

# **Neurosurgical Programs**

*Patient Educational Files*

*Kaiser Permanente Northern California*

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# Kaiser Permanente – Northern California Intrathecal Baclofen (ITB) Management and Surgical Centers

## Surgical Implantation Sites

### Redwood City (650) 299 - 2290:

- Ramon Quesada, MD: Chief of Physical Medicine and Rehabilitation
- Elizabeth Heilman, MD: Physical Medicine and Rehabilitation
- Taissa Cherry, MD: Anesthesiologist, Interventional Pain
- Mark Sedrak, MD: Director of Functional Neurosurgery, Northern California Kaiser Permanente
- Patrick Pezeshkian, MD: Functional Neurosurgeon
- Diana Bruce, PA: Physician Assistant in Functional Neurosurgery
- Ivan Bernstein, PA: Physician Assistant in Functional Neurosurgery, Surgery Scheduling Supervisor
- Julie Perez: Medical Assistant to Functional Neurosurgery

### Sacramento (916) 973 - 5490:

- Conrad Papas, MD, Phd: Functional Neurosurgeon

## Locations of Regional Intrathecal Baclofen Programs



**Red** are implant surgical and management sites

**Blue** are medical management sites

## Medical Management and Refill Sites

**South Sacramento** (916) 688-2005  
Susan Scholey, MD

**Redwood City** (650) 299-4741  
Ramon Quesada, MD  
Elizabeth Heilman, MD

**Santa Rosa** (707) 571-3086  
Andrea Rubinstein, MD  
Tabitha Washington, MD

**Stockton** (209) 476-2080  
Michael Rehbein, MD

**Sacramento** (916) 973-7481  
Marian TeSelle, MD

**South San Francisco** (650) 742-7226  
Dennis Nakamura, MD

**San Jose** (408) 972-3033  
Wayne Smith, MD

**Santa Clara** (408) 554-9810  
Benjamin Mandac, MD

**Union City** (510) 675-3070  
Eunice Lau, MD

**San Rafael** (415) 444-2000  
Vincenzo Vitto, MD

**Fresno/Clovis** (559) 324-5035  
Muhammad Akbar, MD

**Oakland** (510) 752-2679  
Joshua Rittenberg, MD

**Martinez** (925) 313-4740  
Eric Alexander, MD

**Vallejo** (707) 651-1044  
Lynn Kostecki-Csanyi, MD

**San Francisco** (415) 833-4342  
Xiao-Ping Cheng, MD

## **Intrathecal Baclofen (ITB) Therapy**

Intrathecal baclofen therapy (ITB) is a system that utilizes baclofen for infusion directly around the nerves of spine for the treatment of spasticity. The advantage of ITB is that it can afford a continuous infusion of medicine and one can achieve much higher doses than what can be delivered with pills, often times with lower side-effects. The disadvantage of the therapy is that it required physical filling of the pump with a needle procedure and carries more long-term risk, especially of withdrawal problems which can be lethal. Also, the amount of spasticity relief varies for each person.

### ***Trial Period***

While ITP can be helpful in a number of people, it does not work in everybody. To help decide in whom this may or may not work, almost all patients have a trial to test the effectiveness. There are two forms of trials: bolus or catheter. A bolus trial involves placement of the medication via a needle stick (lumbar puncture) in the back and then assessing the spasticity over the subsequent hours in the hospital then at home in the following days. A catheter trial requires actual placement of a catheter in the spine and then infusing the medication over the following week in the hospital. Typically for this week long trial period, we are looking for a substantial amount of ongoing pain relief, typically more than 50%.

### ***Permanent Implant***

For those who have a successful trial, a permanent full implantation may be the next step. This surgery is typically a much bigger procedure than the trial, involving larger incisions. Patients may also be in the hospital at least overnight after a permanent implant. You may have the full implant surgery as early as three weeks after your catheter trial, but sometimes a bit longer.

The surgery will go much the same as the trial with an incision in the back and in the abdomen on the left or right side. You will have discussed this with your surgeon in advance. The battery in the device lasts about 7 years and will need future replacement around that time.

Your infusion will initially be set at a very low dose to avoid over-infusion problems. Over the next several months and years, the device can be programmed to optimally achieve therapy. You will receive wound care instructions before you go home.

### ***Programming/Adjustment/Refills***

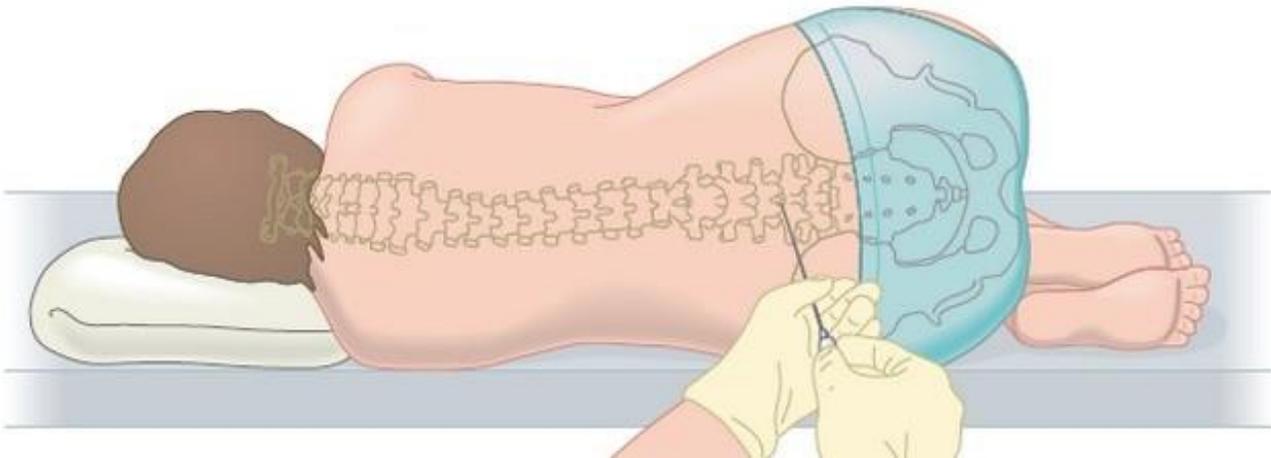
Shortly after your surgery you may return for programming and adjustments. You will have post-operative care and can use those opportunities to have programming done by making arrangements with the care management team. You can request additional sessions when you think you're not exactly where you need to be for spasticity control. It is notable that the infusion rate, and therefore dose, can be adjusted non-invasively with the device. Because this is an infusion system, refills are necessary and typically occur between 6 weeks-3month intervals.

## Appendix

Figure 1: Intrathecal Pump, Medtronic Synchronomed II, there are 20cc and 40cc options



Figure 2: Lumbar Puncture. A procedure where a needle is inserted in the spine to gain access to the cerebrospinal fluid (CSF). For intrathecal baclofen, the medication is injected in this CSF space.



## Comprehensive NeuroVascular Program

### Kaiser Permanente Redwood City

#### Redwood City Neurosurgeons (650) 299 - 2290:

- William Sheridan, MD: Chief of Neurosurgery
- Allen Efron, MD: Assistant Chief of Neurosurgery, Skull Base Specialist
- John Duncan, MD, Phd: Chief of Pediatric Neurosurgery Kaiser Santa Clara, Director of Epilepsy Surgery program
- Nicole Moayeri, MD: Assistant Physician in Chief (APIC) of Surgical Services, Vascular specialist
- Cornelia Von Koch, MD, Phd: Neurosurgeon, Spine specialist
- Aleksandyr Lavery, MD: Neurosurgeon, brain tumor/vascular and spine specialist
- Lyndell Wang, MD: Neurosurgeon, brain tumor specialist
- Lewis Hou, MD: Neurosurgeon, skull base and vascular specialist
- Victor Tse, MD, Phd: Neurosurgeon, director of radiosurgery program, brain tumor and peripheral nerve specialist
- Prasad Reddy, MD: Neurosurgeon, Vascular and Endovascular specialist
- Mark Sedrak, MD: Neurosurgeon, Director of Functional Neurosurgery, brain tumor specialist
- Patrick Pezeshkian, MD: Functional Neurosurgeon and peripheral nerve specialist
- Kevin Chao, MD: Neurosurgeon, Pediatric and Adult specialist

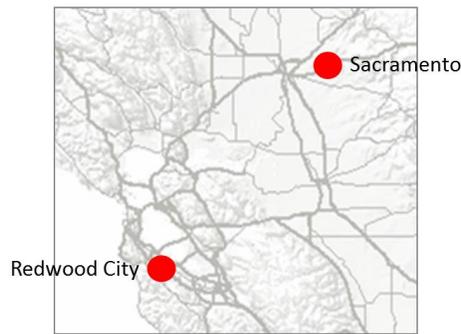
#### Redwood City EndoVascular Team (650) 299 - 2290:

- Sean Cullen, MD: Director of NeuroInterventional Radiology
- Daniel Hsu, MD: NeuroInterventional Radiologist
- Prasad Reddy, MD: Neurosurgeon and Endovascular Specialist

#### Redwood City NeuroCritical Care Team (650) 299 - 2290:

- Vivek Rao, MD: Chief of Neurology, Neurocritical care and stroke physician
- Alexander Flint, MD: Neurocritical care and stroke physician
- Sheila Chan, MD: Neurocritical care and stroke physician

NeuroVascular Care Programs  
Northern California Kaiser Permanente



Red are Surgical NeuroVascular and EndoVascular Sites

**Redwood City Physical Medicine and Rehabilitation Care Team (650) 299 - 2290:**

- William Firtch, MD: Physician in Chief (PIC) of Kaiser Redwood City, Physical Medicine and Rehabilitation physician
- Ramon Quesada, MD: Chief of Physical Medicine and Rehabilitation
- Elizabeth Heilman, MD: Physician Medicine and Rehabilitation physician
- Raymond Lai, DO: Physical Medicine and Rehabilitation physician

**Sacramento Neurosurgeons (916) 973 – 5490:**

- Amit Banerjee, MD: Chief of Neurosurgery, Skull Base and Complex Spine Surgery
- Mark Hawk, MD: Assistant Physician in Chief, Complex Spine surgery and Vascular
- Kaveh Barami, MD: Neurosurgeon
- Kamran Sahrakar, MD: Neurosurgeon, Neuro-Oncology and Radiosurgery
- James Silverthorn, DO: Neurosurgeon
- Abraham Bosckovitz, MD: Neurosurgeon
- Indro Chakrabarti, MD: Neurosurgeon, Neuro-Oncology and Vascular
- Huy Duong, MD: Neurosurgeon
- Adam Griffith, MD: Neurosurgeon
- Kern Guppy, MD: Neurosurgeon, Complex Spine
- Brian Jian, MD: Neurosurgeon
- David Moller, MD: Neurosurgeon
- Conrad Pappas, MD, Phd: Functional Neurosurgeon
- Alan Williams, MD: Neurosurgeon, Vascular
- Sean McNatt, MD: Neurosurgeon Adult and Pediatric

**Sacramento EndoVascular Team (916) 973 – 5490:**

- Jonathan Hartman, MD: Neurointerventional radiologist

**Sacramento Neuro-Critical Care Team (916) 973 – 5490:**

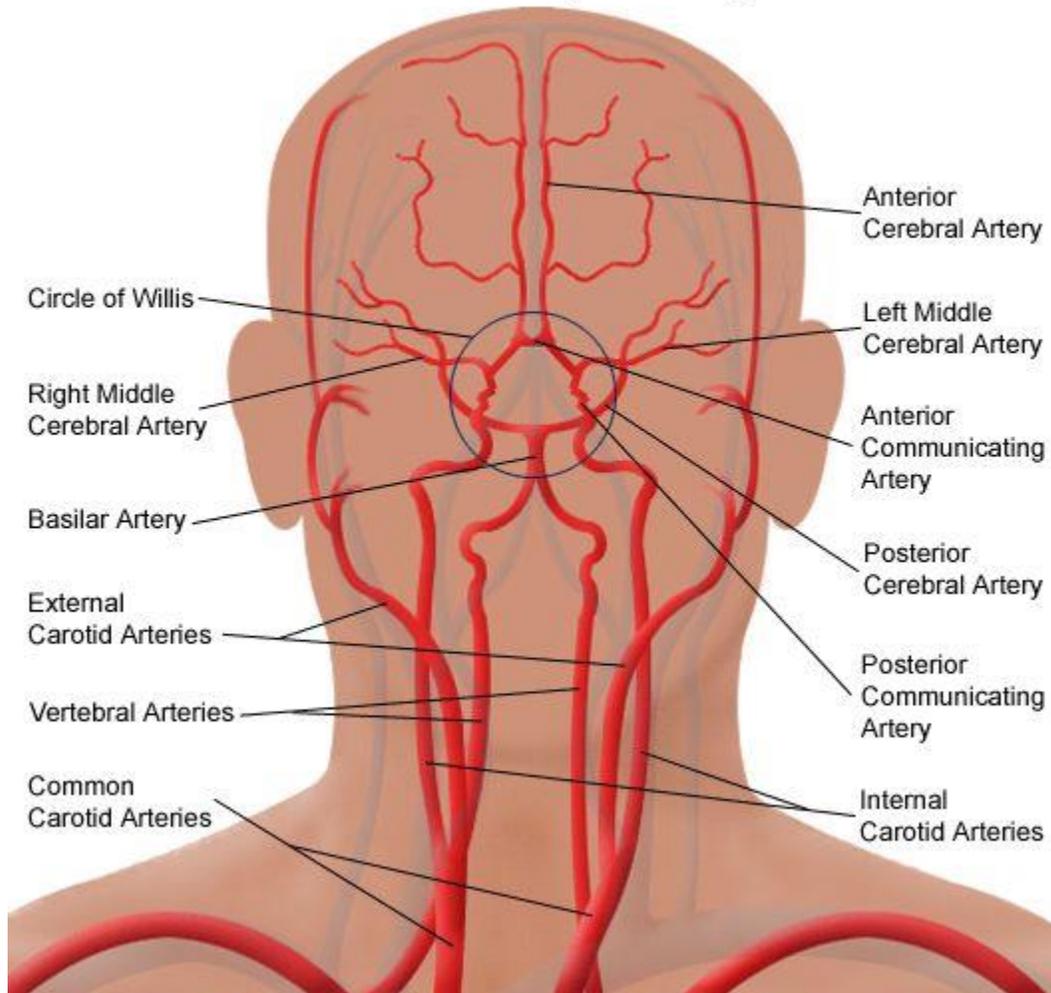
- Paul Akins, MD: NeuroCritical Care Specialist

## NeuroVascular Conditions

### Anatomy:

The brain and spinal cord consists of many arteries that provide blood for the normal function. Because nerves (brain and spinal cord) depend on blood to function, when blood supply is blocked or an artery bleeds, this can impair function of the nervous system, causing a stroke. There are many arteries that can be involved in a stroke and the severity of the problem directly depends on the location.

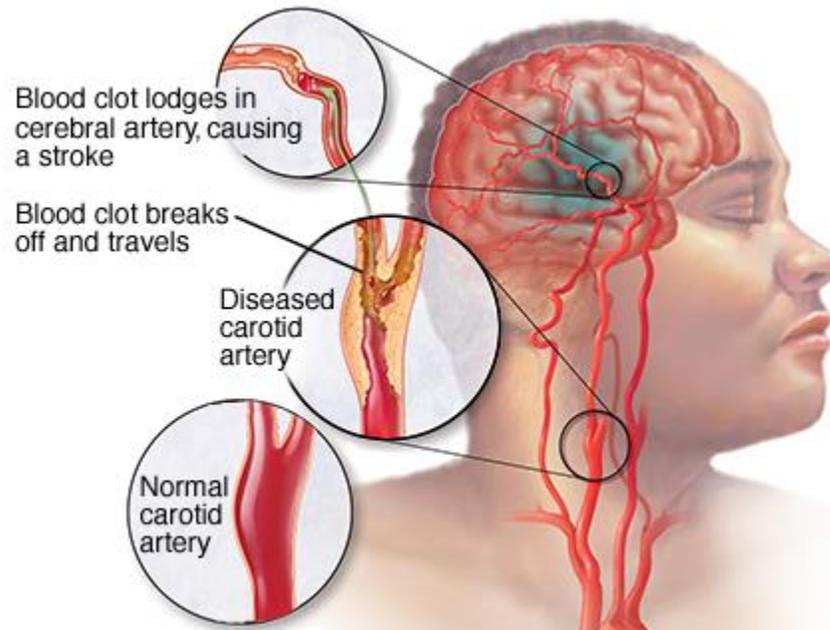
### Arterial Circulation of the Brain, Including Carotid Arteries



### Ischemic Stroke

An ischemic stroke is the most common problem that can occur to the blood vessels of the brain. This occurs when a small clot travels to the arteries of the brain physically blocking the artery, just like a clogged pipe. The nerve cells that depended on that blood supply may die as a result. Typical symptoms of a stroke are sudden and could include weakness/paralysis of face/arm/leg, numbness,

blindness and should be treated as an emergency. Occasionally, if a patient presents to a hospital with a major stroke within hours of the onset, they can be treated with a clot buster (ivTPA) and occasionally could be a candidate for direct clot retrieval. These treatments are very time sensitive, making the detection extremely important to occur in a timely fashion. There are many causes of ischemic strokes, but most common origins of these clots include disease to the carotid arteries (atherosclerosis) and atrial fibrillation. In younger patients, a possible cause is something called a dissection.

