Intracranial Aneurysms and Arteriovenous Malformations

3.0 Contact Hours

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Intracranial Aneurysms and Arteriovenous Malformations

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Objectives:

At the completion of this course, the learner will be able to:

1. Define saccular, fusiform, mycotic, dissecting, and false aneurysm types.
2. Identify the pathophysiology of arteriovenous malformations.
3. Identify procedures used to diagnose and repair or remove an intracranial aneurysm or arteriovenous malformation.
4. List symptoms common to both intracranial aneurysm and arteriovenous malformation.
5. Specify nursing care for patients with intracranial aneurysm or arteriovenous malformation.

Intracranial Aneurysms

Pathophysiology

An intracranial aneurysm (IA) forms in an artery of the brain when a section of the vessel wall is weak. The pressure of the blood flow makes the weakened portion bulge outwards.

Various types of aneurysms can form, the most common being a "berry" or saccular aneurysm. This type has a neck with a stem leading to a round saccule of blood. The less common type is a fusiform aneurysm in which there is a widened area on both sides of the arterial wall, forming an abnormally dilated area on the vessel. Infections can cause a small mycotic aneurysm in a vessel as well.

Dissecting aneurysms may form within the layers of the arterial vessels. They form a bulge in the vessel wall, dissecting the layers as they grow, and causing a weakness in the wall that eventually breaks. A false aneurysm can occur in which the outer layer of a vessel contains a hematoma that pulsates with the blood flow through the artery.

Most intracranial aneurysms form in the anterior brain circulation in areas where vessels branch off from the circle of Willis. The posterior brain sites that form aneurysms include junctions of the basilar artery with cerebellar and vertebral arteries. Up to 20% of those with an IA have more than one.

An IA may not produce symptoms until it becomes big enough to press on nearby brain structures, causing focal symptoms. When an aneurysm ruptures, the resultant

hemorrhage can cause brain injury or death depending on the place in the brain and the size of the hemorrhage. An aneurysm has a 1 or 2% of rupture in each year of its existence. When an IA ruptures, a hemorrhage results, most often subarachnoid, but can also be intraventricular, intracerebral, or subdural, depending on the location of the aneurysm.

When an aneurysm ruptures the leakage of blood may be small and the leak may seal itself with a clot. If the hemorrhage is larger brain damage can occur. Blood acts as an irritant to surrounding brain tissues. It can enter the cerebrospinal fluid and block the flow leading to increased intracranial pressure. About 5 to 8 days after a rupture cerebral vasospasm can result in decreased cerebral perfusion and a stroke over the next several days. When hemorrhage is massive, 50% of those afflicted will die immediately and delayed death will occur in 25%. Those who survive rarely escape without brain damage and neurological deficits.

Etiology and Risk Factors

The etiology of an aneurysm can include:

- congenital malformations or diseases
- trauma
- infection (mycotic aneurysms)
- inflammation (can be induced by pregnancies)
- post-surgical complications
- atherosclerotic degenerative changes in vessels

Risk factors for the formation of intracranial aneurysms include:

- female gender
- smoking
- hypercholesterolemia
- hypertension
- oral contraceptives
- amphetamine and cocaine abuse
- alcoholism
- family history of intracranial aneurysms or subarachnoid hemorrhages
- polycystic kidney disease

Signs and Symptoms

Unruptured aneurysms can cause different focal neurological symptoms depending on the location in the brain:

- localized headache
- pain above or behind the eye
- cranial nerve dysfunction

- pupil dilation
- diplopia

Prior to a rupture, 40% of patients experience warning signs:

- severe localized headache
- vertigo
- nausea & vomiting
- nuchal rigidity
- photophobia
- altered sensation

When an aneurysm ruptures symptoms vary due to location and severity of the hemorrhage and can include:

- severe headache
- lethargy, stupor, confusion, or loss of consciousness
- nausea & vomiting
- vertigo
- nuchal rigidity
- cranial nerve dysfunction
- motor dysfunction
- shock
- seizures
- stroke syndrome
- increased intracranial pressure
- decerebrate rigidity
- visual problems
- tinnitus

