ENDOVASCULAR TREATMENT OF INTRACRANIAL ANEURYSMS

Definition:

Intracranial cerebral aneurysms are abnormal arterial dilatations. These lesions arise in many forms including berry/saccular, fusiform and mycotic (infectious). Most such lesions are saccular eruptions that arise along the arterial tree where arterial blood vessels branch (arterial bifurcations). It is this subtype of intracranial subarachnoid aneurysm that will be discussed below.

Incidence:

In North America, saccular intracranial aneurysms are present in 5% of the population. 15-33% of patients with aneurysms harbor multiple such intracranial lesions

Etiology:

The etiology for intracranial bifurcation aneurysm development remains elusive. Genetic influences are certainly involved since aneurysms are more common in first degree family members of individuals who harbor such lesions. Other potential factors that influence development include turbulent blood flow at arterial branch points which add undue stress to the bifurcation, hypertension, exogenous factors such as tobacco and alcohol, sex (woman more common than men) and underlying connective tissue disorders that may weaken the arterial wall.

Risks:

Intracranial aneurysms most commonly become symptomatic when they rupture (aka: subarachnoid hemorrhage; SAH). Such an event releases blood under high pressure into the intracranial cavity. As a result, the brain can be injured causing various degrees of neurologic injury or death.

Rupture Rate:

A variety of studies quote a range of aneurysm rupture rates. The validity of each of these studies and reports goes beyond the scope of this short newsletter review. Let it suffice to say that the rate of rupture of an unruptured aneurysm is 0.05–5%/year depending upon the lesion's location, size, shape and potentially the existence of other factors such as smoking, hypertension, drug use, infection, age, race and sex. This risk of rupture is cumulative. For example, if an unruptured aneurysm is identified in a 37 year old patient with a normal expected lifespan, and the annual risk of rupture is 0.05-1% then the 44 year risk of rupture (lifetime risk from the age of 37) would be approximately 20%. Once an aneurysm ruptures, the risk of re-

rupture is approximately 3% over the next 48 hours, 20% of the next 2 weeks, and 50% over the next 6 months. After 6-12 months, the rebleed rate is felt to revert to the rate of rupture of an unruptured aneurysm.

Signs and Symptoms:

Signs and symptoms of aneurysm rupture include mild to severe sudden headache, cranial nerve abnormalities, neurologic deficits, altered level of consciousness and, in worse case scenario, death. Approximately 10 to 33% of patients with aneurysm rupture die before reaching medical care. Of those who arrive at a hospital, up to half will die despite receiving medical care. The remaining 50% of those receiving medical care will recover with varying degrees of neurologic injury while some will recover with no residual deficits.

Detection:

An intracranial aneurysm may be detected on CT, CT Angiogram, MRI, MR Angiogram, and Catheter Angiography. Catheter angiography remains the gold standard for aneurysm detection while CT and MR may fail to detect aneurysms three mm or smaller in size. The mode of imaging utilized depends upon the patient's mode of presentation along with his/her signs and symptoms. While lumbar puncture can be used to look for evidence of aneurysmal subarachnoid hemorrhage it can be misleading and at times difficult to interpret.

Management and Treatment:

Patients with unruptured aneurysms are evaluated on a case by case basis. After taking into consideration a patient's age, comorbidities, aneurysm location, aneurysm size, aneurysm shape, medical/surgical history, and preferences a decision is made regarding whether or not the aneurysm should be prophylactically treated and if so, how it should be repaired.

When a patient presents with a ruptured aneurysm, most lesions should be treated as quickly as possible to try and avert aneurysm re-hemorrhage. The time frame for treatment and the mode of treatment is often a matter of professional opinion and can be influenced by factors that are too numerous and complex for the purposes of this discussion.