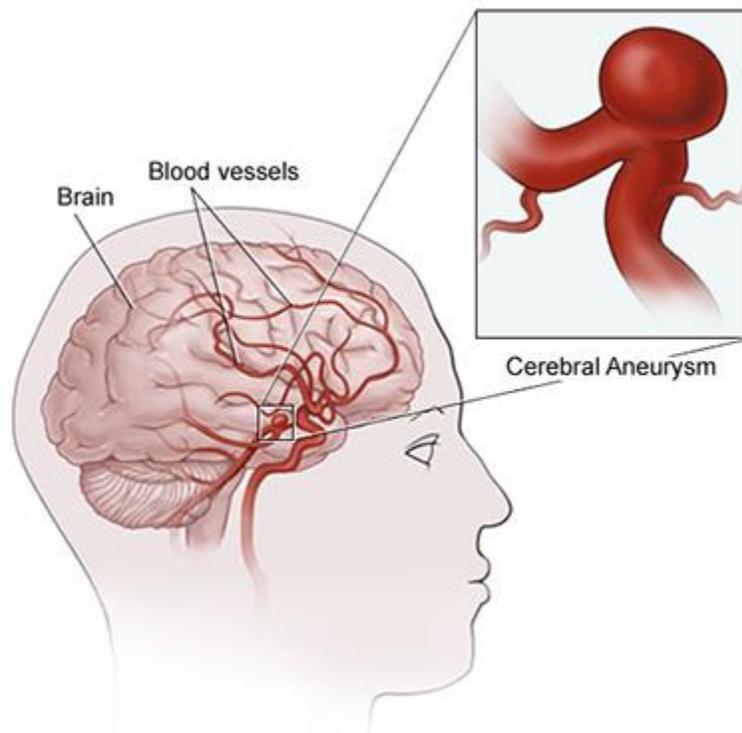


## Hemorrhagic Stroke

Another type of stroke that can occur is when a blood vessel actually breaks or pops, causing blood to leak out around or into the brain itself. Because arteries are under pressure from the beating of the heart, the pressure can be high and cause damage to the brain by shearing through the tissue. There are several causes of a hemorrhagic stroke, but the most common is because of a weakened/diseased vessel which can occur from age, diabetes, or high blood pressure. Unfortunately, there is no direct treatment for this type of weakened vessel which are typically very small except for blood pressure control, control of blood lipids. Please consult your primary care physician for further questions or concerns. Other important causes of a hemorrhagic stroke include aneurysms and arteriovenous malformation.

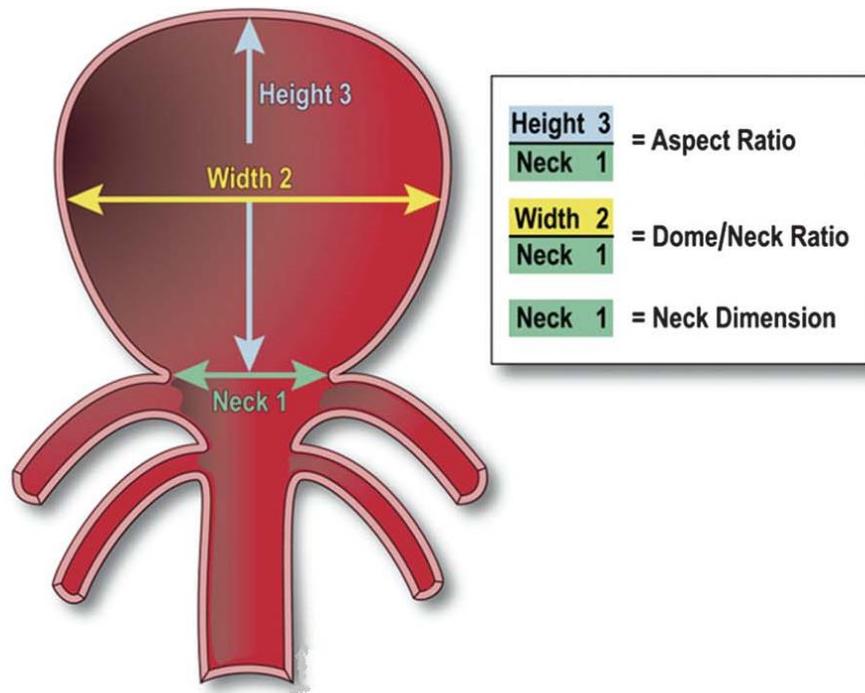
## Cerebral Aneurysms:

A brain/cerebral aneurysm is an outpouching of a blood vessel in the brain. This outpouching signified a weakened wall in that region, which can increase the chances of bleeding called a “subarachnoid hemorrhage”. Subarachnoid hemorrhages are an immediate life-threatening disease and about 50% of patients will not even make it to the hospital because of the high pressure transmitted to the brain, preventing blood flow throughout. However, many patients can present with severe sudden onset lightning bolt headache. When this happens, diagnosis and treatment is needed urgently. There are several steps in the treatment of ruptured aneurysms that needs to be noted, which include direct treatment of the aneurysm with “clipping” or “coiling”, monitoring in the hospital for “hydrocephalus” or backing up of fluid in the brain, and monitoring for delayed “ischemic” strokes from a problem called vasospasm. Many of these issues can become quite problematic even weeks after the subarachnoid hemorrhage (SAH), requiring patients to stay in the hospital for weeks of monitoring.

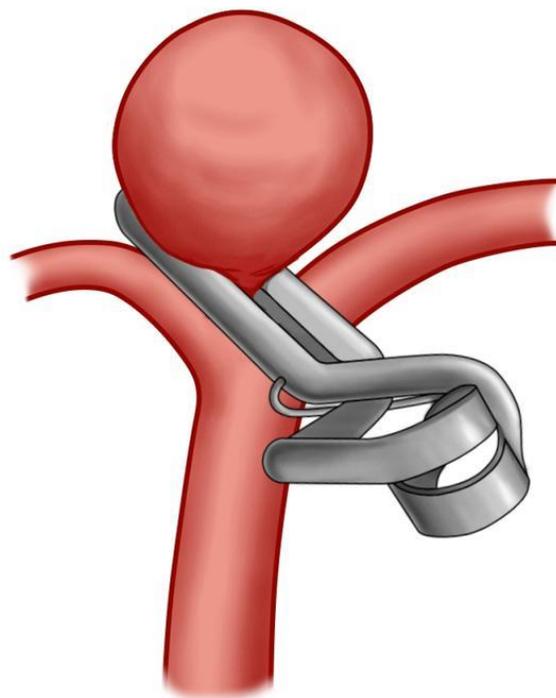


### “Clipping” versus “Coiling”

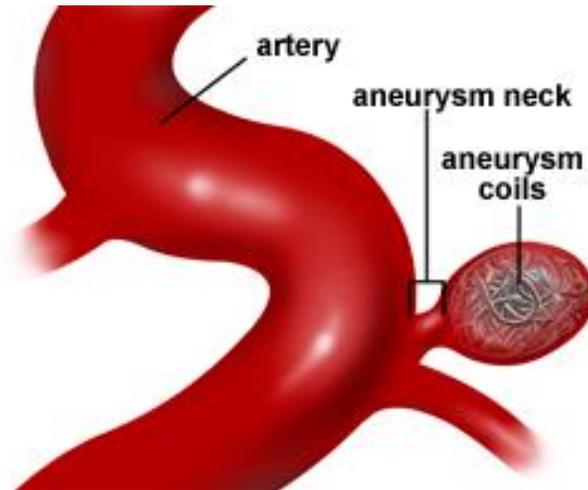
Much progress has been made in the neurosurgical/neurointerventional community geared towards treating and understanding aneurysms. Because of this collaborative effort, we’ve developed certain criteria which dictate the need for surgical clipping or coiling, which are primarily based off of the configuration of the aneurysm. In general, if the aneurysm neck is very wide, clipping is needed, and if the neck is narrow, coiling can be performed.



Clipping of an aneurysm refers to a procedure called a “craniotomy”, where the skull is opened and surgeon with use of a microscope identifies the “neck” of the aneurysm and places a clip to prevent he aneurysm from rebleeding. This procedure is performed by neurosurgeons.

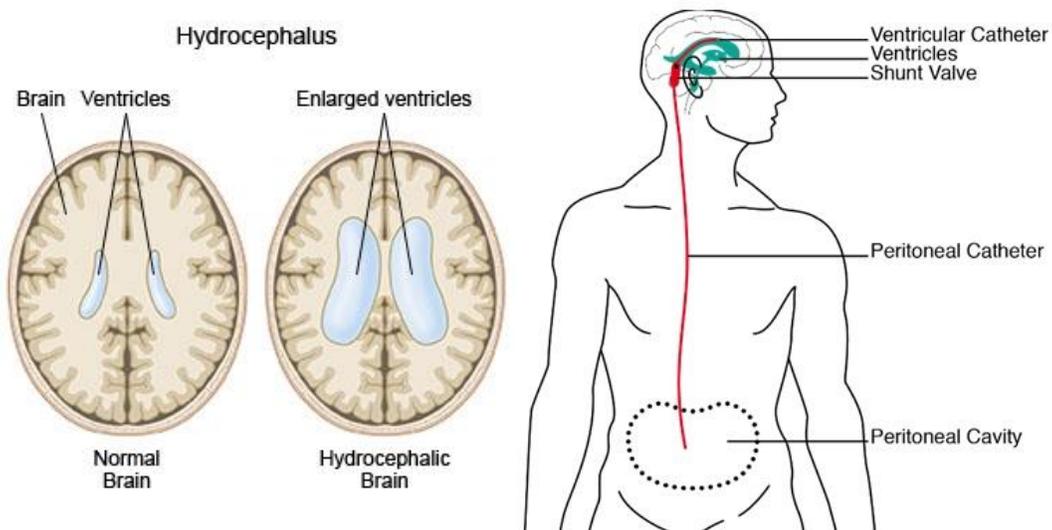


Coiling of an aneurysm is procedure where a small puncture in the artery of the groin is performed, followed by placing a catheter in the arteries of the body all the way up to the arteries of the brain, then placing small metallic coils in the aneurysm dome. The process of placing this catheter from the groin to the brain with injection of contrast is called an “angiogram”. This procedure is minimally invasive and doesn’t require opening of the skull. These coils cause a clot to form which then prevents blood flow into the aneurysm and preventing it from re-bleeding.



### Hydrocephalus

Hydrocephalus is a problem that occurs about 20% of the time after a subarachnoid hemorrhage (SAH). Normally, the fluid spaces of the brain have normal circulation making about ½ liter of cerebrospinal fluid (CSF) that becomes absorbed into the veins. When a SAH occurs, the normal channels for CSF flow are thought to become clogged, causing backing up of CSF like a dam. Hydrocephalus symptoms can include cognitive dysfunction, walking problems and urinary incontinence. Sometimes, this backing up of fluid, called hydrocephalus, needs to be drained with a catheter, which can be external (called a ventriculostomy) or internal (called a ventriculoperitoneal shunt).

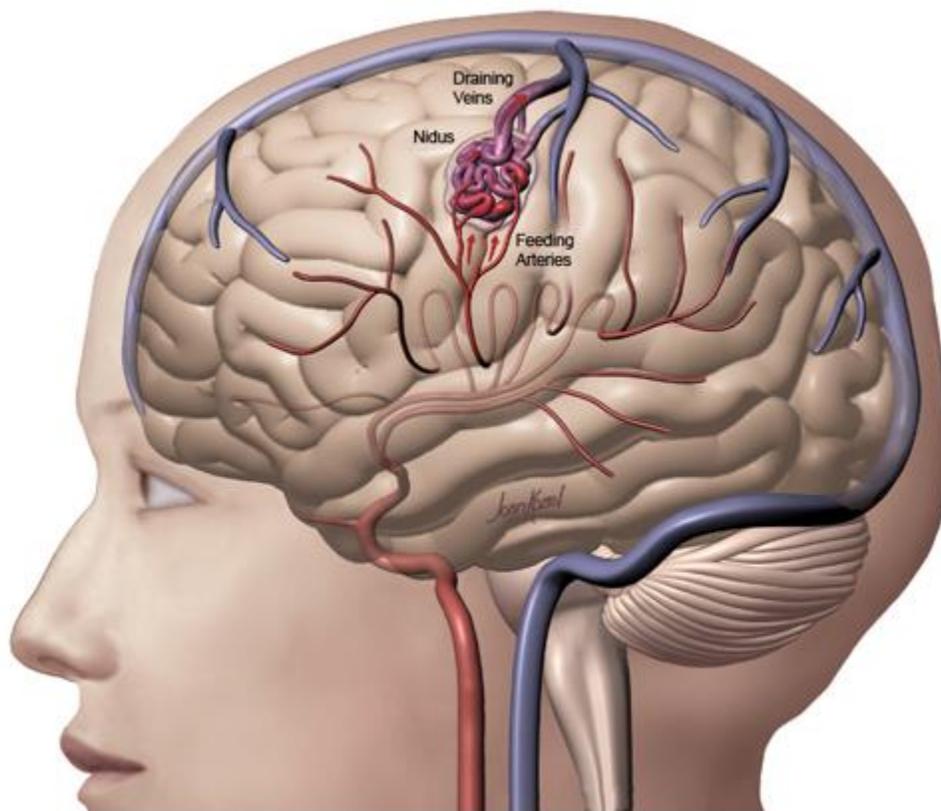


## Vasospasm

Lastly, following an SAH, some patients can develop delayed ischemic strokes, which can occur even up to several weeks after the hemorrhage. Nobody knows the exact reason for this problem, but it is likely related to blood irritation on the arteries of the brain. When vessels go into spasm, patients can develop stroke-like symptoms. They are often then treated with elevation of blood pressure and fluids, but can be treated with specific angiographic interventions such as intra-arterial verapamil or angioplasty. This condition is a reason for ongoing hospitalization after a SAH.

## Arteriovenous Malformations (AVM):

An AVM is a condition where an artery (high flow) is abnormally connected to a vein (low flow). This creates a condition where high flow and elevated pressures are introduced into a vein, rather than being filtered through a series of capillaries or tiny blood vessels (which act like resistors to reduce pressure and flow). Because of this problem, occasionally the blood vessels may bleed into the brain tissue and can occasionally cause seizure disorders. However, we know now that many of these AVMs do not bleed. Typically, when an AVM has bled, it needs to be treated. Treatment of AVMs can include surgical removal (a craniotomy), endovascular treatment (embolization or gluing), or radiosurgery treatment.

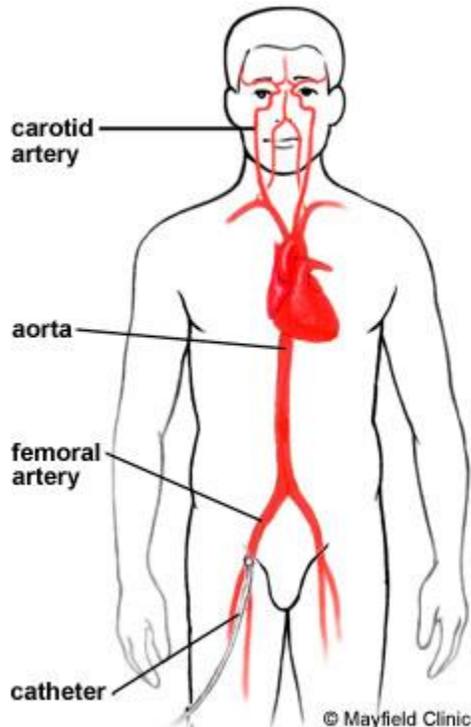




## Procedures

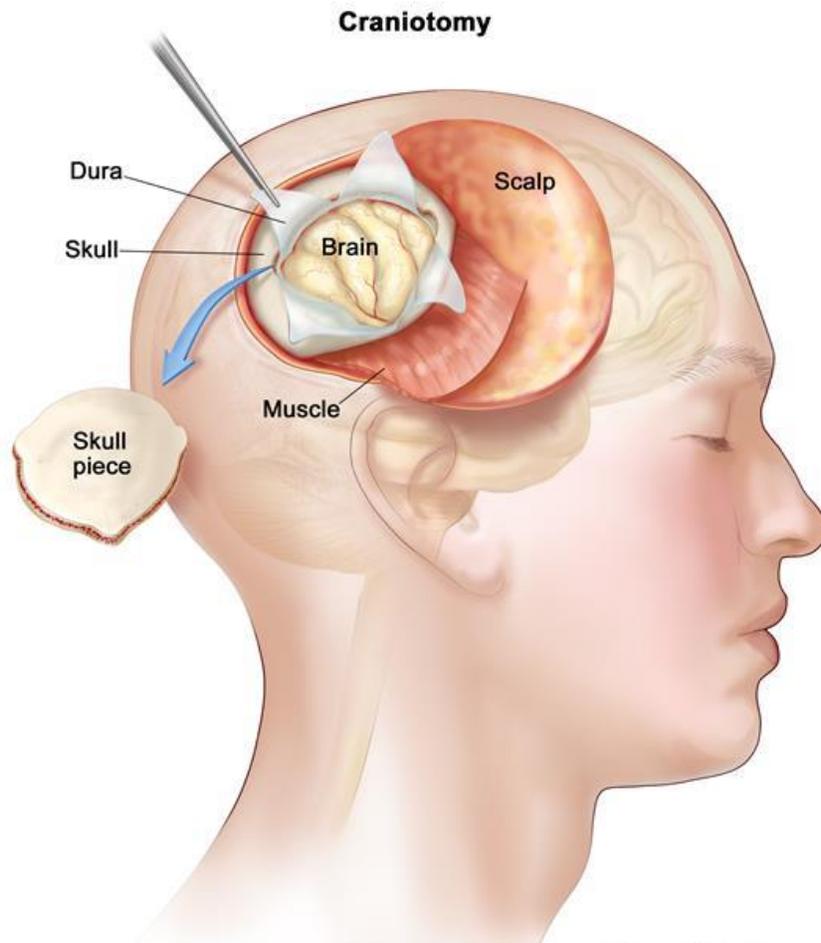
### **Cerebral/Brain Angiogram:**

An angiogram is a procedure performed by interventional neuro-radiologists, where a catheter is inserted into the groin and tunneled all the way up into the arteries of the brain. Once in position, contrast is injected into the arteries which can be seen with special Xray imaging. It is important to not move during these Xrays so as to prevent a fuzzy picture and needing to repeat the injections.



### **Craniotomy:**

Craniotomies (entering the brain for surgery) can be done with great success. A craniotomy is often the procedure needed access the brain to remove an AVM or clip an aneurysm. The actual location of the surgery would depend on the location of the vascular. There are several stages to a typical procedure. Most often, patients are completely under general anesthesia. The head is put into a surgical clamp to make sure no movement can occur during the procedure. Depending on the type of operation of and location of the vascular abnormality, neuro-monitoring can also be used to physiologically map important parts of the brain, such as the motor regions to prevent major paralysis. After the surgery is complete, the bone is replaced using metallic plates and screws that are MRI safe to bridge the flap to the remainder of the skull, which are permanent implants.



## Appendix

Figure 1: Symptoms of a Stroke is an emergency and need to act FAST.

# Stroke – there's treatment if you act FAST.



Figure 2: Two major types of a stroke, ischemic (blocked /clogged artery) and hemorrhagic (bleeding artery).