Diagnostic Tests

Prior to rupture, an IA is often found when testing is done due to risk factors and/or symptoms of an IA. These tests are repeated just prior to surgical treatment and can include:

- CT scan
- CT angiography
- MRI angiography
- cerebral angiogram

Medical Treatment

The decision to repair an aneurysm depends on several factors. The location, type, and size of the aneurysm are important. Aneurysms that are over 7mm or growing quickly are at high risk for rupture and are usually repaired if possible. Family history of IA and any ruptures are considered. The age, general health, and surgical risks of the patient are also important. Surgery poses a 5% risk of brain trauma whereas the yearly risk of rupture is 1-2%. However a rupture that causes a massive subarachnoid hemorrhage poses a 25% chance of survival with neurological deficits. Repair of an IA requires less recovery time than treatment for a subarachnoid hemorrhage since the damage to brain tissue is less. However there is still a risk of tissue damage with intervention so IA repair is not undertaken lightly.

When the risk of rupture is low the patient and physician may elect to watch the aneurism over time. The patient should avoid situations that elevate the blood pressure such as straining to defecate. Risk factors that increase the chance of rupture are minimized if possible including smoking, contraceptive use, drug abuse, alcoholism, infections, atherosclerosis, hypercholesterolemia, and hypertension. Phenylpropanolamine (PPA) should be avoided since it increases the risk of hemorrhage. It is found in some cough and cold medicine and diet aids.

There are three ways to repair an IA. These techniques are also used if a rupture occurs to stop the bleeding. An open craniotomy involves cutting a flap of the skull anterior to the ear allowing the surgeon to open the brain, locate the IA from the side and apply a clip or synthetic material to neutralize the IA. If this is not possible the artery may be occluded and a bypass grafted in place. Recovery depends on the extent of surgery and amount of tissue damaged.

Supraorbital minicraniotomy is a minimally invasive technique that seeks to minimize the damage done during surgery by using small keyhole incision above the eyebrow for a frontal approach to the IA. Endoscopic instruments are inserted through the opening to repair the IA. There is less overall tissue damage, a lower risk of infection, and improved cosmetic result.

Endovascular therapy is a third option in which a catheter is inserted into the femoral artery and guided to the IA location via angiography. The IA is entered and a platinum coil is fed into the IA until it is filled by a ball of wire which blocks the IA from the body of the blood vessel. Perforation of the IA can occur when the wire is introduced.

Endovascular therapy has a slightly higher chance than surgical clipping of rebleeding at the end of one year but a 22.6% lower incidence of neurological defects or death. At the end of seven years, the situation reverses and endovascular therapy has a higher chance of late rebleeding but it still remains very low. It is the treatment of choice for single IA but surgery may be needed for multiple or ruptured IAs.

Nursing Care

Nursing care of the patient with an IA depends on the status of the aneurysm. When the aneurysm is unruptured the nursing focus is on preventing an increase in blood pressure and preparing the patient for the procedure. If the aneurysm is large or leaking slowly, the patient will be admitted immediately to wait for surgical or endovascular repair.

Pre-Operative Care

Maintain absolute bed rest. All care must be passive since blood pressure can rise with any patient movement. Bathe and feed the patient. Do not allow the patient to read. Remind the patient not to flex or extend the neck to prevent blockage of the carotid vessels. Do not allow any activity requiring exertion. The patient should avoid sneezing or coughing if possible.

Teach avoidance of the Valsalva maneuver during voiding or defecating by keeping the mouth open. Administer stool softeners or gentle laxatives to keep straining to a minimum.

The patient environment should be as non-stimulating as possible. Keep the lighting dim. Prohibit loud noises, TVs, and radios.

Place a sign on the door to the patient room to warn those who enter to consult with the nurse about aneurism precautions to avoid raising the patient's blood pressure in any way. Restrict visitors to family after they have been taught precautions. Their visits can help the patient decrease anxiety and relax.

Sedation and analgesics may be given to prevent anxiety, pain, and to keep the activity to a minimum. Antihypertensives may be given to control the blood pressure. Do not give the patient caffeinated beverages.

Avoid a DVT by applying TED hose or compression devices. Monitor legs for red, warm, tender, swollen areas. Perform passive ROM if allowed.