Treatment Methodologies:

Aneurysms (ruptured and unruptured) can be treated using open surgical clipping or endovascular techniques. The former involves opening the skull, exposing the brain and the involved blood vessels and then placing metal clips across the aneurysm opening (aka: aneurysm neck) to exclude the aneurysm sac (aka: fundus) from the circulating blood. The latter involves placing a small catheter into or near the aneurysm and then advancing devices through the catheter that act to exclude

the aneurysm from the circulating blood. While both open surgical and endovascular approaches are complex, the endovacular technique does not require opening the skull and as such, is termed minimally invasive. Because most studies have shown that endovascular therapy has superior long term outcomes compared to open surgical clipping of lesions that can be addressed equally effectively by both approaches, this report will concentrate on the endovascular management.

History and Current State of Endovascular Therapy for Intracranial Aneurysms:

Beginning in the mid 1960's, surgeons began to consider treating aneurysms using less invasive techniques. These included the use of balloons, metal filings, wires, and magnets. From the 1970's through the 1980's, endovascular therapy continued to primarily involve the use of balloons that were either placed into blood vessels to eliminate flow to the aneurysm or into the aneurysm sac itself to eliminate filling of the aneurysm with circulating blood. Outcomes were marginal due to the fact that the devices being used were crude and patients deemed eligible for endovascular treatment were of the highest risk for intervention.

In 1990, endovascular therapy for intracranial aneurysms entered the modern era with the development of the Guglielmi Detachable Coil (GDC) system. This technology involves placing catheters from the femoral artery into the blood vessels of the neck (internal carotid artery or vertebral arteries). Ultimately a small microcatheter is advanced over a wire into the aneurysm and small platinum coils are advanced through the microcatheter into the aneurysm. Once the aneurysm is filled with platinum coils, blood no longer enters the sac. Over time the aneurysm thrombosis off and is no longer at risk for rerupture.

From the 1990's into the early 2000's, endovascular aneurysm treatment primarily involved various types of coils. While similar to the original GDC coils, newer coils were manufactured in a variety of shapes, lengths, stiffnesses and with particular coatings. Each of these variables was aimed at making the coiling procedure safer and more effective. During this same period of time new types of arterial stents (aka: neck remodeling devices) such as the Enterprise (Codman, Raynham, MA) were developed that could be used in conjunction with the coils to make treatment safer and more effective and to increase the types of aneurysms eligible for endovascular therapy.

In the 2000's endovascular surgeons began investigating the applicability of using liquid adhesive/cohesive materials (Onyx, Covidien, Boston, MA) as well as stent type devices (Pipeline Device, Medtronic, Minneapolis, MN; Silk, Balt Extrusion, Montmorency, France; FRED, Microvention, Aliso Viejo, CA; p64, Phenox, Bochum, Germany) alone to occlude aneurysms. The stent like device is termed a "flow diverters". It functions by redirecting blood flowing through a blood vessel so that less blood flows into the aneurysm. Blood that does flow into the aneurysm becomes turbulent. These two actions induce the aneurysm sac to thrombose over

time and exclude itself from the arterial circulation. More recently, flow diverting devices that are placed into the aneurysm itself have come to market (Web Device, Microvention, Aliso Viejo, CA).

Treatment Outcomes:

The majority of literature comparing surgical clipping and endovascular therapy has shown superior long term outcomes when patients are treated using minimally invasive endovascular approaches. Nevertheless, when unruptured aneurysms are treated using either endovascular or open surgical clipping, morbidity and mortality is generally less than 5-10% unless the lesion being treated is excessively complicated based primarily upon its location, size and geometry.

Outcomes following treatment of ruptured aneurysms is significantly influenced by the patient's neurologic condition at the time of presentation. The better an individual's preoperative neurologic condition when they present for therapy, the better their chance of a good outcome. The Hunt and Hess Grading System describes a patients condition. Grade 0 patients are unruptured. Grade 1-5 describes patients with ruptured lesions. Grade 1 patients are asymptomatic or have a mild headache and stiff neck. Grade 2 patients may have a cranial nerve palsy and/or a moderate headache/neck stiffness. Grade 3 patients have a mild focal deficit, lethargy and/or confusion. Grade 4 patients demonstrate stupor, moderate/severe hemiparesis, decorticate posturing and/or early decerebrate posturing. Grade 5 patients are in deep coma, show decerebrate rigidity or are moribund. While Grade 1, 2, and 3 patients have worse outcomes than Grade 0 patients, they generally have a better than 50% likelihood of good treatment outcome (normal or mild/moderate disability). Grade 4 and 5 patients that undergo aneurysm treatment have up to a 73% chance of poor long term outcome (severe disability or death).