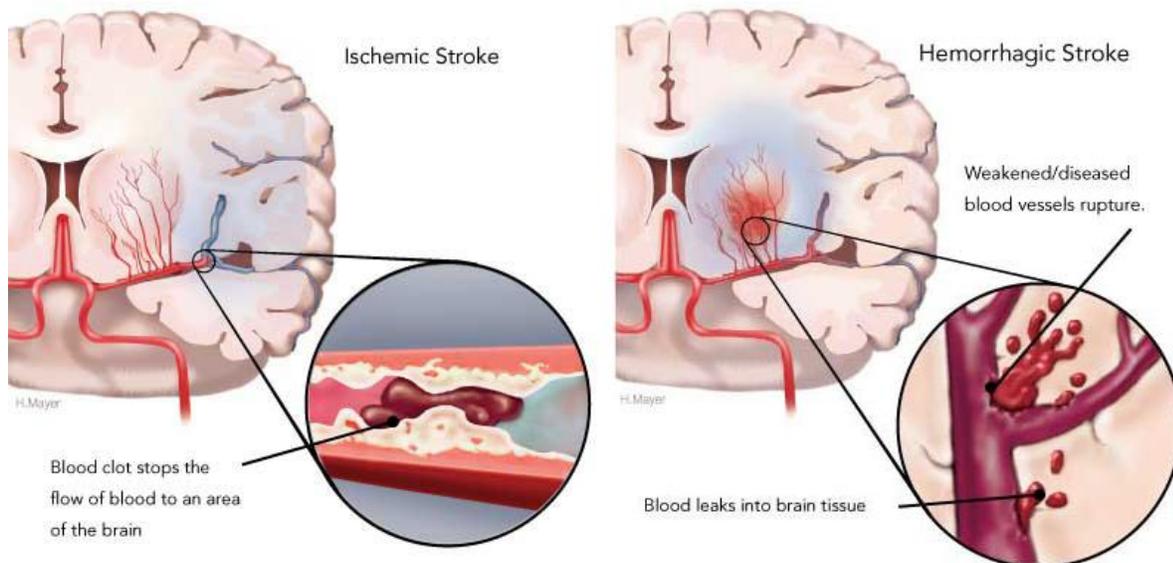


Figure 3: Arterial Dissection. This occurs when the wall of an artery physically tears, causing blocking of the artery and sometimes clots that can dislodge and cause strokes.

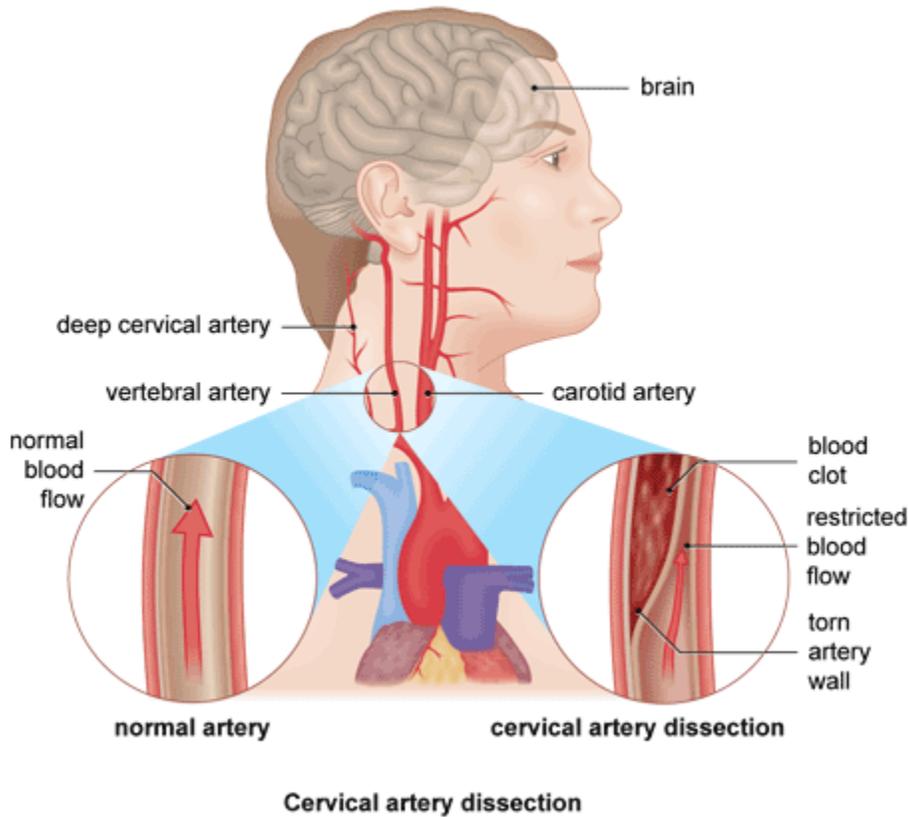


Figure 4: Atrial Fibrillation. This is a condition of the heart which causes the heart to beat abnormally, causing clots within the heart. Typically, patients need to be on blood thinners to prevent these clots from forming and moving into the brain, producing strokes.

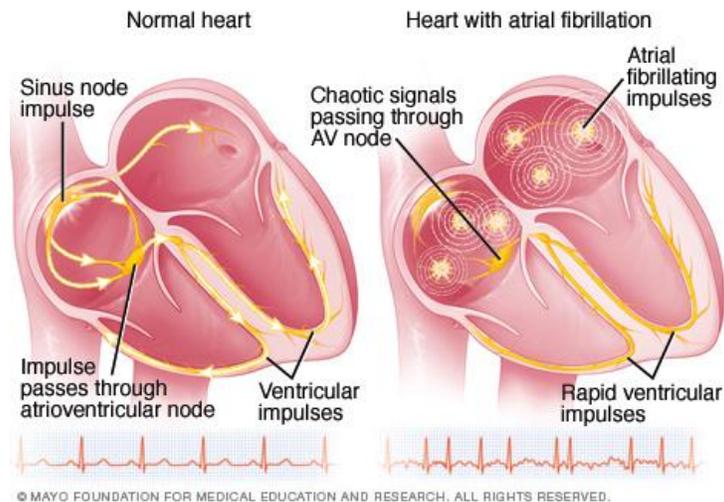


Figure 5: Atherosclerosis is a major cause of narrowing arteries, which can cause clots that travel to arteries of the brain producing strokes.

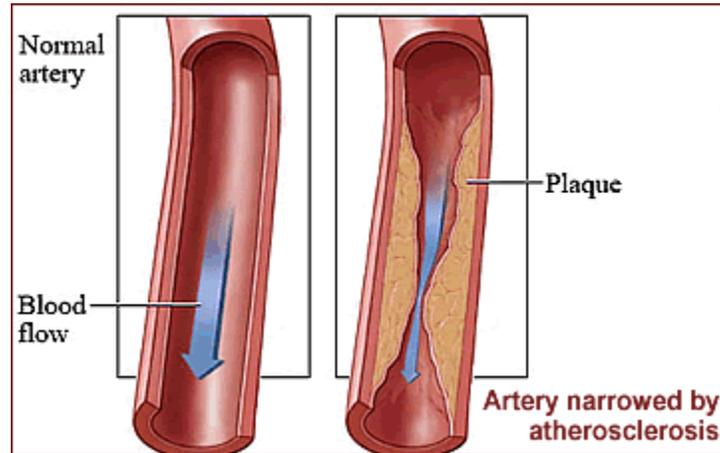


Figure 4: Using a catheter angiogram type procedure, some arterio-venous malformations (AVMs) can be blocked with either glue or coils to help reduce flow and treat the abnormality.

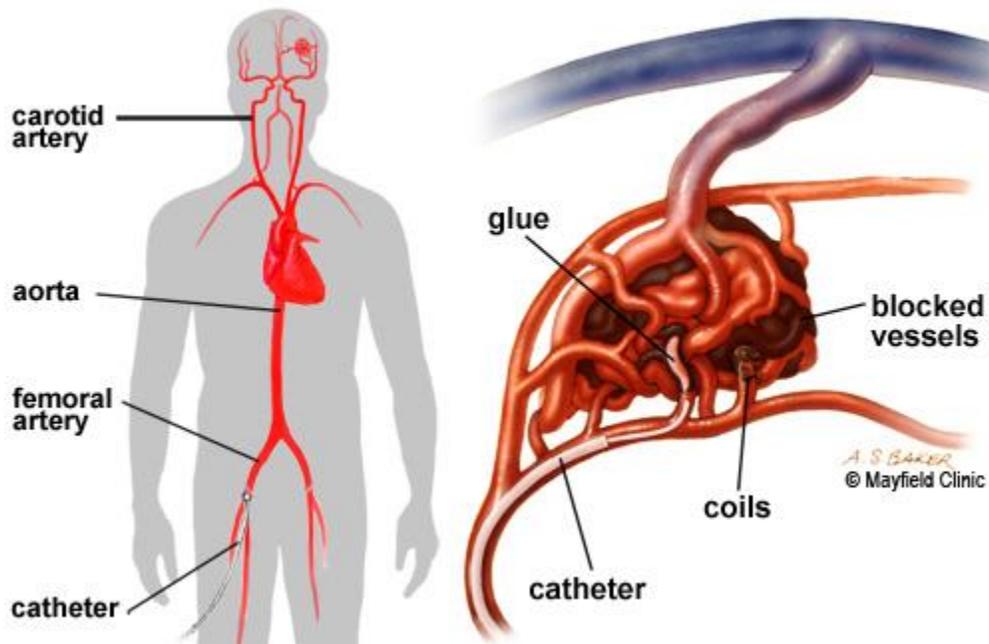
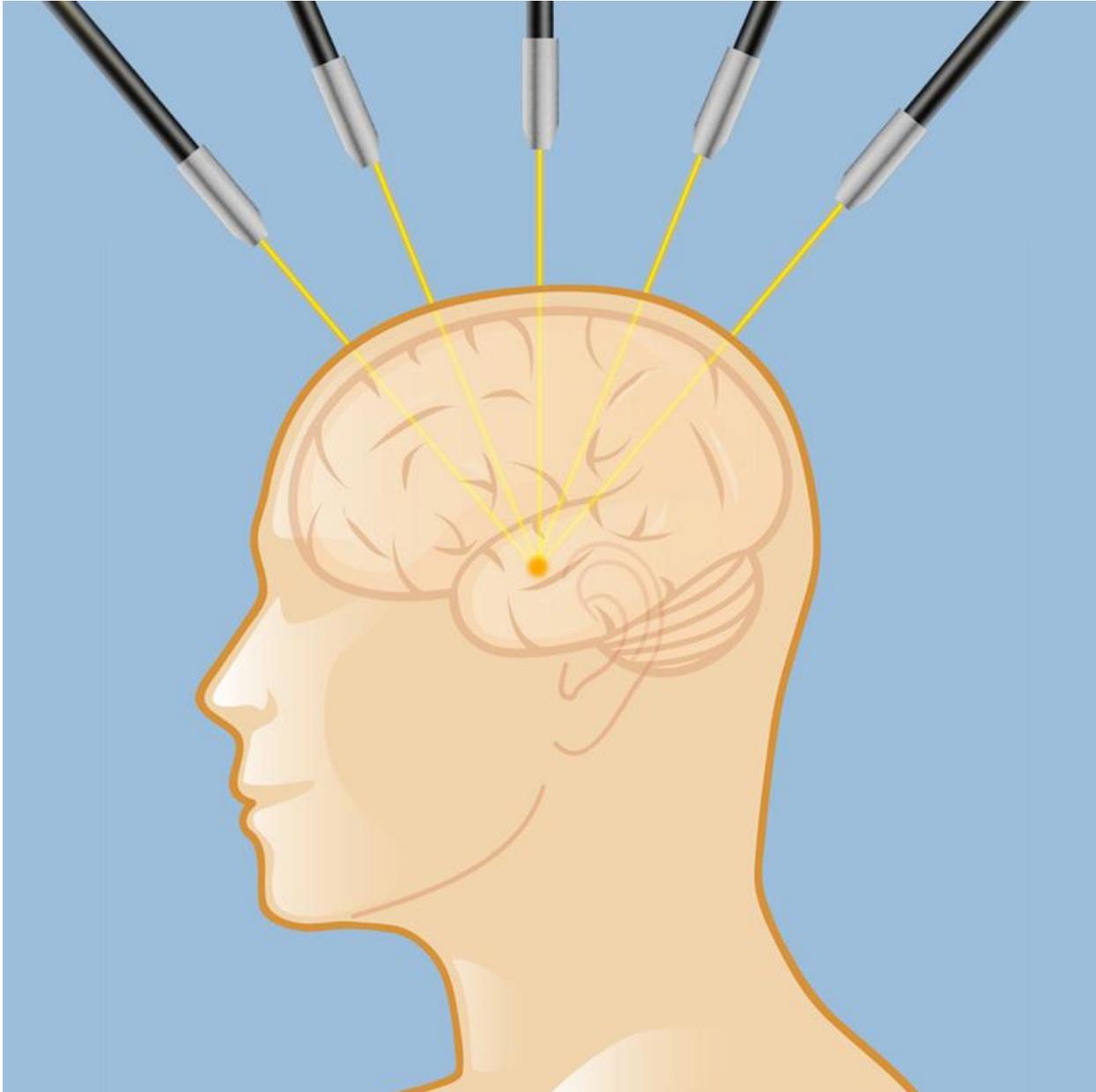


Figure 5: Stereotactic Radiosurgery (SRS) is a procedure where focused radiation is targeted on an AVM. Typically, the radiation effects take between 3 months to 3 years to take effect, causing clogging of the arteries in that area. Each beam of radiation is notably minimal, but when all the beams converge there is a high dose at that target site.



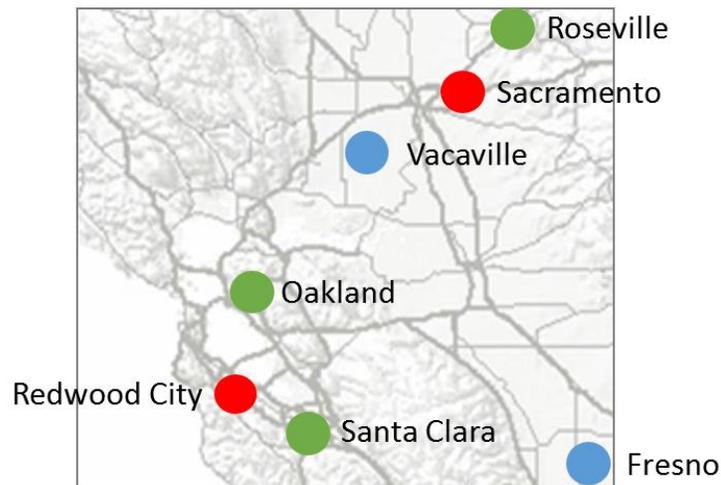
## Comprehensive Hydrocephalus Programs

### Kaiser Permanente Redwood City

#### Redwood City Neurosurgeons (650) 299 - 2290:

- William Sheridan, MD: Chief of Neurosurgery
- Allen Efron, MD: Assistant Chief of Neurosurgery, Skull Base Specialist
- John Duncan, MD, Phd: Chief of Pediatric Neurosurgery Kaiser Santa Clara, Director of Epilepsy Surgery program
- Nicole Moayeri, MD: Assistant Physician in Chief (APIC) of Surgical Services, Vascular specialist
- Cornelia Von Koch, MD, Phd: Neurosurgeon, Spine specialist
- Aleksandyr Lavery, MD: Neurosurgeon, brain tumor/vascular and spine specialist
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- Mark Sedrak, MD: Neurosurgeon, Director of Functional Neurosurgery, brain tumor specialist
- Patrick Pezeshkian, MD: Functional Neurosurgeon and peripheral nerve specialist
- Kevin Chao, MD: Neurosurgeon, Pediatric and Adult specialist

#### Neurosurgical Sites in Northern California Kaiser Permanente



Red are primary neurosurgical

Blue are neurosurgical site with primary focus on spine

Green are pediatric neurosurgical sites

**Sacramento Neurosurgeons (916) 973 – 5490:**

- Amit Banerjee, MD: Chief of Neurosurgery, Skull Base and Complex Spine Surgery
- Mark Hawk, MD: Assistant Physician in Chief, Complex Spine surgery and Vascular
- Kaveh Barami, MD: Neurosurgeon
- Kamran Sahrakar, MD: Neurosurgeon, Neuro-Oncology and Radiosurgery
- James Silverthorn, DO: Neurosurgeon
- Abraham Bosckovitz, MD: Neurosurgeon
- Indro Chakrabarti, MD: Neurosurgeon, Neuro-Oncology and Vascular
- Huy Duong, MD: Neurosurgeon
- Adam Griffith, MD: Neurosurgeon
- Kern Guppy, MD: Neurosurgeon, Complex Spine
- Brian Jian, MD: Neurosurgeon
- David Moller, MD: Neurosurgeon
- Conrad Pappas, MD, Phd: Functional Neurosurgeon
- Alan Williams, MD: Neurosurgeon, Vascular
- Sean McNatt, MD: Neurosurgeon Adult and Pediatric

**Santa Clara Neurosurgical Group (408) 851 – 1240:**

- John Duncan, MD, Phd: Chief of Pediatric Neurosurgery Kaiser Santa Clara, Director of Epilepsy Surgery program
- Kevin Chao, MD: Pediatric Neurosurgeon

**Roseville Pediatric Neurosurgery Group (916) 474 – 2600:**

- Sean McNatt, MD: Pediatric Neurosurgeon

**Oakland Pediatric Neurosurgery Group (510) 752 – 1749:**

- Dachling Pang, MD: Chief of Pediatric Neurosurgery
- John Zovickian, MD

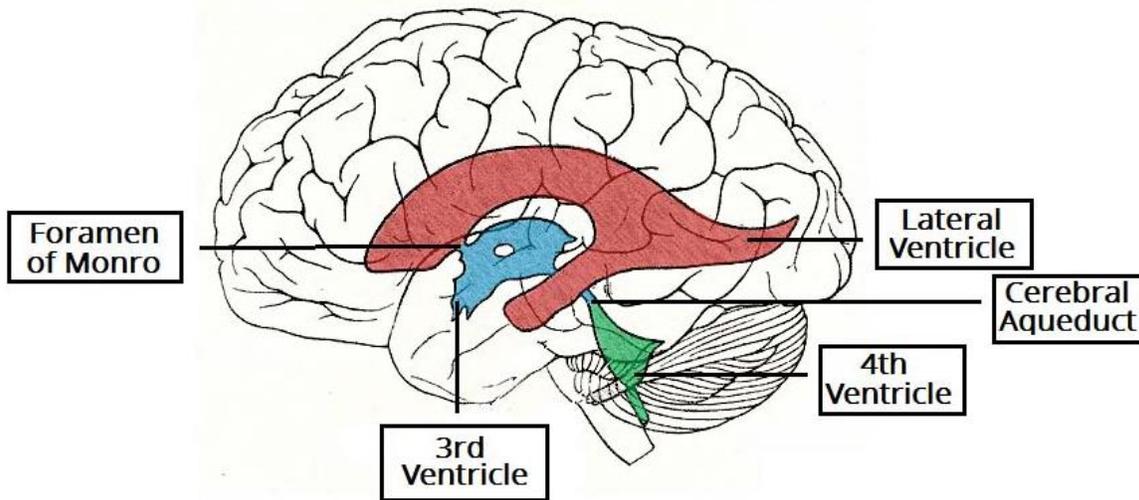
**Fresno Neurosurgery Group (559) 448 – 4437:**

- Steven Hysell, MD
- Donald Myers, MD

## Hydrocephalus

### Anatomy:

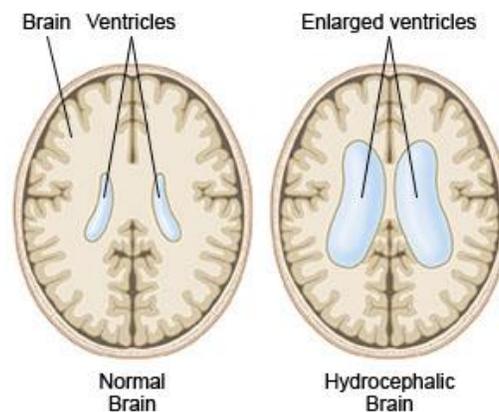
The brain consists of fluid spaces and a circulation system, similar to that of the heart and blood vessels. The brain produces about 500 mL of cerebrospinal fluid (csf) each day that circulates and becomes reabsorbed into the blood stream. The fluid spaces of the brain are called “ventricles” and they are interconnected with small channels.