Monitor vital signs and neurological status frequently. Report any deterioration of condition immediately to the physician. Obtain pre-operative labwork and notify the physician of any abnormal results.

Teach the patient and family as needed about the condition and treatment. Explain intra-operative procedures and post-operative care. Provide honest reassurance to decrease anxiety. Warn the patient if there will be a femoral angiography puncture site postoperatively. The affected leg will be immobilized. The head may be shaved in the area where a craniotomy will be performed if this method is planned or necessary due to intra-operative complications. An arterial line may be inserted before surgery to monitor blood pressure.

Post-Operative Care

The patient will be admitted to the ICU for 1 day if an endovascular procedure was used followed by a day on the medical-surgical floor before discharge. A craniotomy will result in 2 days in ICU and an additional 3 days on the medical-surgical floor.

Monitor vital signs and neurological status and compare with pre-surgical baselines. Monitor wounds for signs of bleeding or infection.

Discharge instructions should include signs and symptoms of cerebral hemorrhage and post-operative wound infection.

If a hemorrhage occurs intraoperatively or postoperatively, intracranial monitoring may be in place. Report any signs of increased intracranial pressure or decreased cerebral perfusion.

Nursing care for subarachnoid or other types of cerebral hemorrhage will depend on the amount of brain damage sustained. The brain will be given time to heal from the trauma and complications such a vasospasm, re-bleeding, and hypertension will be avoided and treated if they occur.

Extensive rehabilitation may be needed for neurological deficits. The patient and family will need to learn self-care, and signs and symptoms of complications. Home health care with evaluation of the home environment, patient and family learning needs, assessment of patient recovery and physical, occupational, and speech therapy may be needed upon discharge.

Arteriovenous Malformations (AVM)

Pathophysiology

Vascular lesions of the central nervous system consist of various types of malformations of vessels of arterial, venous, or combined origin. Arteriovenous malformations are a combined type and is the one most frequently treated. AVMs are abnormal connections or fistulas between arteries and veins that manifest as a knot of fragile vessels on the surface of the brain or spinal cord or deep within the brain tissues. They allow pressurized blood from an artery to bypass tissues it should nourish and rush into veins with more force than is usual in the venous network. AVMs vary in size from a large mass of tortuous vessels to small mass a few millimeters wide. The walls of the involved vessels are not normal in structure and form aneurysms in half of all AVMs.

AVMs can occur in all parts of the brain and spinal cord and in other places in the body as well. The posterior hemispheres are the most common site of large V-shaped masses of AVM that stretch from the outer cortex inward to the ventricles.

Large AVMs can divert significant amounts of blood, robbing other brain tissues from getting adequate circulation. They can press on surrounding structures causing ischemia. Rupture of the AVM can occur and the resultant hemorrhage can be small or large causing neurological deficits.

There are other vascular abnormalities that involve only arteries or only veins, not both. The blood flowing through these malformations flows more slowly than it does through an AVM so they are less dangerous in general, but they can still cause neurological damage when they are large enough or are numerous.

- Cavernous malformations are tight bundles of small vessels that occur within the cerebral white matter or brainstem. The blood within them moves very slowly and clots. There seems to be a chromosomal cause but their etiology remains a mystery. Some patients have more than one. They are usually less than 1 cm but can be bigger and occur often near venous anomalies. This defect is fragile but hemorrhage is usually minor when it occurs. If they poses a significant danger of bleeding or seizures and are near the brain surface, surgery will be done to remove them, but any nearby venous anomalies are left alone.
- Capillary telangiectasias are extensive tangles of tiny capillaries that are up to an inch wide. They occur within the otherwise normal tissues of the pons or deep within the cerebral white matter. The amount of blood from any hemorrhages that occur is very small, so they only pose a threat when they occur in numbers due to congenital syndromes, causing headaches and seizures.
- Venous anomalies are veins that are larger than normal. They function as part of the venous system and are not threatening and should be ignored when found during testing for other problems. When they are detected the brain MRI is searched for cavernous malformations which can be present as well.