Timing of Treatment:

Asymptomatic unruptured aneurysms are in most cases treated electively. Ruptured aneurysms, however, represent a neurosurgical emergency since delays in therapy leave the patient at risk for recurrent aneurysm rupture. Literature has clearly shown that for surgical clipping, treatment within 48-72 hours of aneurysm rupture in patients presenting Hunt and Hess 1-3 has superior outcomes to delayed treatment. Delayed open surgical treatment in patients presenting Hunt and Hess Grade 4-5 has been shown to possibly yield better outcomes compared to early treatment. The latter finding, however, is debatable as surgical technique has improved.

There is no clear evidence that such findings as described above hold true for aneurysms treated using endovascular techniques. Because catheter based interventions do not require brain exposure and tissue manipulation, most endovascular surgeons advocate early (within less than 24 hours of hemorrhage) treatment of ruptured aneurysms no matter the patients Hunt and Hess grade. The

decision to treat, however, may be influenced by a patient's neurologic condition, age, comorbidities, family desires and/or a patient's pre-morbid known preferences.

Conclusion:

Intracranial aneurysms may present as asymptomatic lesions or may reveal themselves following intracranial subarachnoid hemorrhage. Most aneurysms can be treated using minimally invasive endovascular therapy. Outcomes correlate most closely with the patient's neurologic condition at the time of treatment.