### Hydrocephalus:

Hydrocephalus is a problem that occurs when there is reduced absorption somewhere in the system, possibly an obstruction, or rarely very increased production. We distinguish two main types of hydrocephalus as communicating and non-communicating (obstructive). Non-communicating hydrocephalus is a more serious condition that when left untreated can become lethal.

#### Hydrocephalus



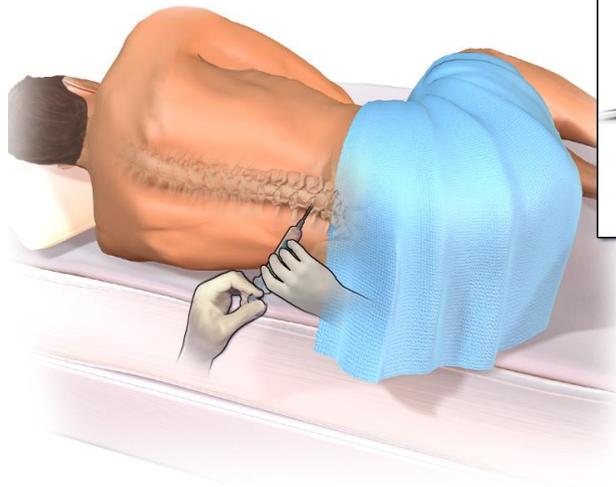
## Communicating Hydrocephalus

Communicating hydrocephalus refers to that type of hydrocephalus that does not have a specific block in any of the csf channels (ie, foramen of Monro or cerebral aqueduct). Typically, there is not an elevated pressure in the brain as a result causing headaches, but more frequently there can be more subtle symptoms. The classic triad of symptoms related to hydrocephalus include: “wet”, “wacky”, and “wobbly”, which is to say patients may have urinary incontinence, cognitive dysfunction, and difficulty walking. One of the common types of communicating hydrocephalus is “normal pressure hydrocephalus”, which usually occurs in older age, and the exact reason this problem occurs is largely unknown. Other causes of communicating hydrocephalus include subarachnoid hemorrhage (from aneurysm), traumatic brain injury, perinatal hemorrhages, and after some tumor operations.

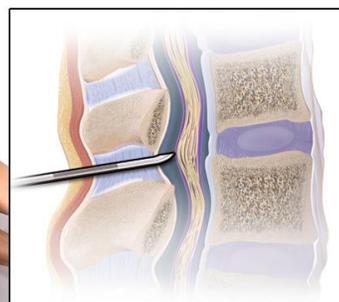
In children with perinatal hemorrhages (intraventricular hemorrhage), a baby may be monitored for signs of enlarging head or pressure (bulging soft spot or fontanelle). Sometimes, when the baby is too small to accommodate a shunt or major surgery, a catheter may be placed in those fluid spaces with a reservoir that can be accessed through the skin of the scalp. Eventually, these babies may need to have a full shunt implanted to divert the csf indefinitely.

In the setting of normal pressure hydrocephalus (NPH), patient can present typically after about 60 years old, and may have some symptoms of walking problems, memory issues and urinary incontinence. At that point, an MRI or CT scan of the brain may be obtained. If the scan shows increased ventricle size (“ventriculomegaly”), that still does not prove the diagnosis of NPH as many patients in elderly age have increased ventricle size without NPH. At this point, the patient may be seen by a neurologist for evaluation and if there is suspicion for NPH, the patient may receive 1 to 3 high volume lumbar punctures to further evaluate the problem. After the CSF removal via the lumbar puncture, we would like to see a dramatic improvement in walking or urinary incontinence to justify an even more invasive procedure called a shunt.

## Lumbar Puncture



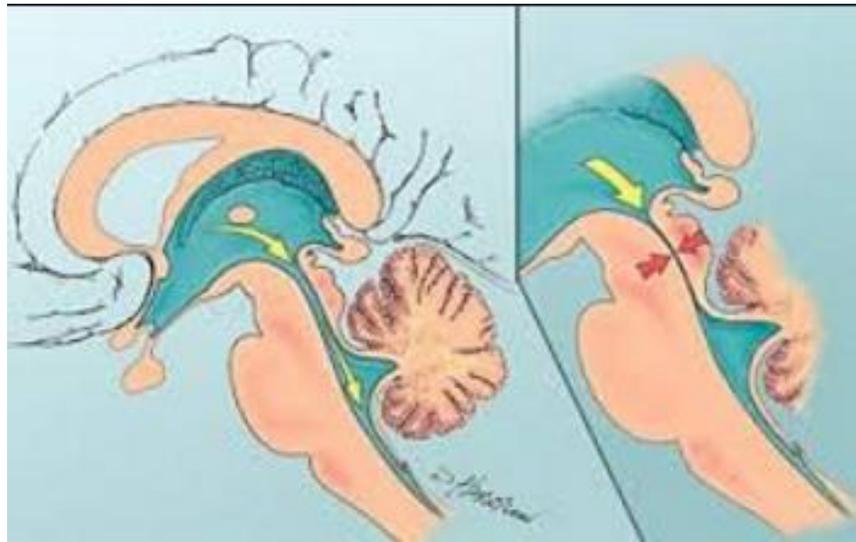
Lying Position



Sitting Position

## Non-communicating “Obstructive” Hydrocephalus

Obstructive hydrocephalus refers to the type of hydrocephalus in which there is in fact a specific block in the channel of flow of CSF. Typically this can occur at the level of the aqueduct (called aqueductal stenosis) or from a mass/tumor (such as a colloid cyst which blocks the third ventricle). Because there is a specific block in the fluid flow, the CSF may build up like a dam causing elevated pressures in the brain. Depending on the cause of the obstruction, treatments may vary but include “bypass” type procedures such as what’s called an endoscopic third ventriculostomy (ETV) or removal of the tumor/mass. If these are not options, performing a shunting procedure may be the best option.



*Example of Aqueductal Stenosis*

## Other Conditions that May Require Shunting:

### Pseudotumor Cerebri

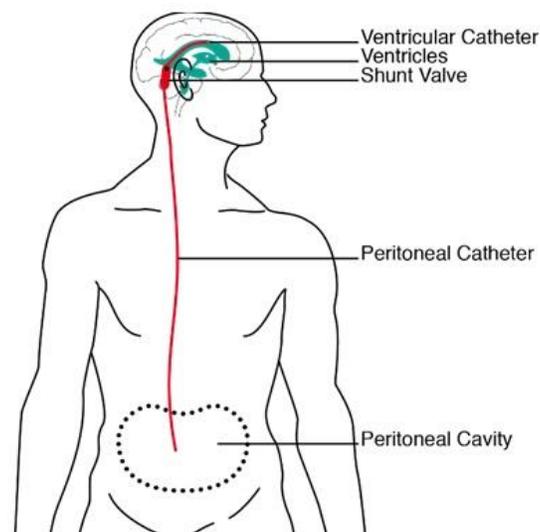
Another type of problem that may require a neurosurgical procedure is called pseudotumor cerebri. Typically, the fluid spaces in the brain are small, rather than being enlarged with this condition. This is a condition where pressures in the brain are increased and can cause a problem called papilledema, which may cause vision changes and blindness if untreated. Nobody knows the exact cause of this syndrome, but it typically occurs in overweight young females around the age of 40. A cure for this problem could include significant weight loss notably. Also, we typically would want to exclude other problems, such as a vein issue called sinus thrombosis, which can mimic the syndrome. Many of these patients can be treated medically with a medication called Diamox, which reduces CSF production, repeat lumbar punctures, and significant weight loss or even gastric surgery. If significant visual impairment occurs, the treatment need is more urgent which may include optic sheath fenestration, shunting or ICP monitoring.

## Surgical Procedures

There are many types of surgical procedures geared towards treating hydrocephalus. The mainstay of treatments include implanting tubing that redirects CSF to a different location in the body to become reabsorbed, which are called shunts. Occasionally only in specific situations, a different type of procedure can be performed, which does not involve implanting any tubing material, called an endoscopic third ventriculostomy (ETV).

### Types of Shunts:

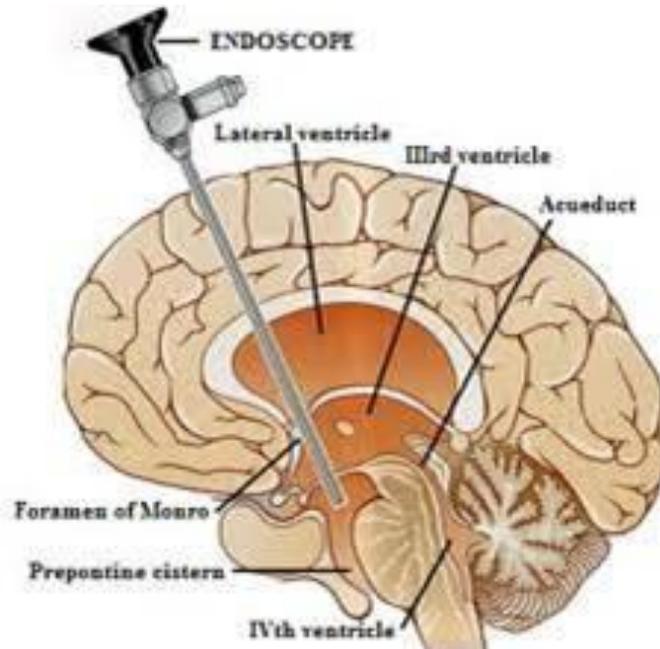
There are several types of shunts that involve implanting tubing with a valve. The most common of these is called a VentriculoPeritoneal Shunt (VPS). In these shunts, a catheter is placed from the brain fluid spaces (ventricle) and tunneled underneath the skin all the way into the abdomen. Occasionally, the abdomen may not be a good place for CSF to be reabsorbed because of prior surgery, so other locations that can be used include the chest/lung space called the “pleural” or the main vein which goes into the heart called “atrial”. These two are called ventriculopleural and ventriculoatrial shunts, respectively. In addition, sometimes it’s unnecessary to place the main catheter in the brain and one can place that main catheter in the back (“lumbar”), which is then usually tunneled into the abdomen (lumboperitoneal shunt).



### Endoscopic Third Ventriculostomy (ETV)

An endoscopic third ventriculostomy is a procedure that performed using an endoscope camera, which is placed into the brain fluid spaces (ventricles) and a physical hole is made at the base of the

brain (technically called the tuber cinerium). That region that's punctured is a very thin membrane which does not have any physical function and is usually thinned as a result of the hydrocephalus. This procedure effectively re-routes the CSF past the blocked channel into a new direction which allows for more normal flow. An ETV may not work for long-standing hydrocephalus or in patients who have had prior catheter shunts and typically can only work with a new diagnosis of obstructive hydrocephalus.



## Types of Shunt Implants

There are two main types of shunt implants, programmable and non-programmable. Programmable shunt allow for pressure adjustments non-invasively, which can then be tailored to an individual patient. The disadvantage of these programmable shunts is that they are often affected by strong magnetic fields, such as which is present in an MRI, which means the shunt needs to be reset after each MRI scan. Some valves may be MRI resistant notably.

Non-programmable valves are valves with a set pressure. These valves do not require as much “maintenance” and are implanted and essentially left alone. These non-programmable valves are not affected by magnetic fields and so patients do not need shunt adjustment or assessment after an MRI.

Lastly, there is often an option of placing an extra in the shunt tubing called an “antisiphon device”. This antisiphon device prevents overshunt as a result of gravity as the tip of the tube is often below the head. Siphoning is akin to placing a water hose in a pool and placing the other end underneath the pool, which results in water flowing through the hose “downhill”. The antisiphon device prevents this problem. However, sometimes siphoning can be used to the advantage of a patient to promote treatment of the hydrocephalus.

## Appendix

Figure 1: Anatomy of cerebrospinal fluid (CSF) with creation of the fluid in the choroid plexus of the center of the brain and reabsorption into the sagittal sinus through the arachnoid villi. The blue circles are common sites of obstruction.

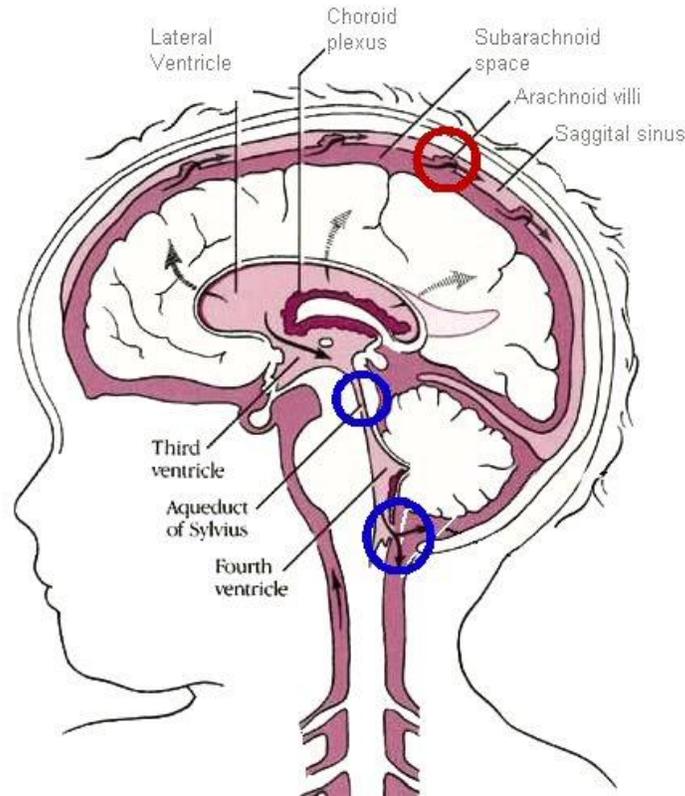


Figure 2: Lumboperitoneal Shunt where a catheter is placed in the lumbar region of the back and the catheter is terminated into the abdomen.

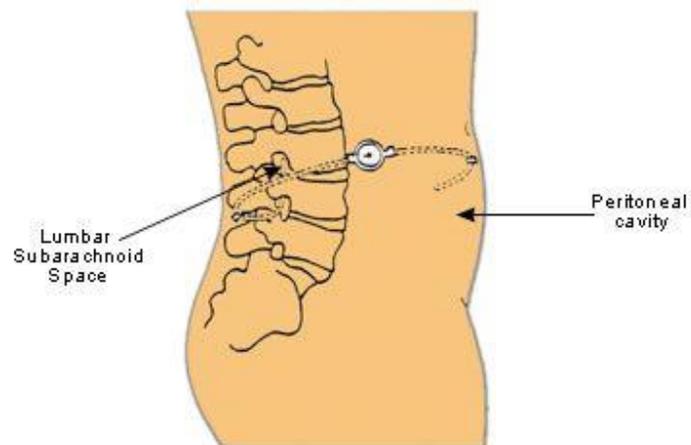


Figure 3: Ventriculopleural shunt where there is a catheter inserted into the brain and the terminus is in the chest cavity around the lungs.

Ventriculopleural Shunt (VPL)

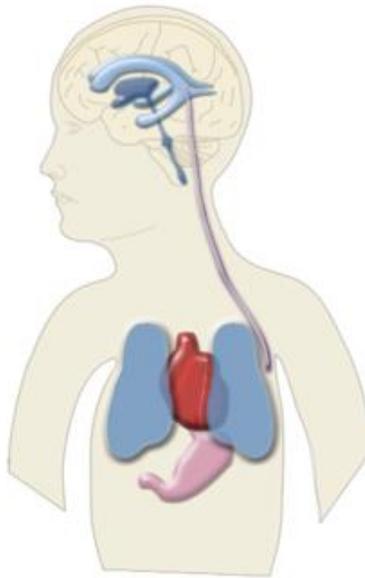


Figure 4: Ventriculoatrial shunt where there is a catheter inserted into the brain and the terminus is in the major veins leading into the heart.