Etiology and Risk Factors

AVMs are often errors in formation during embryonic and fetal development. Some are hereditary and accompany various syndromes. Injury to brain tissues or the spinal cord account for a small number of vascular malformations. Men and women seem to be at equal risk. All races are affected.

About 300,000 Americans have AVMs. AVMs cause death in 1% of those afflicted each year. Symptoms occur in 12% leading them to diagnosis and treatment of these malformations. Hemorrhage occurs in 2 to 4% but is often so small that it is undetected. About 2% of all hemorrhagic strokes are caused by ruptured AVMs. Malformations that are deep within brain tissue cause the worst damage when they rupture.

The risk of hemorrhage from an AVM increases in those who have had previous hemorrhage. Smaller lesions actually are more likely to bleed. Deeper, narrow lesions bleed more easily. Pregnancy increases blood volume and pressure and the risk of

hemorrhage is therefore increased during this time. These factors and the presence of signs and symptoms determine whether an AVM will be removed.

Signs and Symptoms

Symptoms are related to the area of the AVM and the size. Congenital AVMs are usually non-symptomatic for the lifetime of the individual. They are found when an MRI or CT scan is done for another purpose. It is thought that they may cause the appearance of behavior or learning problems in children prior to the age of 20 years old. When they do cause neurological symptoms it is usually between the ages of 20 and 50, after enough tissue damage accumulates.

General symptoms causes by larger AVMs include a throbbing headache that can be on one side of the head or generalized within the entire head. One third of patients have seizures or other neurological deficits. Bruits can be present that can be auscultated over the eye, forehead, or neck and some are strong enough for the patient to feel. They can cause pulsatile tinnitus, lack of sleep and other psychological distress. When AVMs interfere with the flow of cerebral spinal fluid hydrocephalus can result.

Diagnosis

AVMs are diagnosed by accident during testing for other cerebral disease or when tests are performed due to the presence of symptoms. They may be seen by CT scan but an MRI shows them more clearly. Cerebral angiography is then performed to determine the vessels involved. Magnetic resonance angiography is also used for diagnosis.

Medical Treatment

Asymptomatic AVMs may be observed periodically and treated when they become symptomatic or they may be treated when surgical risk is deemed acceptable.

Endovascular therapy with the insertion of glues, balloons, or coils is often done prior to surgical excision to decrease the amount of bleeding during surgery. It may be all that is required to treat smaller AVMs.

Conventional open surgical excision may be performed through a cranial flap when the AVM is superficial.

Stereotactic radiosurgery is a safer option when the AVM is deep within the brain or the surgical risk is high. It is also a more cost-efficient method of treatment than surgery resulting in less bleeding, infection, and side effects. It can also be done 2 to 3 months after hemorrhage has occurred to reduce the risk of rebleeding. This method uses a high-

dose, focused radiation beam delivered using the GammaKnife, CyberKnife, or proton beams to cause inflammation of the vessels of the AVM.
The patient's head is immobilized in a frame. MRI, CT, and angiography are done to define the specific location in the brain to be treated. The treatment is done once in the OR, where preparations are made to revert to open cranial surgery if bleeding occurs during the radiation treatment. The patient is anesthetized during the procedure.

A dose of methylprednisone is given once after the procedure to reduce cerebral edema. Analgesics are given for pain as needed, and antiepileptics continue if the AVM caused seizures to occur preoperatively.

Radiosurgery causes gradual obliteration of the defect by sclerosis over time. The patient is followed by MRI every 6 to 12 months for 3 years to track the progress of obliteration. After 3 years an angiography is done to confirm that the AVM is no longer a threat. If at that time the AVM is found to still be functional, radiosurgery may be performed again.

AVM or other vascular malformation hemorrhage is treated as an intracranial hemorrhage. Surgery may be done to evacuate the blood and to do emergency excision of the defect to reduce bleeding or to prevent rebleeding. Symptoms such as increased intracranial pressure are treated as they arise. Neurological deficits are assessed and the patient who survives must receive rehabilitation as needed.

Nursing Care

Nursing care depends on the symptoms shown prior to and after treatment and the method of treatment used. Cerebral hemorrhage, rebleeding, seizures, increased intracranial pressure, and neurological deficits are treated if they occur.

