at diagnostic evaluation: large quadrigeminal cyst causing hydrocephalus and compressing the brainstem and the fourth ventricle.

Large quadrigeminal cyst

The technique of fenestration is a completely separate treatment for arachnoid cysts than the shunting technique. It can either be the only treatment given to a patient or can be done concurrently with shunting. The size of the cyst and the projected outcome of the treatment are factors that lead doctors to suggest

one or the other. Usually, the decision to perform both surgeries is a result of precaution to avoid the failure of the initial surgery that would necessitate a second surgery. Both treatments can also be done at the same time since they both involve accessing the cyst through the same pathway.

Fenestration is the preferred method of treatment for cysts in the posterior fossa, or posterior cavity in the brain that contains the cerebellum and brainstem (Shim, 2009). Although this is the major form of treatment for cysts in this region, the fenestration may or may not be accompanied by insertion of a shunt or by marsupialization (see next paragraph). Fenestration is also the most common treatment for cysts at the Sylvian fissure, which separates the temporal lobe from the parietal lobe on each side of the brain. For cysts in this location, fenestration can be done endoscopically or openly with concurrent cystocisternostomy. The open cyst fenestration is the more common treatment to date, but the endoscopic treatment is rapidly becoming the preferred treatment as sufficient technology to perform this surgery becomes more available. The main technological advances that are leading to the increase in endoscopic surgeries are the small cameras that doctors can attach to their equipment to allow them to see where they are inserting the equipment as they guide it to the cyst.

In addition to shunting and fenestration, third form of treatment for arachnoid cysts is marsupialization. Marsupialization is the process of cutting a slit in the cyst and sewing each edge of the slit to the tissue outside the cyst and away from the incision to allow the cyst to remain open and continuously drain. Marsupialization is the most popular treatment for cysts in the convexity of the

brain, which is located in the frontal lobe. It is used when the cyst cannot be completely removed, and is another alternative to shunting and fenestration when this is the case.

A final form of treatment that is in use today is called Burr hole drainage. This is the least commonly used treatment for arachnoid cysts and is almost exclusively used on cysts that are present at the Sylvian fissure. The process of Burr hole drainage involves accessing the cyst, cutting a small opening in it, and draining some of the excess fluid before closing the incision back up ("Burr hole drainage," 2012). This procedure is only a temporary solution to a cyst that is causing excess intracranial pressure, especially if the cyst is still growing at any rate. This is one of the reasons that this procedure is only used as treatment in about five percent of arachnoid cyst cases (Shim, 2009).

Overall, the form of treatment for arachnoid cysts is decided based on the location and size of the cyst and the preference of the patient after discussing options with their surgeon. Currently, shunting and fenestration are the most popular forms of treatment for cysts that doctors cannot remove completely. Each treatment has its own advantages and disadvantages. As technology advances more options are becoming available to patients. These new options are made possible by developing techniques, and the options are optimizing the ways that doctors can operate on cysts that were previously inaccessible.

CHAPTER 4

Developing Technology and Potential Future Treatments

There are several different techniques that are currently being used to treat arachnoid cysts. Throughout the last decade, the number of potential treatments for cysts has increased. The newest treatments include endoscopic fenestration of cysts and cauterization of these fenestrations in order to keep them open. The endoscopic treatment allows doctors to make much smaller incisions in the patient, therefore leaving much smaller scars after surgery. The cauterization allows a fenestration to remain open permanently, whereas in the past any fenestration would have had a very good chance of closing over time. No doubt these two new techniques will continue to be refined and improved, since they are the only two new techniques that are at the forefront of medicine for the treatment of arachnoid cysts at this time.

The first new treatment available for arachnoid cysts is endoscopic fenestration. While fenestration of cysts has been a technique in practice for many years now, endoscopic fenestration has only become a reliable option for treatment over the last thirteen years. Doctors perform this surgery by guiding small instruments to the location of the cyst. This guidance is accomplished by using a tube called an endoscope which has a small camera attached to its end. Once the endoscope has identified the location of the cyst, different tools can be strung through the tube to the cyst. These different instruments are then used to poke a

hole in the cyst and enlarge the hole to the desired size. Another advantage of the endoscopic fenestration is that it can be done in a relatively short period of time. If the patient is only having fenestration of their cyst performed, then the surgery will usually take thirty minutes to an hour (Weill Cornell Medical College). One great advantage of endoscopic fenestration is that this surgery is minimally invasive. The surgery only requires a small incision and subsequently leaves only a small scar visible, which is more aesthetically pleasing for the patient than the alternative.

There is one disadvantage to performing fenestration as opposed to some other treatments that involve more complicated surgeries. With fenestration, there is always a chance that the opening will heal over time and potentially become fully closed once again. If this closure occurs, then another surgery will be necessary in the future because the cyst will no longer be communicating with the surrounding fluid, and therefore will not continue to drain. The closure of the fenestration occurs because the tissues surrounding the fenestration treat the opening like an injury and work to repair the apparent injury by closing the tear. If the pressure from the fluid in the cyst is not great enough to prevent this reparation from occurring, then this closure will occur. As mentioned earlier, sometimes fenestration is performed concurrently with insertion of a shunt. In this case, the shunt may be sufficient to relieve the excess pressure caused by the cyst, and the fenestration will close due to the pressure not being great enough to keep it open. This problem has led to development of a new technique in the last few years called cauterization (MacFarlane, 2010).

Cauterization of the tissue surrounding a fenestration, also called electrocauterization, involves burning, or cauterizing, the tissue surrounding the fenestration with a metal probe that is heated by an electric current (Medscape). In this fashion, the surrounding tissue dies and is therefore unable to perform its reparative action that causes the fenestration to close. Cauterization is the most recent technique that has been developed to enhance surgery for arachnoid cysts. It is the first available surgery technique that does not involve the significant risk of needing a second surgery in the future if the cyst is not completely removed. The discovery of this technique has helped to solve several problems. In the past, doctors were very cautious of trying to keep cysts open because they feared what tissue they would damage that was surrounding and beyond the cyst. However, the new cauterization technique avoids this damage and allows doctors to keep them open without much difficulty.

Overall, there are several techniques for treating arachnoid cysts that are available today. The developing technologies of endoscopic fenestration and cauterization have added to these treatments, and are becoming more widely used either as the only surgery performed or along with other techniques to aid in treating arachnoid cysts. Scientists continue to look for better treatments for arachnoid cysts that will be more effective and will allow doctors to completely remove cysts that are currently treated with some kind of long-term drainage system that must ultimately be revised when it fails. The hope is to develop techniques that will allow for permanent removal of these cysts regardless of their location in the brain without causing any damage to surrounding tissues.

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