Ventriculoatrial Shunt (VA)

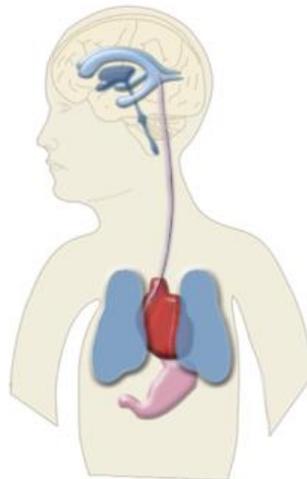
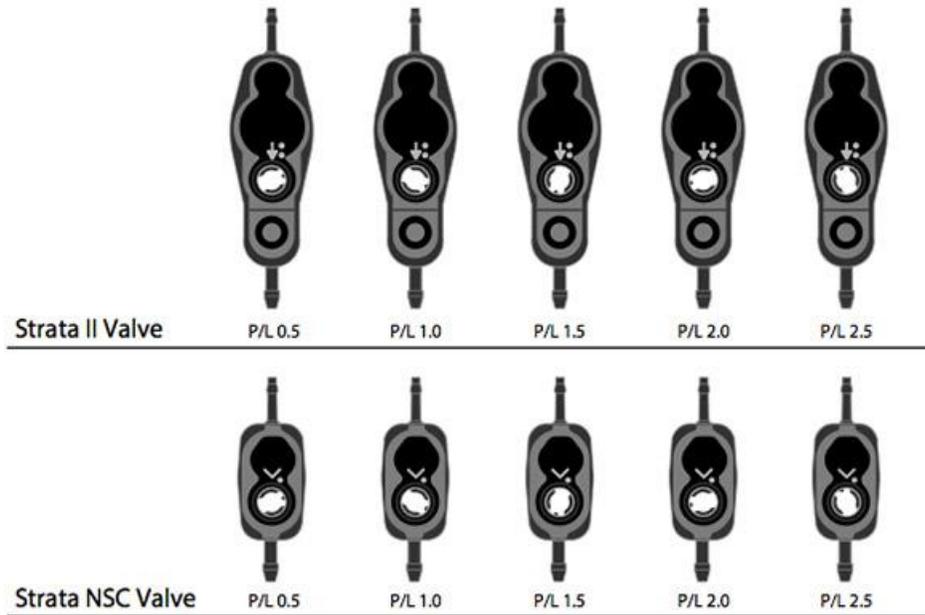


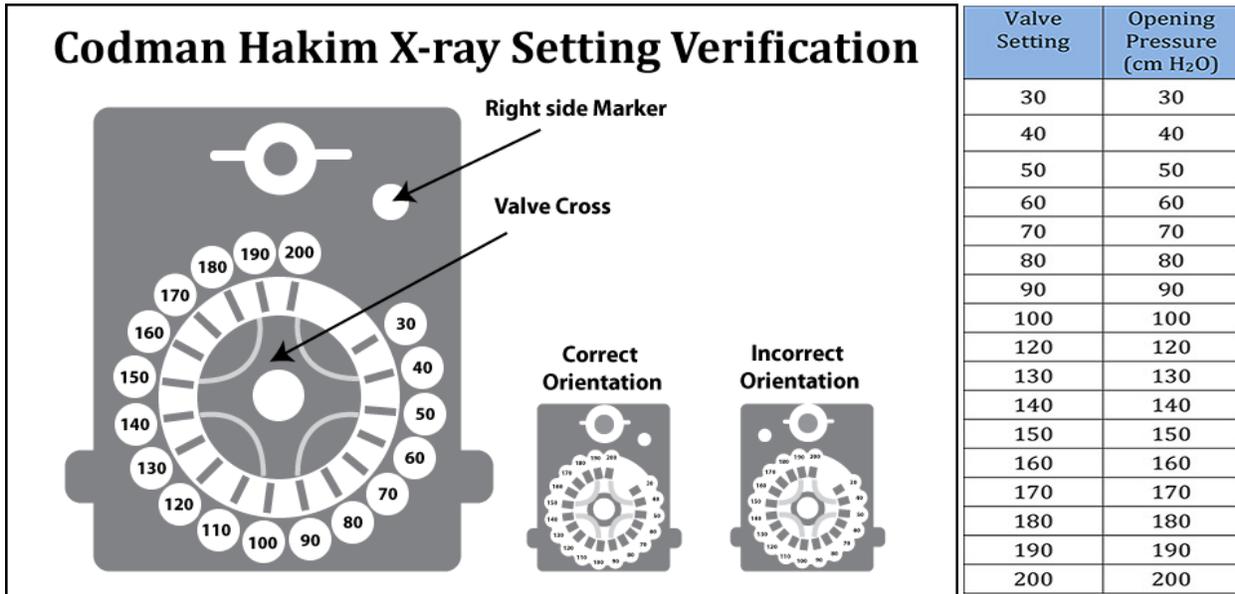
Figure 5: Strata Valve Adjustable valve. NSC valve does not have an antisiphon device, whereas the II does have that additional component. These valves need adjustment after an MRI. The pressures listed are the opening pressures for the Strata II



Valve Performance Level	Opening Pressure (cm H <sub>2</sub> O)	Opening Pressure (cm H <sub>2</sub> O)
	 Lying	 Standing
0.5	1.5	3.0
1.0	3.5	5.0
1.5	7.0	8.5
2.0	10.5	12.0



Figure 7: Codman-Hakim Programmable Valve. Valve needs adjustment after exposure to MRI.



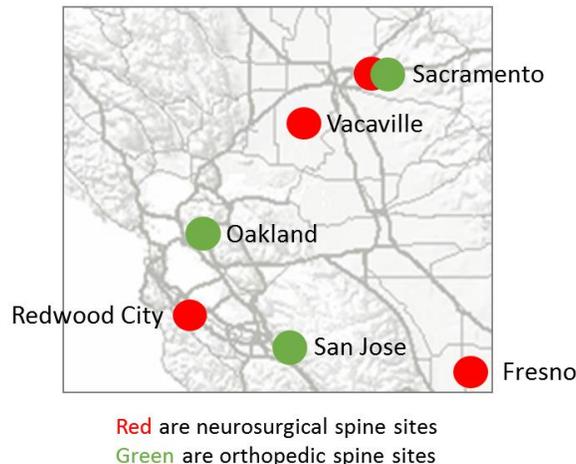
## Comprehensive Spine Surgery Program

### Kaiser Permanente Redwood City

#### Redwood City Neurosurgeons (650) 299 - 2290:

- William Sheridan, MD: Chief of Neurosurgery
- Allen Efron, MD: Assistant Chief of Neurosurgery, Skull Base Specialist
- John Duncan, MD, Phd: Chief of Pediatric Neurosurgery Kaiser Santa Clara, Director of Epilepsy Surgery program
- Nicole Moayeri, MD: Assistant Physician in Chief (APIC) of Surgical Services, Vascular specialist
- Cornelia Von Koch, MD, Phd: Neurosurgeon, Spine specialist
- Aleksandyr Lavery, MD: Neurosurgeon, brain tumor/vascular and spine specialist
- Lyndell Wang, MD: Neurosurgeon, brain tumor specialist
- Lewis Hou, MD: Neurosurgeon, skull base and vascular specialist
- Victor Tse, MD, Phd: Neurosurgeon, director of radiosurgery program, brain tumor and peripheral nerve specialist
- Prasad Reddy, MD: Neurosurgeon, Vascular and Endovascular specialist
- Mark Sedrak, MD: Neurosurgeon, Director of Functional Neurosurgery, brain tumor specialist
- Patrick Pezeshkian, MD: Functional Neurosurgeon and peripheral nerve specialist
- Kevin Chao, MD: Neurosurgeon, Pediatric and Adult specialist

Surgical Spine Locations  
Northern California Kaiser Permanente



**Sacramento Neurosurgeons (916) 973 – 5490:**

- Amit Banerjee, MD: Chief of Neurosurgery, Skull Base and Complex Spine Surgery
- Mark Hawk, MD: Assistant Physician in Chief, Complex Spine surgery and Vascular
- Kaveh Barami, MD: Neurosurgeon
- Kamran Sahrakar, MD: Neurosurgeon, Neuro-Oncology and Radiosurgery
- James Silverthorn, DO: Neurosurgeon
- Abraham Bosckovitz, MD: Neurosurgeon
- Indro Chakrabarti, MD: Neurosurgeon, Neuro-Oncology and Vascular
- Huy Duong, MD: Neurosurgeon
- Adam Griffith, MD: Neurosurgeon
- Kern Guppy, MD: Neurosurgeon, Complex Spine
- Brian Jian, MD: Neurosurgeon
- David Moller, MD: Neurosurgeon
- Conrad Pappas, MD, Phd: Functional Neurosurgeon
- Alan Williams, MD: Neurosurgeon, Vascular
- Sean McNatt, MD: Neurosurgeon Adult and Pediatric

**Santa Clara Neurosurgical Group (408) 851 – 1240:**

- John Duncan, MD, Phd: Chief of Pediatric Neurosurgery Kaiser Santa Clara, Director of Epilepsy Surgery program
- Kevin Chao, MD: Pediatric Neurosurgeon

**Roseville Pediatric Neurosurgery Group (916) 474 – 2600:**

- Sean McNatt, MD: Pediatric Neurosurgeon

**Oakland Pediatric Neurosurgery Group (510) 752 – 1749:**

- Dachling Pang, MD: Chief of Pediatric Neurosurgery
- John Zovickian, MD

**Fresno Neurosurgery Group (559) 448 – 4437:**

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- Donald Myers, MD

**Oakland Orthopedic Spine Group (559) 448 – 4437:**

- Ravinder-Raj Bains, MD
- Andrew Slucky, MD
- Josef Gorek, MD
- Todd Lincoln, MD

**San Jose Orthopedic Spine Group (408) 972 – 6100:**

- Anthony Matan, MD
- Joseph Matthews, MD
- Elliot Carlisle, MD
- Steven Spisak, MD

**Kaiser Permanente – Northern California Non-Surgical Spine/Pain  
Service Areas**

**DIABLO Service Area (WCR, MTZ, ANT) 925-372-1741**

**DIABLO 1 ANS Epidural Clinic**

Dr Angela Chiang                      Dr Cynthia Rahn  
Dr Mark Rahn                              Dr Sabrina Martinez  
Dr Prakash Raygor                      Dr Mark Moore

**DIABLO 2 ANS Interventional Pain Clinic 925-372-1283**

Dr Andrew Maher  
Dr James Mura  
Dr Darko Vodopich  
Dr. Norm Aleks

**DIABLO 3 PMR/SPINE CLINIC (925) 313-4740**

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Dr. Rupinder Singh (ER)  
Dr. Marta Bator (ANS - Pool)

**Modesto & Stockton Chronic Pain & Interventional Pain 209-735-3255**

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Dr. Raul Calderon

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**Redwood City 1 of 2- ANS/NSG** 650-299-5454

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Dr. Patrick Pezeshkian (NSG)

PA Ivan Bernstein

PA Diana Bruce

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Dr Maratukulam

Dr Nguyen

Dr Treinen

**Richmond PMR/SPINE CLINIC** 510-307-1661

Dr John H Lim PMR/SPINE CLINIC

Dr Angelita Balbas PMR/SPINE CLINIC

**Roseville PMR/SPINE CLINIC** 916-771-6611

Dr William Fenton - ANS

Dr Mark Tyburski

Dr Ryan Carver

**Sacramento (916) 973-5490**

Conrad Pappas, MD (Neurosurgery)

**San Francisco Pain Interventional Center- ANS 415-833-0095**

Dr Justin McKendry ANS

Dr Taissa Cherry ANS

Dr Salman Dasti

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Dr Eunice Lau (chief) - PMR/SPINE CLINIC

Dr Sergiy Rybiy

Dr Raghu Katragadda ANS

**San Jose (Santa Theresa) Interventional Pain ANS 408-972-6283**

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**South Sacramento Pain Clinic (ANS)** (916) 688-6353

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Dr Rod Youssefi

Dr Kegang Hu

Dr Sabina Tahera

**South San Francisco ANS Pain Services** 650-742-2395

Dr Eddie Busracamwongs ANS

Dr. Hamid Motamed

Dr. Tin-Na Kan

Dr. Ali Abdollahi-Fard

**Santa Clara PMR/SPINE CLINIC** 408-851-9200

Dr Richard Kim

Dr Kevin Wang

Dr Dhiruj Kirpalani

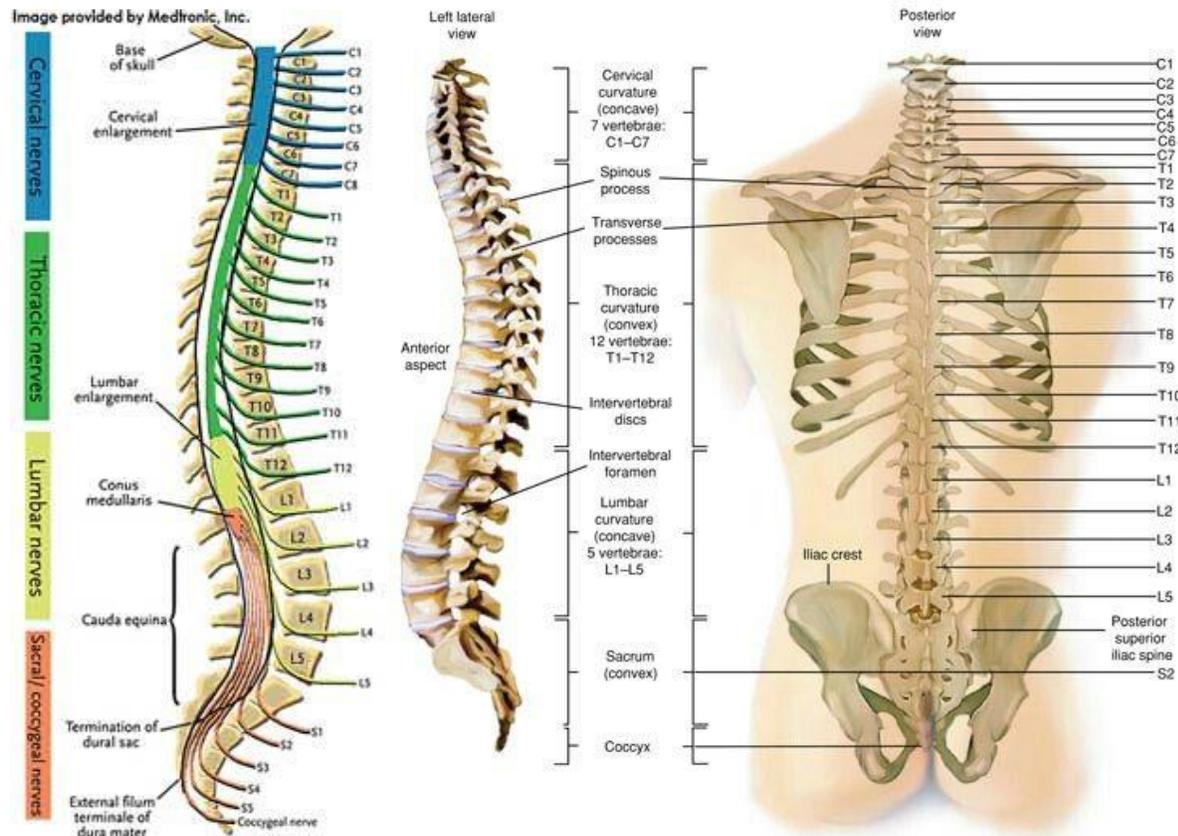
**Vallejo – PMR/SPINE CLINIC (707) 651-1025**

Dr. Linda Cho (PMR/SPINE CLINIC)

## Conditions of the Spine

### Anatomy:

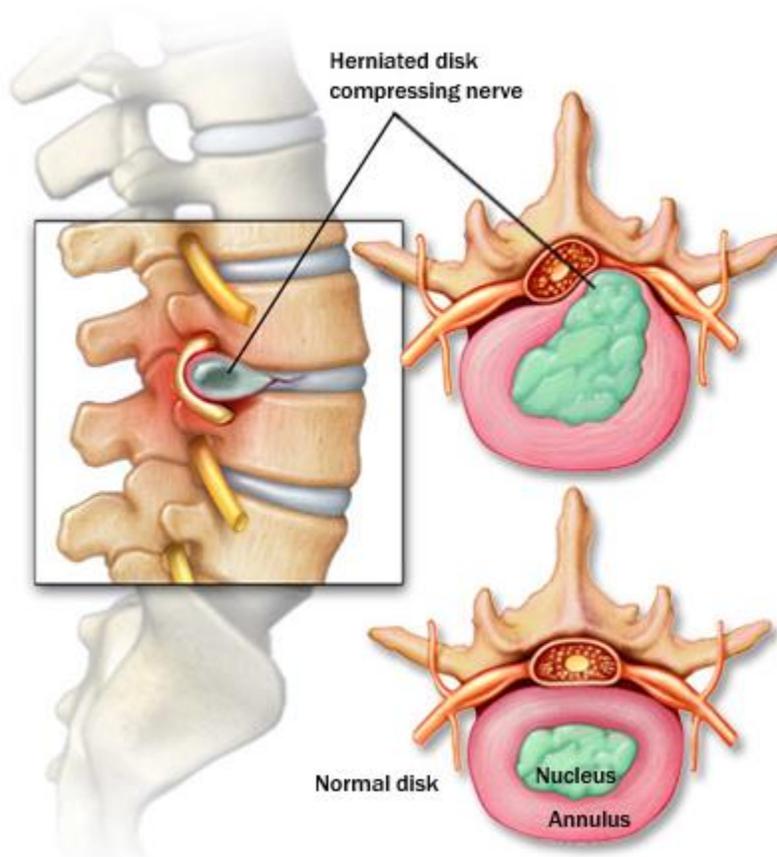
The spine consists of bone, discs, muscles, ligaments and nerves. Each one of these can cause conditions that produce pain or other problems. The most common reason for a patient to see a spine surgeon, however, is related to problems of the bone, nerves and/or discs. Nerves, both the nerve roots and spinal cord, pass through small tunnels throughout the spine. When these tunnels become narrowed, such as from a herniated disc, they can compress the nerve causing pain, numbness, weakness. It's notable that many patients who have no symptoms can actually have what appears to be compression of a nerve on an MRI, making correlation between symptoms and a scan of utmost importance. In addition, many patients may have pain from muscles, ligaments, or even nerves without compression, making direct spine operations not a reasonable option.



### Disc Herniation

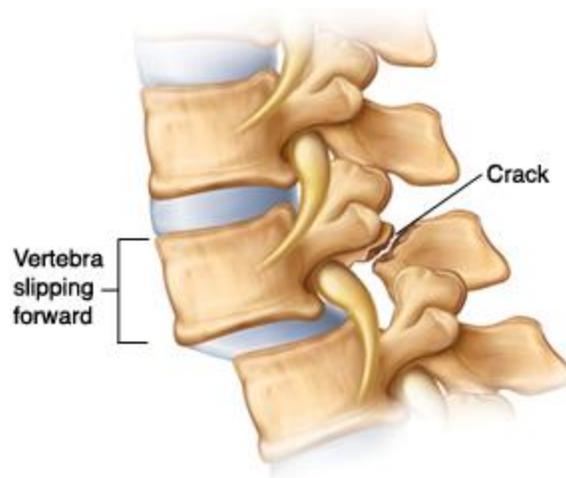
The disc of the spine is located in between each level of bone or vertebra, which is why we call it the intervertebral disc named after the surrounding bones. For example, in between L4 and L5 is the

L4/5 intervertebral disc. The disc material is made up of thick tissue (annulus) and soft tissue (nucleus, consistency of crab meat). When a disc herniation occurs, usually a hole in the thick tissue causes the soft material to pop out, which can then compress a nerve. Many surgeries are therefore geared towards removing that soft disc material in order to decompress the nerves.