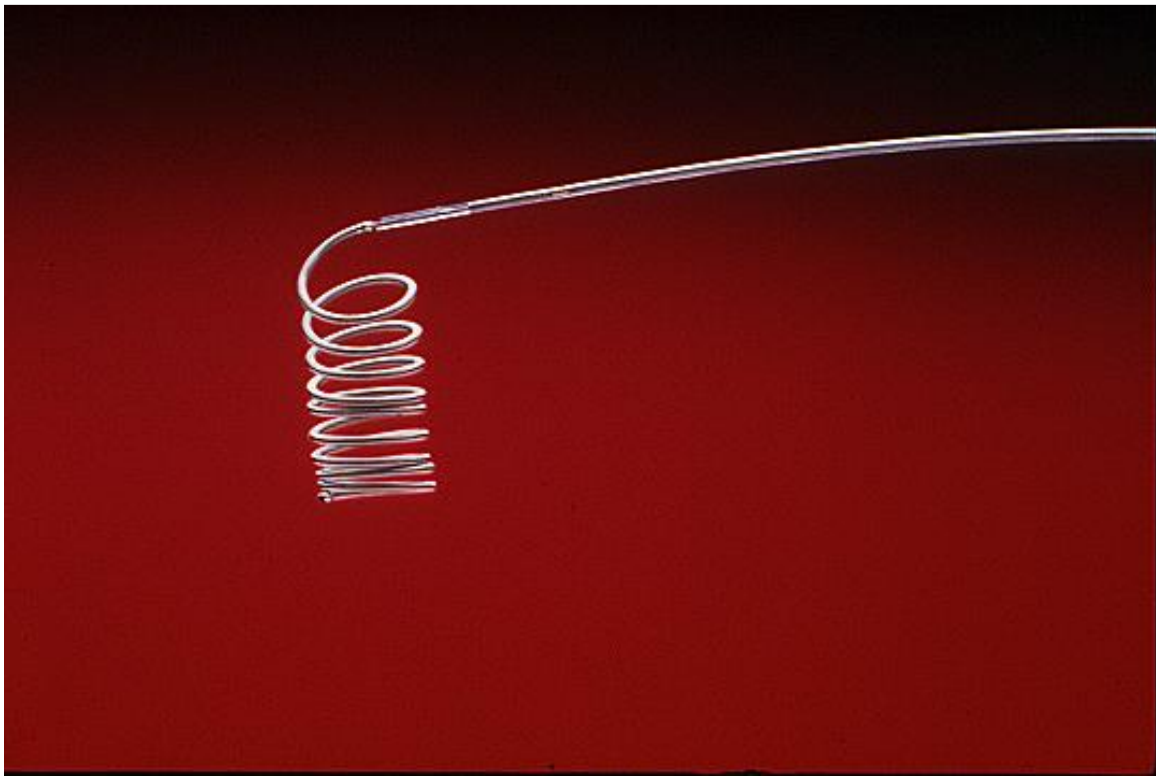


Figure 1: Example of a platinm detachable coil that can be inserted into an aneurysm using endovascular technique