Patients who receive stereotactic radiosurgery will need premedication with a sedative prior to surgery. A head frame may be attached to the head with screws for the procedure. Check these sites for bleeding after the procedure and teach care to the patient and family.

Watch for acute side effects of radiosurgery in the post-operative period:
- headache
- fatigue
- dizziness
- nausea and vomiting
- bleeding or infection of the screw sites from the head frame

Assess for signs of complications from any method of treatment such as:
- neurological deficits
- seizures
- cerebral edema
- hemorrhage

Teach the patient and family late complications to report:

- a headache that will not go away
- decreased level of consciousness or cognition
- persistent nausea and vomiting
- loss of hair
- radiation damage to the scalp
- cranial nerve damage (nerves 3 to 7)
- hormonal changes

Both aneurysms and AVMs can cause headaches and neurological symptoms depending on the area of the brain involved. Both pose the threat of intracranial hemorrhage. Symptoms can alert the patient to their presence so that they can be removed before hemorrhage occurs. Nursing care focuses on pre-operative and postoperative care that varies with the method of treatment and the patient's symptoms. Nursing care for cerebral hemorrhage is needed if a rupture occurs before diagnosis, or during or after treatment.

Monitor these websites for any changes in standards of care for intracranial aneurysms or arteriovenous malformations:

The Brain Aneurysm Foundation: http://www.bafound.org/info/index.php

Familial Intracranial Aneurysm: http://www.fiastudy.org/

National Institute of Neurological Disorders and Stroke: http://www.ninds.nih.gov/disorders/cerebral_aneurysm/detail_cerebral_aneurysm.htm

National Guideline Clearinghouse: http://www.guideline.gov/

References

McQuillan KA. The Neurologic System. In Alspach JG ed. *Core Curriculum for Critical Care Nursing, 6th ed.* St. Louis, MO. Saunders Elsevier; 2006: 480-489.

Ameltzer SC, Bare BG, Hinkle JL, Cheever KH. *Brunner & Suddarth's Textbook of Medical-Surgical Nursing*, Philadelphia, PA: Lippincott Williams & Wilkins; 2008: 997-8, 2223-2230.

Smith WS, Johnston C, Easton JD. Cerebrovascular Diseases. In Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson JL, eds. *Harrison's Principles of Internal Medicine, 16th ed.* New York, NY: McGraw-Hill; 2005: 2392-3.

Hauser SL, Ropper AH. Diseases of the Spinal Cord. In Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson JL, eds. *Harrison's Principles of Internal Medicine, 16th ed.* New York, NY: McGraw-Hill; 2005: 2444-5.

Tortora GJ, Derrickson B. *Principles of Anatomy and Physiology, 11th ed.*. Hoboken, NJ; John Wiley & Sons, Inc; 2006:767, 799.

Molyneux A, Kerr R, Stratton I, Sandercock P, Clarke M, Shrimpton J, Holman R. International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomized comparison of effects on survival, dependency, seizures, rebleeding, subgroups, and aneurysm occlusion. *Lancet (abstract)*. 2005 Sept 3-9: 366(9488):809-17. Retrieved December 12, 2007: http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed&uid=16139655&cmd=showdetailview&indexed=google

The Brain Aneurysm Foundation. Information. Retrieved December 11, 2007: http://www.bafound.org/info/index.php

National Institute of Neurological Disorders and Stroke. Cerebral Aneurysm Fact Sheet. Retrieved December 12, 2007: http://www.ninds.nih.gov/disorders/cerebral_aneurysm/detail_cerebral_aneurysm.htm

Wright, I. Cerebral aneurysm-treatment and perioperative nursing care. AORN Journal, June 2007. Retrieved January 15, 2008: http://findarticles.com/p/articles/mi_m0FSL/is_6_85/ai_n19312267/print

International RadioSurgery Association (IRSA). Radiosurgery Practice Guideline Report; no. 2-03: Complete Summary: Stereotactic radiosurgery for patients with intracranial arteriovenous malformations (AVM) (2003). Retrieved January 16, 2008: http://www.guideline.gov/summary/summary.aspx?ss=15&doc_id=4360&nbr=003285&string=%22arteriovenous+malformations%22