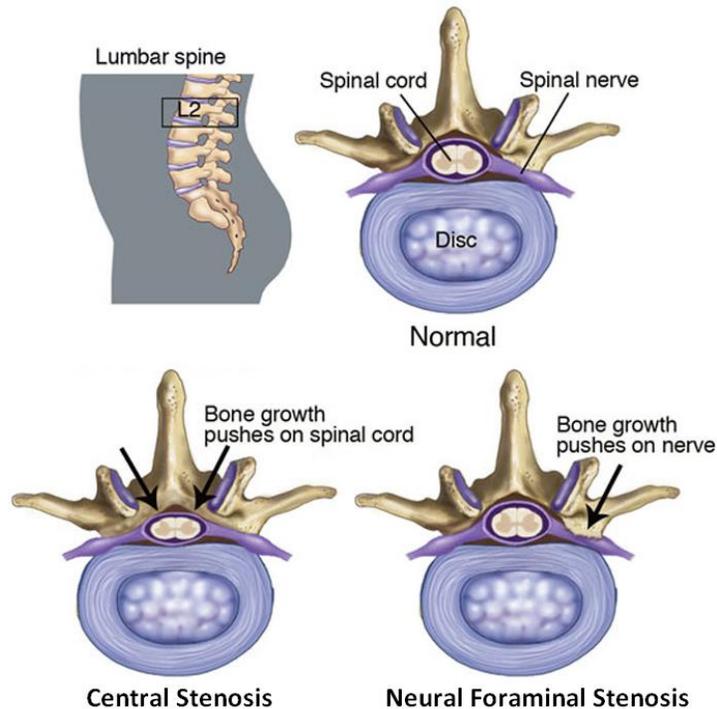
## Spondylolisthesis

The normal spine has a gentle curve in the neck, the upper back and the lower back. In the neck and low back we call these curves “normal lordosis”. In some patients, we can see a step-off in these gentle curves, which suggests that the bones are slipped on each other. When that slippage is present, we call that a spondylolisthesis (or “spondy”). This spondy might be a sign of loose bones that, when moving, can pinch nerves and cause pain and weakness. The slippage is evaluated with bending XRays. Many times, the spondy is stable and doesn’t move and is from long-term degeneration. When a mobile spondy is present and causing symptoms of severe pain, numbness, or weakness, a surgical fusion and decompression is usually performed. When the spondy is stable, many times a fusion may not be necessary, but these individual decisions should be discussed with your surgeon.



## Stenosis

Stenosis refers to narrowing of the canal that the nerves are passing through. There are many passage ways that can have stenosis, but generally speaking we refer to the “central canal” and the “neural foramen”. The central canal is the canal that the spinal cord and the clump of nerve roots travel. The neural foramen is where the nerve root exit the main spinal canal before going to our arms or legs. Stenosis can be caused by disc herniations, bone spurs from arthritis, ligaments growing (“hypertrophy”). The main goal of surgeries aimed at stenosis is to open the canal and provide room for the nerves passing through their canal.

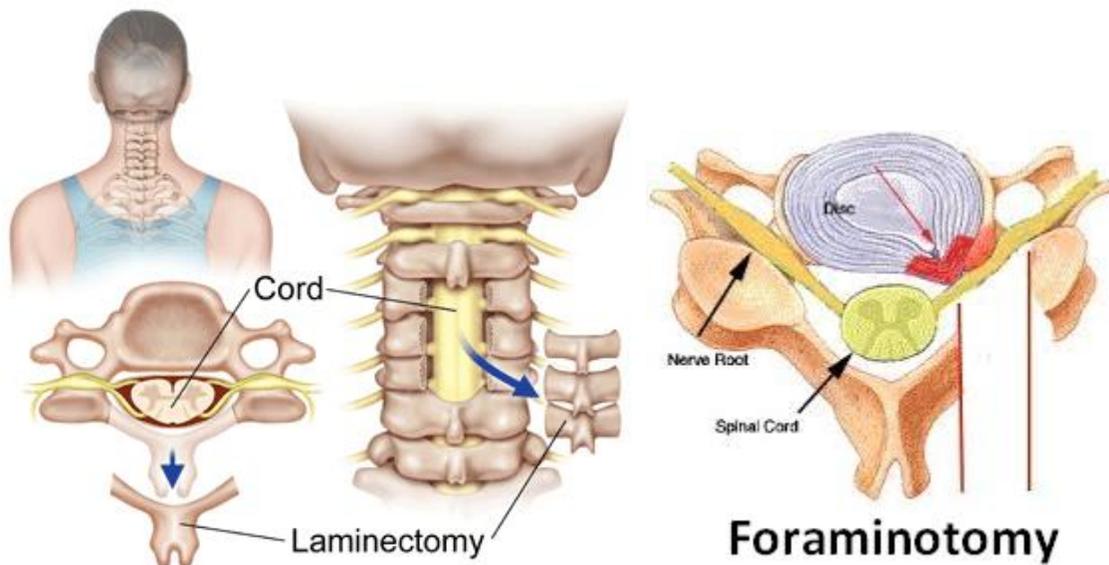


## Types of Spinal Surgery

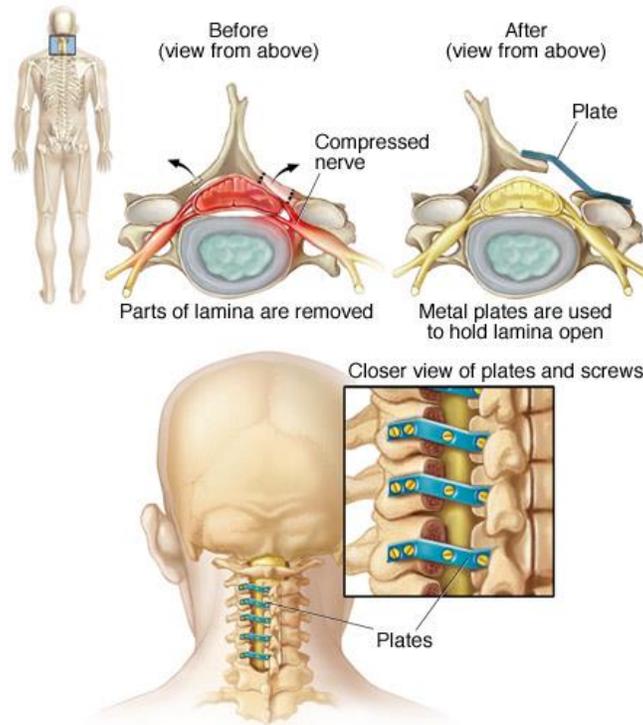
There are many types of spinal operations, but the main two are those of decompression and those of fusion. Many times, surgery would include both a decompression and fusion.

### Decompression:

A decompressive operation is an operation geared towards opening a canal where nerves are passing. If the central canal has stenosis, typically we'd perform a procedure called a "laminectomy". This is akin to removing the soft side of a lobster tail, which then opens one side of the canal and provides room for the nerves. Sometimes, the canal that needs decompression is the neural foramen and the procedure performed can include a "foraminotomy". Many times, both a laminectomy and foraminotomy can be performed.



In the neck in particular, it's notable that there is a procedure that can provide more space for the spinal cord without the need for fusion, which is called a laminoplasty. In this case, the lamina of the spine is elevated, allowing it to be hinged in a way that increases the amount of room for the spinal cord.



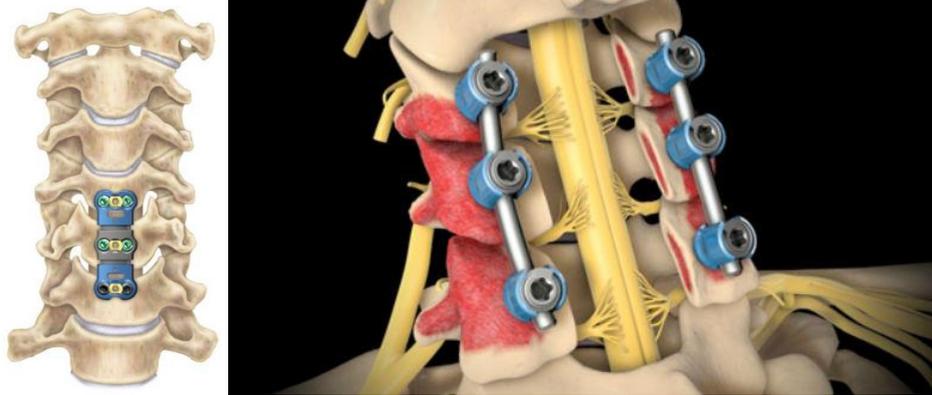
## Fusion:

A fusion procedure is a procedure performed to stabilize the bones and prevent future movement. There are numerous types of spinal fusion procedures that vary based off of the location in the body.

### Cervical Region (Neck):

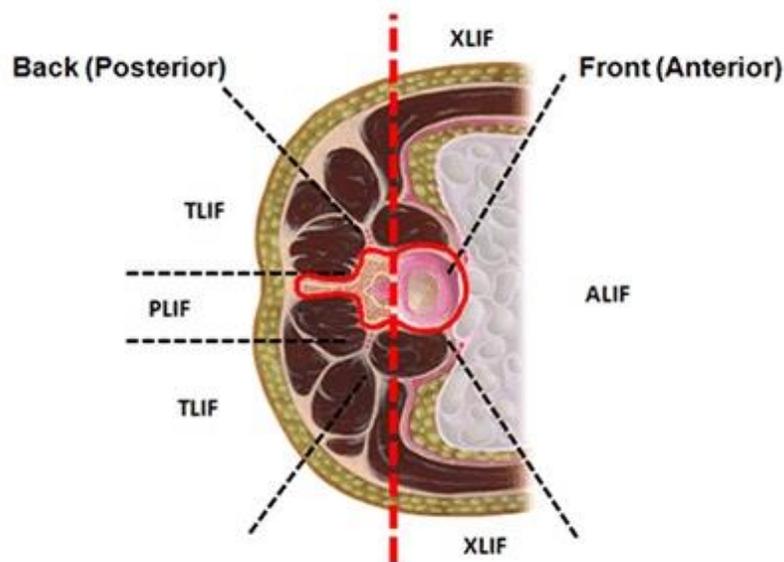
In the neck, there are two main fusion procedures, one from the front (ACDF) and one from the back. The surgery from the front goes through the neck to the spine and is technically called an “anterior cervical discectomy and fusion”. This procedure allows excellent removal of the disc space and the ability to fuse the bones well. Most common issues that can occur with this procedure include temporary swallowing and a hoarse voice, which usually are transient problems. This procedure typically carries the least pain afterwards compared to other spine procedures and is one of the most common procedures of the spine performed.

The other option is a fusion procedure from the back of the neck. Typically, that procedure is combined with a laminectomy as well. In this instance, screws are placed at the desired levels and are connected with rods. The bone is usually prepared in a way that allows ingrowth of bone cells over the next several months, creating a solid bone mass.



### Lumbar Region (Back):

There are generally three main spinal fusions in the lumbar spine which are determined by the abnormality and direction of the surgical approach. The surgeon can approach the spine from the back (pedicle screw fixation or “TLIF/PLIF”), from the side (lateral fusion or “XLIF”) or from the front (anterior fusion or “ALIF”). Much of decision making regarding the surgical approach should be discussed with your surgeon, as it is often determined by the problem site. All of these procedures involve placing screws and hardware around and into the spine in order to provide stabilization.

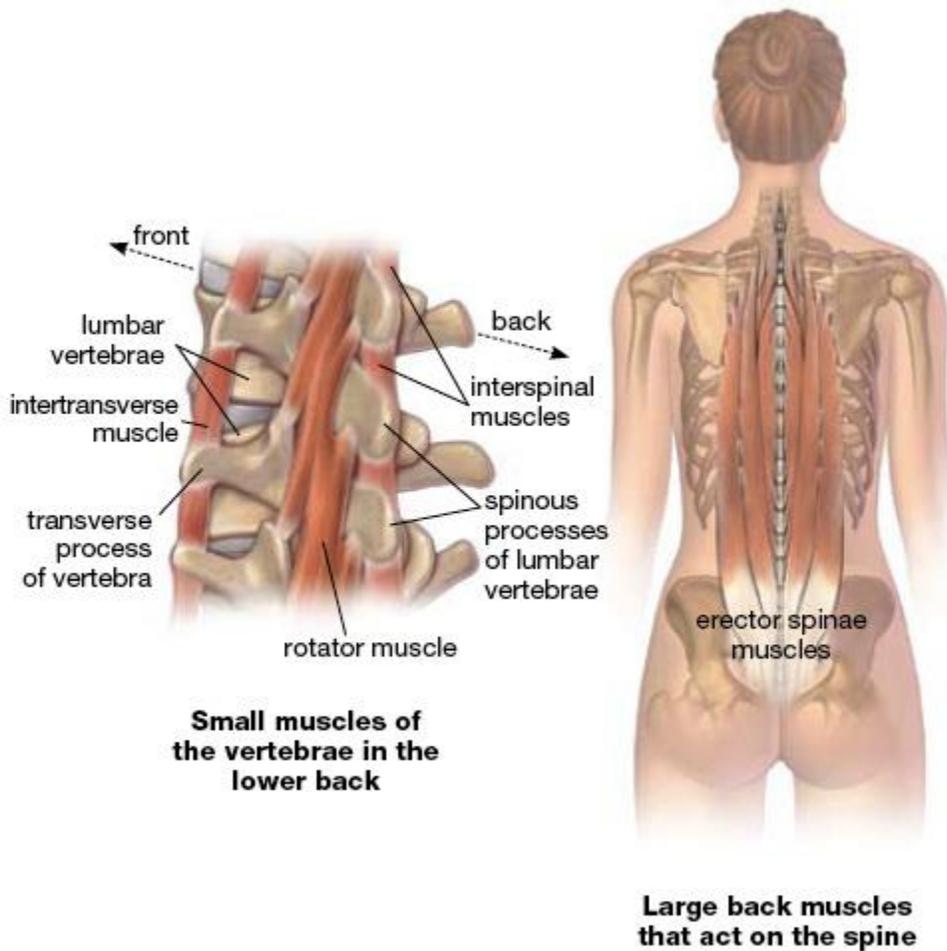


### Other treatment options for pain

In essentially every situation, the most important care one can provide for diseases of the spine include diet/excellent nutrition (low fat) and exercise. This provides the most strength to the spine, as the surrounding muscles can help the bones and ligaments, preventing worsening arthritis. Back

strengthening exercises are very useful, including swimming/aquatherapy, pilates/yoga and physical therapy.

Further, in many instances no surgical options to decompress or fuse the spine are reasonable. In these situations, besides medications and epidural steroid injections (ESI), other treatments could include spinal cord stimulation, intrathecal pump therapy, ketamine infusions or other functional neurosurgical procedures. Typically, a patient would need to have stable and refractory pain for years before undergoing these advanced procedures. Please consult your chronic pain physician if you feel like you may be at the point of needing these types of procedures.

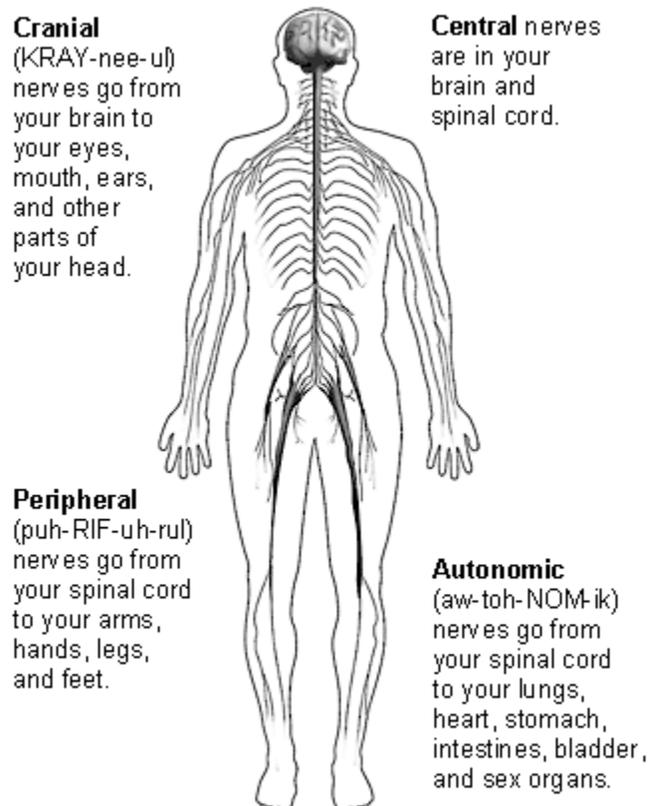


## Other Non-Compressive Spine Related Pain Syndromes

There are many syndromes which give rise to pain that is related to the spine. It's notable that many pain syndromes are not caused by nerve compression in the spine, but rather of an origin that's likely an abnormal reflex or circuit involving either the spinal cord itself or the dorsal root ganglion. So often times, an MRI or CT scan show no obvious problem to explain the origin of pain.

### Chronic Regional Pain Syndrome (CRPS)

CRPS is a chronic pain condition most often affected the arms, legs, hands or feet and most typically after a trauma (herniated disc or surgery). A portion of the nervous system involved with this pain syndrome is called the autonomic nervous system, rather than the peripheral nervous system or central nervous system. Typically patients can develop sensitivity to touch (called allodynia) and pain can spread beyond a single site, there can be changes in color (blotchy/purple/red), swelling, joint stiffness, hair loss. Since MRI's/CT's are often negative, there is no good diagnostic test to confirm this disorder, but rather it's a clinical diagnosis and a diagnosis where other problems are excluded on imaging. Typically, treatment includes: rehabilitation therapy, psychotherapy, medications, sympathetic nerve blocks, ketamine infusion, and spinal cord stimulation. It's important to both recognize and treat this condition as soon as possible to prevent it from worsening or becoming a chronic condition.