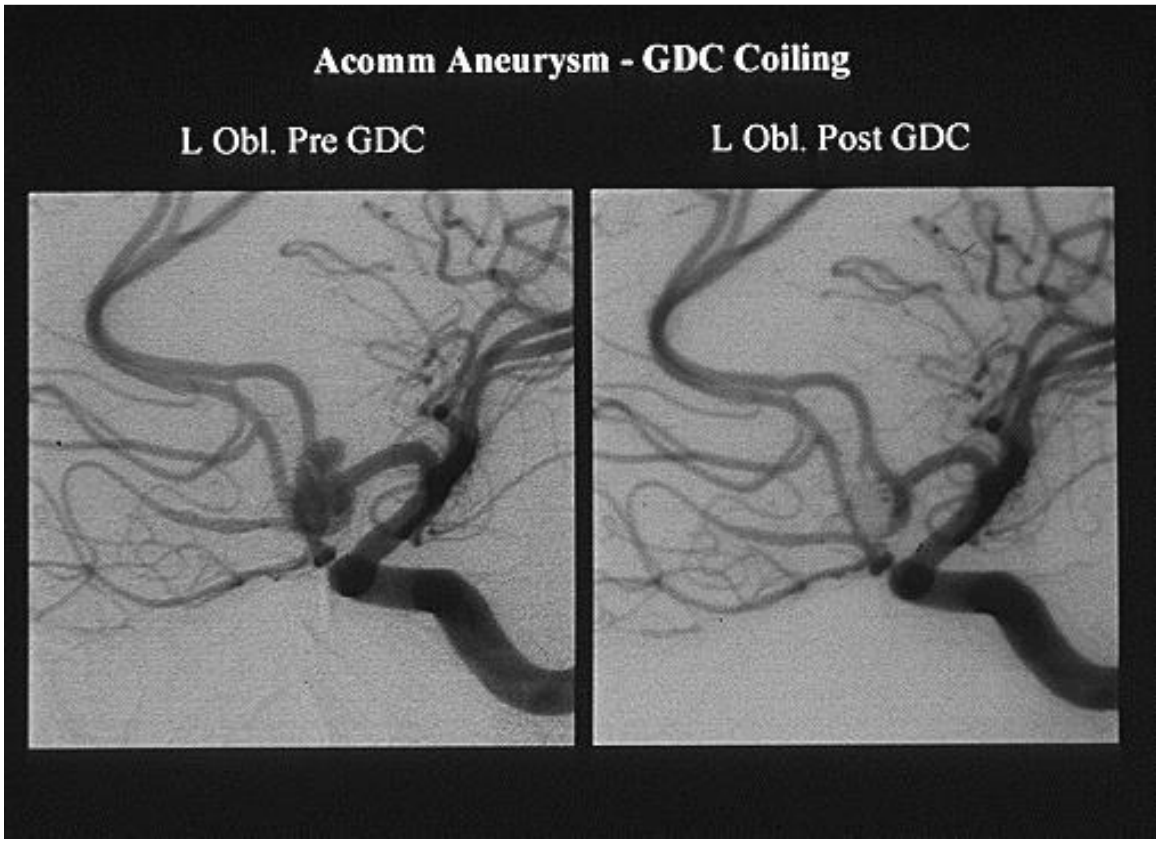
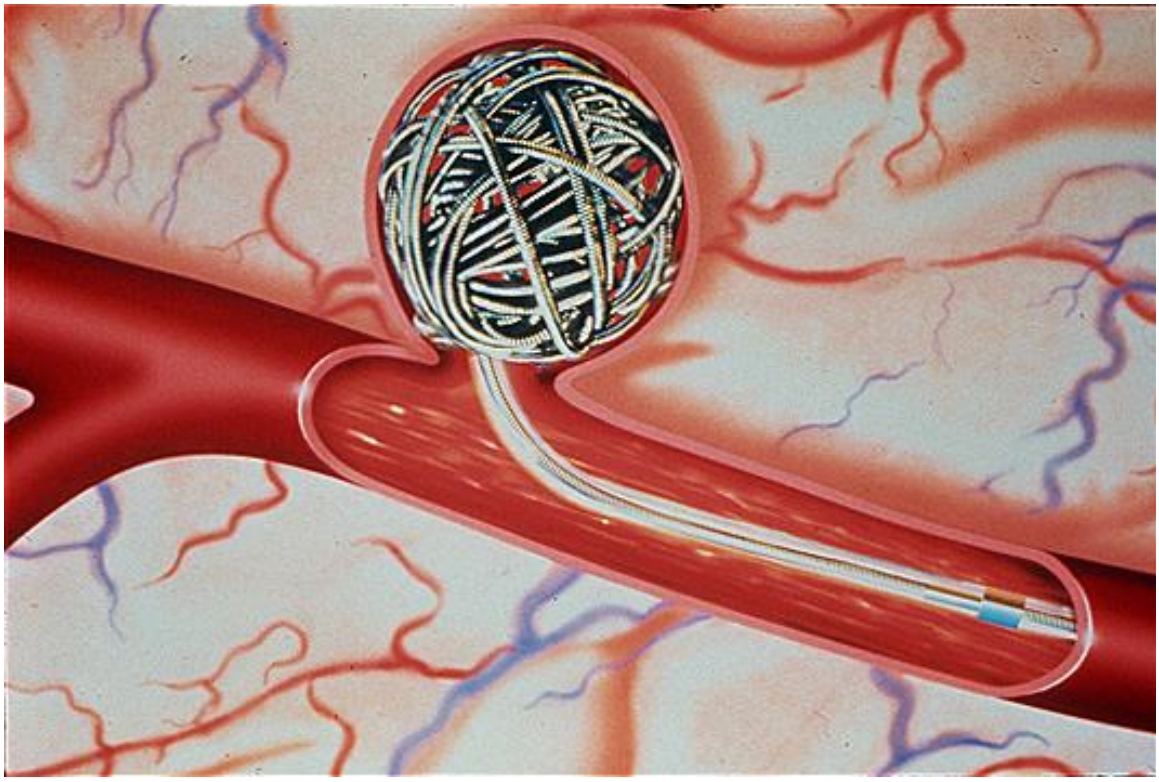
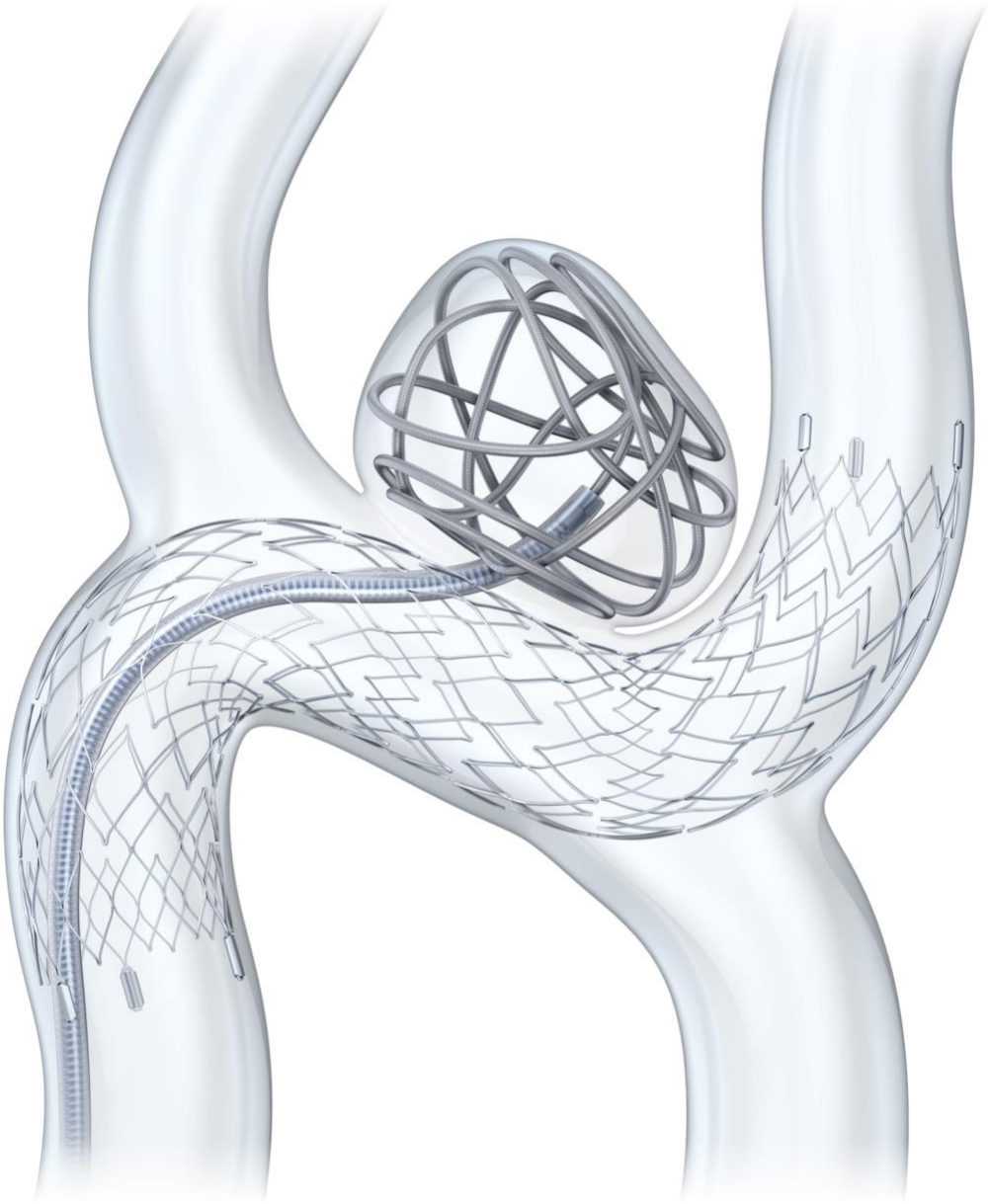


Figure 2: Image on left shows anterior communicating artery aneurysm prior to endovascular coiling. Image on right shows aneurysm after it has been filled with several platinum detachable coils using endovascular technique.

Figure 3: Figure 3 shows an artist's rendering of a catheter in an aneurysm and the platinum coils that were advanced through the catheter and deposited within the aneurysm. The catheter will be removed at the end of the procedure.

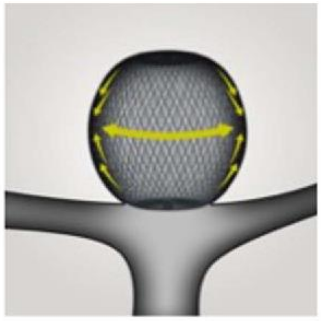




Hemorrhagic Solutions Image
Image courtesy of Stryker

WEB-SL
(Single Layer)

WEB SLS
(Single Layer Spherical)



Radial compression holds WEB in aneurysm sac while conforming to aneurysm wall and sealing the neck