### Failed back surgery syndrome (FBSS)

FBSS is a group of issues related to the spine that result in persistent back pain with a prior history of spine surgery. Patients can often have back pain or shooting pain that persists without any evidence of continued pinched nerves or unstable joints. It's important to know that the spine is made up of not only nerves and discs, but has a constellation of joints, muscles and ligaments, which may all contribute to pain in addition to nerves that are not compressed. Patients with FBSS are typically

treated with physical therapy, medical management, epidural steroid injections and can also be candidates for spinal cord stimulation, dorsal root ganglion stimulation, intrathecal pump therapy.

## Appendix

Figure 1: Types of Epidural Steroid Injections (ESI) including: Translaminar epidural injection and transforaminal epidural injection

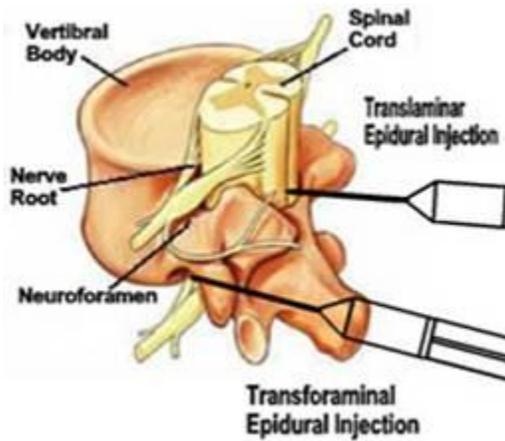


Figure 2: Dermatomal map, which helps to correlate a nerve compression problem

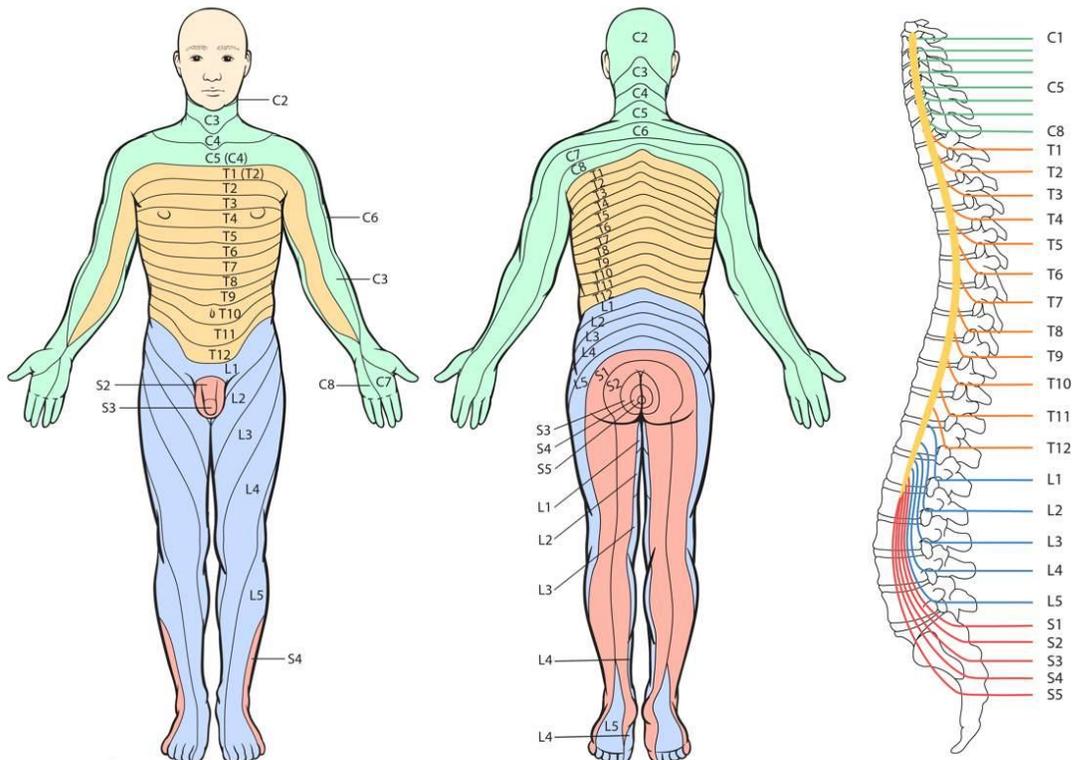


Figure 3: TLIF Procedure from back

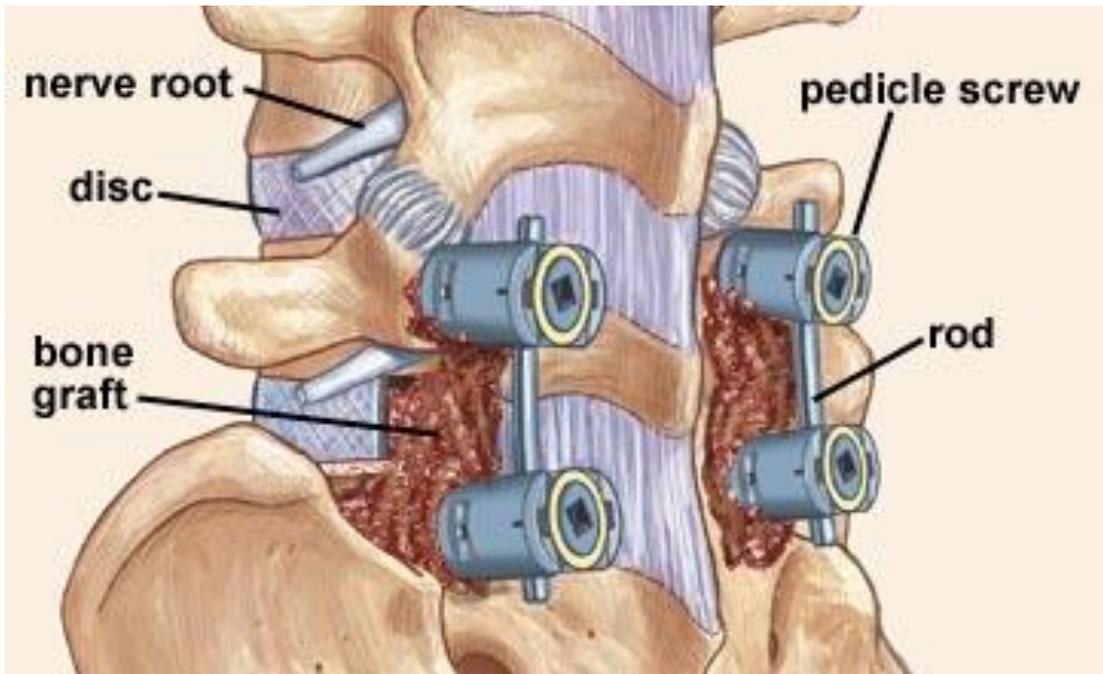


Figure 4: XLIF/DLIF procedure or extreme lateral from side

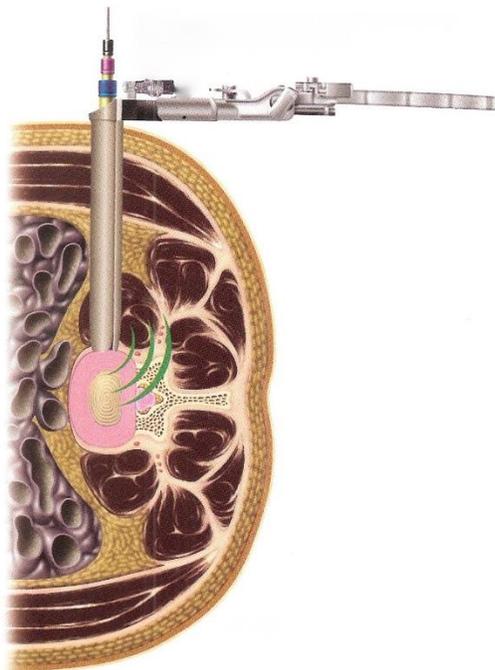


Figure 5: ALIF procedure, anterior or from front

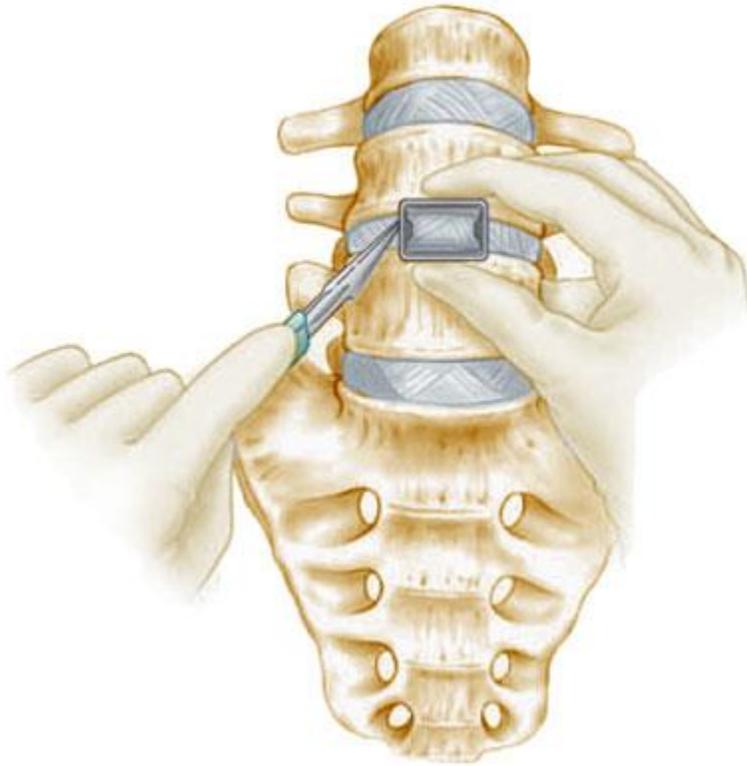
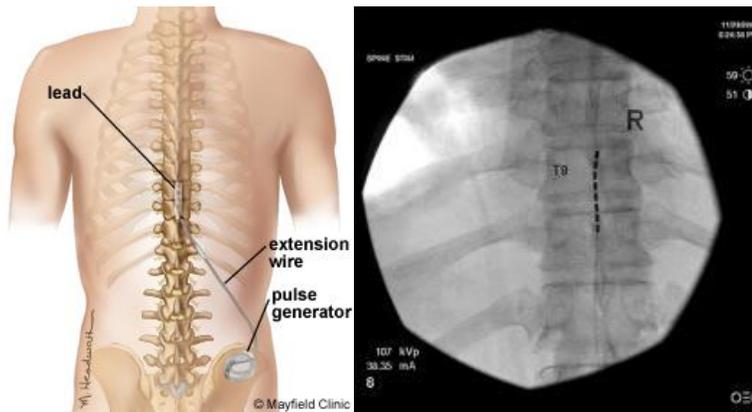


Figure 6: Example of Spinal cord stimulation to help chronic pain conditions



Spinal cord Stimulator as implanted      X-ray of a single lead in place

## Comprehensive Brain Tumor Program

### Kaiser Permanente

#### Redwood City Neurosurgeons (650) 299 - 2290:

- William Sheridan, MD: Chief of Neurosurgery
- Allen Efron, MD: Assistant Chief of Neurosurgery, Skull Base Specialist
- John Duncan, MD, Phd: Chief of Pediatric Neurosurgery Kaiser Santa Clara, Director of Epilepsy Surgery program
- Nicole Moayeri, MD: Assistant Physician in Chief (APIC) of Surgical Services, Vascular specialist
- Cornelia Von Koch, MD, Phd: Neurosurgeon, Spine specialist
- Aleksandyr Lavery, MD: Neurosurgeon, brain tumor/vascular and spine specialist
- Lyndell Wang, MD: Neurosurgeon, brain tumor specialist
- Lewis Hou, MD: Neurosurgeon, skull base and vascular specialist
- Victor Tse, MD, Phd: Neurosurgeon, director of radiosurgery program, brain tumor and peripheral nerve specialist
- Prasad Reddy, MD: Neurosurgeon, Vascular and Endovascular specialist
- Mark Sedrak, MD: Neurosurgeon, Director of Functional Neurosurgery, brain tumor specialist
- Patrick Pezeshkian, MD: Functional Neurosurgeon and peripheral nerve specialist
- Kevin Chao, MD: Neurosurgeon, Pediatric and Adult specialist

#### Redwood City Neuro-Oncology Group (650) 299 – 2290:

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- Victor Levin, MD: Neurooncologist
- Piia Thomas, MD: Neurooncologist
- Nisha Hazari, NP: Neurooncology Nurse Practitioner

#### Neurosurgical Sites in Northern California Kaiser Permanente



**Red** are primary neurosurgical and neurooncology sites  
**Blue** are neurosurgical site with primary focus on spine  
**Green** are pediatric neurosurgical sites

**Sacramento Neurosurgeons (916) 973 – 5490:**

- Amit Banerjee, MD: Chief of Neurosurgery, Skull Base and Complex Spine Surgery
- Mark Hawk, MD: Assistant Physician in Chief, Complex Spine surgery and Vascular
- Kaveh Barami, MD: Neurosurgeon
- Kamran Sahrakar, MD: Neurosurgeon, Neuro-Oncology and Radiosurgery
- James Silverthorn, DO: Neurosurgeon
- Abraham Bosckovitz, MD: Neurosurgeon
- Indro Chakrabarti, MD: Neurosurgeon, Neuro-Oncology and Vascular
- Huy Duong, MD: Neurosurgeon
- Adam Griffith, MD: Neurosurgeon
- Kern Guppy, MD: Neurosurgeon, Complex Spine
- Brian Jian, MD: Neurosurgeon
- David Moller, MD: Neurosurgeon
- Conrad Pappas, MD, Phd: Functional Neurosurgeon
- Alan Williams, MD: Neurosurgeon, Vascular
- Sean McNatt, MD: Neurosurgeon Adult and Pediatric

**Sacramento Neuro-Oncology Group (916) 973 – 5490:**

- Enrico Lallana, MD

**Santa Clara Neurosurgical Group (408) 851 – 1240:**

- John Duncan, MD, Phd: Chief of Pediatric Neurosurgery Kaiser Santa Clara, Director of Epilepsy Surgery program
- Kevin Chao, MD: Pediatric Neurosurgeon

**Roseville Pediatric Neurosurgery Group (916) 474 – 2600:**

- Sean McNatt, MD: Pediatric Neurosurgeon

**Oakland Pediatric Neurosurgery Group (510) 752 – 1749:**

- Dachling Pang, MD: Chief of Pediatric Neurosurgery
- John Zovickian, MD

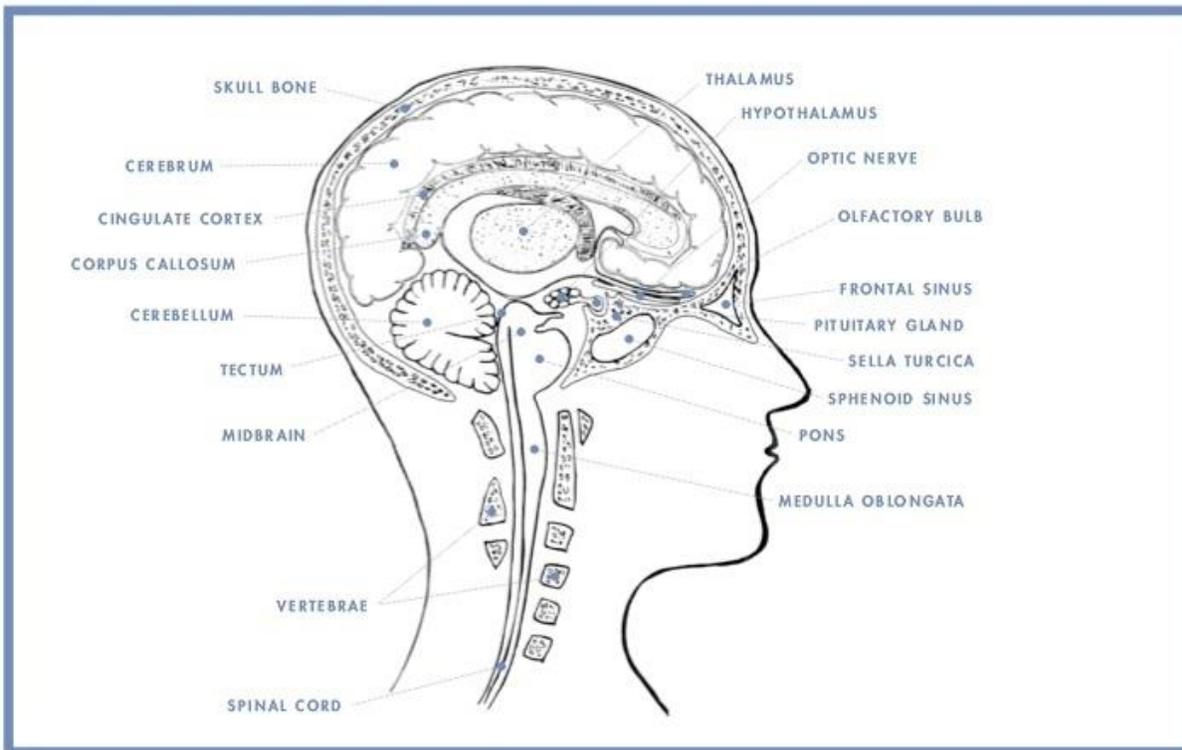
**Fresno Neurosurgery Group (559) 448 – 4437:**

- Steven Hysell, MD
- Donald Myers, MD

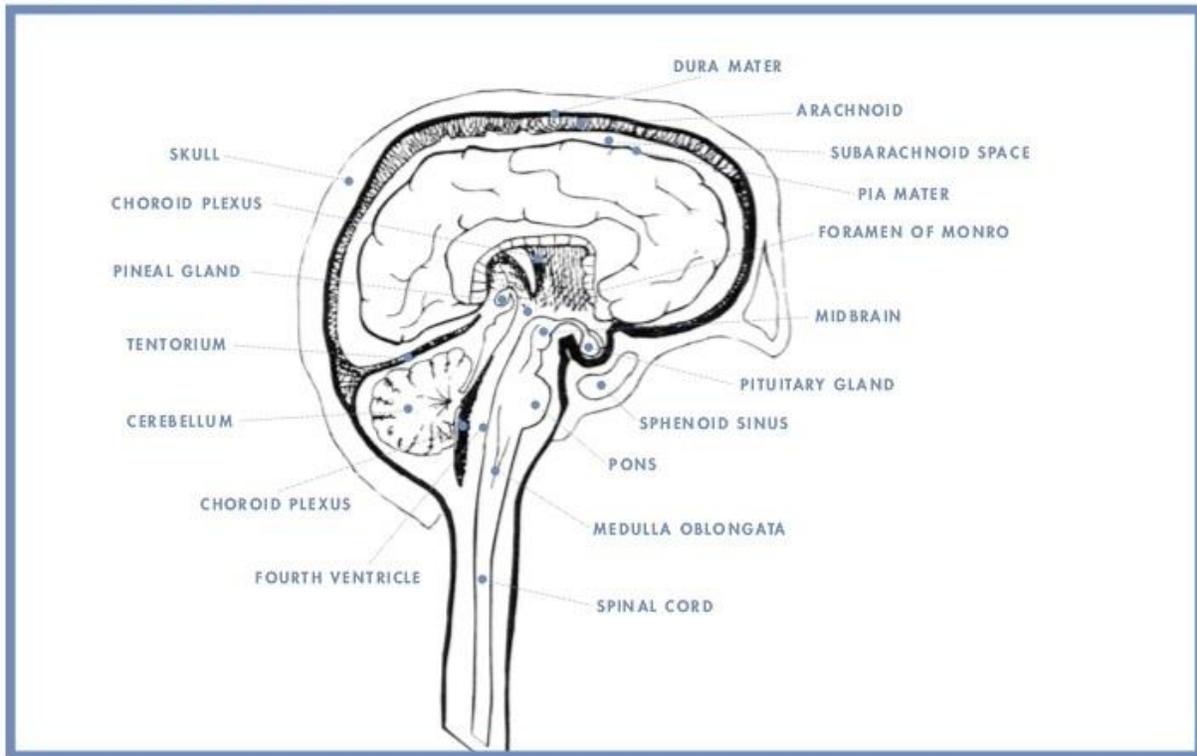
## GENERAL INFORMATION ABOUT BRAIN TUMORS

Tumors can arise from essentially any living cell in the body. With respect to the brain, tumors often arise from the meninges (meningioma), brain cells (glioma's), pituitary gland (pituitary adenoma's), surrounding skull/bone (chordoma's), white blood cells (lymphoma). Depending on the type of tumor, different treatment strategies can be planned which may include surgery, chemotherapy, and or radiation. Oftentimes, the diagnosis is the first step in the treatment plan, which typically involves surgery to obtain a piece or remove the tumor/mass.

### CROSS SECTION OF THE BRAIN

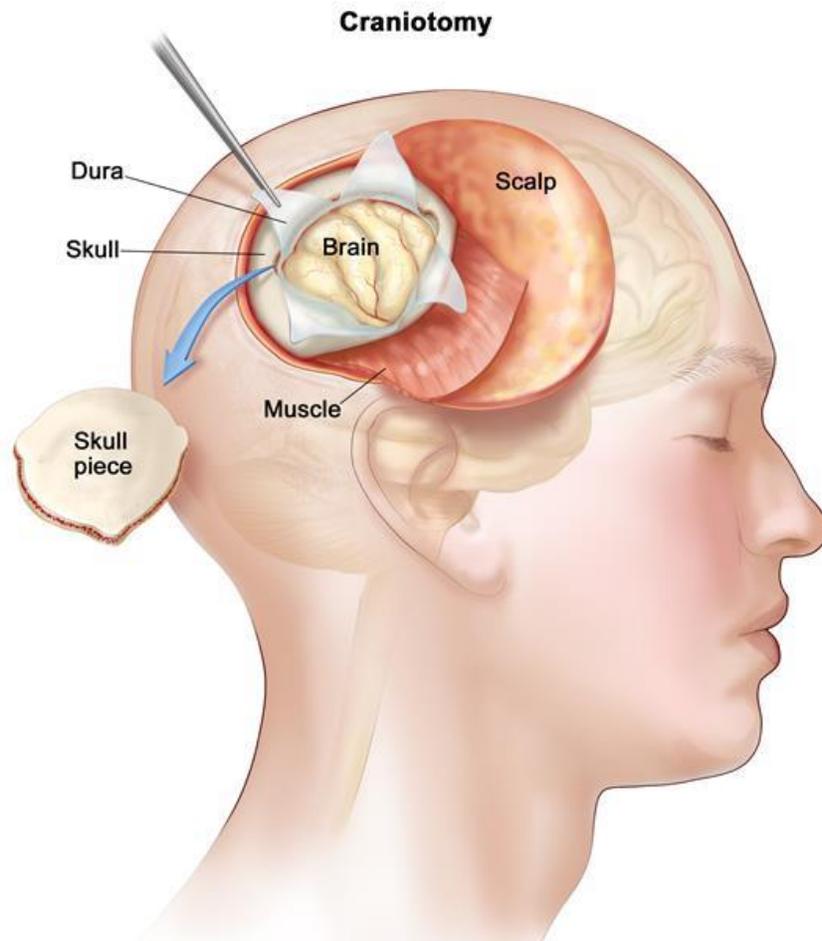


## SIDE VIEW OF THE BRAIN



### **Craniotomy or Tumor Biopsy:**

Craniotomies (entering the brain for surgery) can be done with great success. A craniotomy is often the procedure needed to remove a brain tumor. Depending on the tumor site, tumor removal may be attempted or possibly a biopsy. There are several stages to a typical procedure. Most often, patients are completely under general anesthesia. However, on occasion, it may be necessary to perform the surgery awake with mapping of speech centers. Once in position, the surgeon will often utilize a clamp that will both hold the head and be used to register your head to a special MRI that was obtained prior to surgery, called a “navigation” scan. This “navigation” scan is used during surgery, like GPS to help locate and pinpoint the tumor location. Depending on the location of the tumor, neuro-monitoring can also be used to physiologically map important parts of the brain, such as the motor regions to prevent major paralysis. After the surgery is complete, the bone is replaced using metallic plates and screws that are MRI safe to bridge the flap to the remainder of the skull, which are permanent implants.



Typically, after a craniotomy procedure, patients will be in the hospital on average 3 days, but that time-frame may vary based on patient’s status and tumor type/location. A bandage will be present on the incision that will be kept clean and dry for approximately 3 days, then removed and left open to air. Staples or stitches will be used on the skin surface, which can be removed at the home Kaiser facility in 2-3 weeks after surgery. Once the bandage is removed in 3 days, it would be okay to shower using baby shampoo with brief washing and without aggressive combing or brushing of the hair. We recommend avoiding direct sunlight on the incision or heavy physical activity for about 6 weeks. If a hat or beanie are worn, make sure they are loose fitting, cleanly washed daily, and that there is no significant pressure or sweating on the incision site. Total healing time from any operation is about 6 weeks to 3 months. Patients may often need chemotherapy or radiation after surgery, which typically are not started for approximately 4 weeks after surgery.

**Pathology:**

Within about 3-7 days after surgery, the pathology results may become finalized. This tells your doctors what kind of tumor was present and will help to dictate subsequent treatment. The reason it

takes several days is that the tissue must be processed with special stains and microscopy. Sometimes after first processing rounds, further processing and stains are needed to refine the diagnosis which may extend the length of time to have the results. On occasion for difficult tumors, the pathologists may also collaborate with other neuropathologists to decide on the diagnosis.

### **Chemotherapy:**

The type of chemotherapy recommended depends on the tumor type. For many high grade gliomas, Temodar (Temozolomide) is utilized. Temodar is often delivered along with radiation, which may work synergistically to fight the tumor. Other kinds of chemotherapy include Avastin (bevacizumab), which is often used as a backup for recurrent glioblastomas or radiation necrosis.

### **Radiation:**

There are many types of radiation. Typically, two forms of radiation exist to treat brain tumors: stereotactic radiosurgery (SRS) and IMRT/EBRT. With stereotactic radiosurgery, radiation beams are focused on the tumor, which receives a high dose whereas all the surrounding tissues receive very little. SRS is often used for meningiomas and schwannomas where the focus is most easily identified. For other tumors, such as high grade gliomas, the margins of the tumor are not clearly defined and a more broad form of radiation is delivered over many fractions or doses, to reduce the risk of collateral damage to important portions of the brain. This type of radiation, which can treat a wider field for invasive or large tumors, is often referred to as IMRT (Intensity-modulated radiation therapy) and maybe delivered over the course of a month.

## TUMOR TYPES

<http://www.abta.org/brain-tumor-information/>

### **Meningiomas:**

#### **Description**

Meningiomas usually grow inward, causing pressure on the brain or spinal cord. They also can grow outward toward the skull, causing it to thicken. Most meningiomas are noncancerous, slow-growing tumors. Some contain sacs of fluid (cysts), mineral deposits (calcifications), or tightly packed bunches of blood vessels.

#### **Symptoms**

Meningiomas usually grow slowly, and may reach a large size before interfering with the normal functions of the brain. The resulting symptoms depend on the location of the tumor within the brain. Headache and weakness in an arm or leg are the most common symptoms. However, seizures, personality changes, and/or visual problems may also occur.

#### **Incidence**

Meningiomas account for about 36.1% of all primary brain tumors, which are tumors that form in the brain or its coverings. They are most likely to be found in adults older than 60; the incidence appears to increase with age. Rarely are meningiomas found in children. They occur about twice as often in women as in men.

#### **Cause**

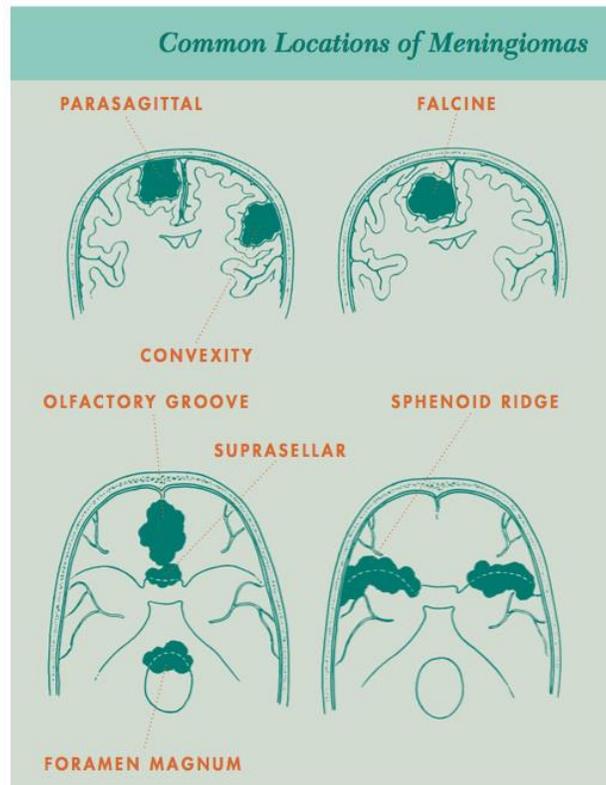
Researchers are studying meningiomas carefully to find out what causes them. Between 40% and 80% of meningiomas contain an abnormal chromosome 22. The cause of this abnormality is not known. We do know, however, that this chromosome is normally involved in suppressing tumor growth. Meningiomas also frequently have extra copies of the platelet-derived growth factor (PDGFR) and epidermal growth factor receptors (EGFR), which may contribute to the growth of these tumors.

Previous radiation to the head, a history of breast cancer, or neurofibromatosis type 2 may be risk factors for developing meningioma. Multiple meningiomas occur in 5% to 15% of patients, particularly those with neurofibromatosis type 2.

Some meningiomas have receptors that interact with hormones, including progesterone, androgen, and less commonly, estrogen. Although the exact role of hormones in the growth of meningiomas has not been determined, researchers have observed that meningiomas occasionally grow faster during pregnancy.

#### **Treatment**

Surgery and radiation are the most common forms of treatment for meningioma. Surgery is the primary treatment for meningiomas, although some tumors may not be removed this way. Radiation therapy may be used to tumors that cannot be removed with surgery, tumors that are not completely removed in surgery, malignant/anaplastic tumors, or recurrent tumors.



Burger, Scheithauer, and Vogel. *Surgical Pathology of the Nervous System and Its Coverings*. Fourth Edition. Churchill Livingstone, New York, 2002. Diagram reproduced with permission.

## **Lymphoma**

Lymphoma is a cancer that arises from the cells of the lymphatic system. In the brain, this type of cancer is called Primary CNS Lymphoma (PCNSL).

### **Location**

Lymphoma occurs most often in the cerebral hemisphere, but may also involve the cerebrospinal fluid, the eyes, or the spinal cord. In addition, some people may have evidence of lymphoma elsewhere in the body. It is not unusual for this tumor to be found in multiple areas of the cerebral hemisphere, as it can spread throughout the central nervous system.

### **Description**

Lymphoma is a cancer that starts in the cells of the lymphatic system.

### **Symptoms**

The most common symptoms of CNS lymphoma include personality and behavioral changes, confusion, symptoms associated with increased pressure within the brain (eg, headache, nausea, vomiting, drowsiness), weakness on one side of the body, and seizures. Problems with eyesight may also occur.

### **Incidence**

This disease affects people with healthy immune systems, as well as those whose immune systems are not functioning properly, for example organ transplant recipients, patients with autoimmune disease or people who are HIV positive.

The incidence of CNS lymphoma has been increasing over the past 20 years; it now represents between 2% and 3% of all primary brain tumors.

### **Cause**

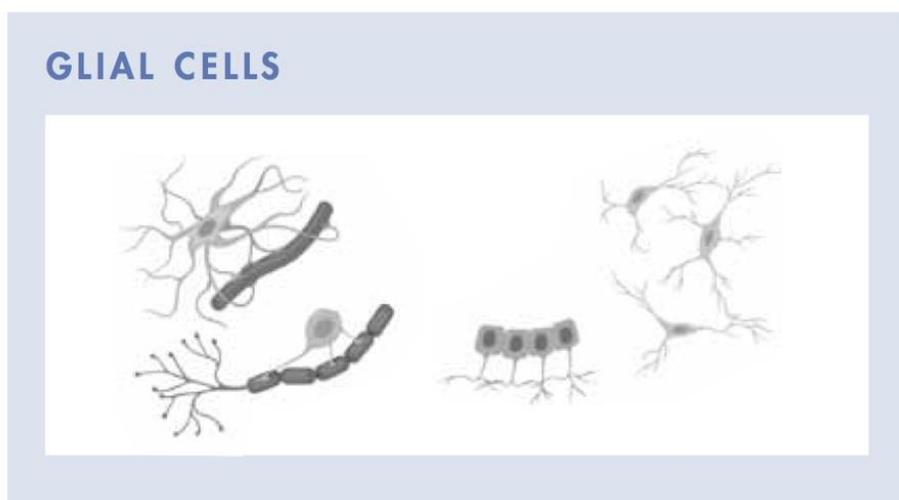
CNS lymphoma usually originates from B lymphocytes and is classified as non-Hodgkin's (meaning it is different from Hodgkin's disease).

### **Treatment**

Once a diagnosis is confirmed, steroids are used to control brain swelling; this may result in the immediate disappearance of the tumor on a later scan. Chemotherapy and radiation, or chemotherapy alone may then be used the primary treatment. Surgery is not usually an option because lymphomas tend to occur deep within the brain and the risk of surgical complications is too high.

### **Glioma:**

"Glioma" is a general term used to describe any tumor that arises from the supportive ("gluey") tissue of the brain. This tissue, called "glia," helps to keep the neurons in place and functioning well.



There are three types of normal glial cells that can produce tumors. An astrocyte will produce astrocytomas (including glioblastomas), an oligodendrocyte will produce oligodendrogliomas, and

ependymomas come from ependymal cells. Tumors that display a mixture of these different cells are called mixed gliomas.

Tumors such as “optic nerve glioma” and “brain stem glioma” are named for their locations, not the tissue type from which they originate.

### Location

The location of the tumor depends on the type of cells from which it originates.

### Description

Three types of normal glial cells can produce tumors—astrocytes, oligodendrocytes, and ependymal cells. Tumors that display a mixture of these cells are called mixed gliomas.

- **Astrocytoma:** [Click here to learn more](#) about astrocytomas, including juvenile pilocytic astrocytoma, low grade astrocytoma, anaplastic astrocytoma, or glioblastoma.
- **Ependymoma:** [Click here to learn more](#) about ependymoma.
- **Mixed Glioma (also called Oligoastrocytoma):** These tumors usually contain a high proportion of more than one type of cell, most often astrocytes and oligodendrocytes. Occasionally, ependymal cells are also found. The behavior of a mixed glioma appears to depend on the grade of the tumor. It is less clear whether their behavior is based on that of the most abundant cell type.
- **Oligodendroglioma:** [Click here to learn more](#) about oligodendroglioma.
- **Optic Glioma:** These tumors may involve any part of the optic pathway, and they have the potential to spread along these pathways. Most of these tumors occur in children under the age of 10. Grade I pilocytic astrocytoma and grade II fibrillary astrocytoma are the most common tumors affecting these structures. Higher-grade tumors may also arise in this location. Twenty percent of children with neurofibromatosis (NF-1) will develop an optic glioma. These gliomas are typically grade I, pilocytic astrocytomas. Children with optic glioma are usually screened for NF-1 for this reason. Adults with NF-1 typically do not develop optic gliomas.
- **Gliomatosis Cerebri:** This is an uncommon brain tumor that features widespread glial tumor cells in the brain. This tumor is different from other gliomas because it is scattered and widespread, typically involving two or more lobes of the brain. It could be considered a “widespread low-grade glioma” because it does not have the malignant features seen in high-grade tumors.

The widespread nature of gliomatosis cerebri causes enlargement of any part of the brain it involves. This may include the cerebral hemispheres, or less often, the cerebellum or brain stem.

### Symptoms

Symptoms vary based on tumor type:

- **Astrocytoma:** [Click here to learn more](#) about astrocytoma symptoms.
- **Ependymoma:** [Click here to learn more](#) about ependymoma symptoms.
- **Mixed Glioma (also called Oligoastrocytoma):** The initial symptoms, including headache and nausea, usually are the result of increased pressure inside the brain. Vision problems, as well as changes in behavior and personality, are also fairly common in mixed glioma patients.
- **Oligodendroglioma:** [Click here to learn more](#) about oligodendroglioma symptoms.
- **Optic Glioma:** These tumors may cause few or no symptoms. Their placement along the optic nerve, however, can cause vision loss (depending on the location of the tumor) or strabismus (“crossed eyes”).

Hormonal disturbance might also occur, causing developmental delay(s), early puberty, and other symptoms.

- **Gliomatosis Cerebri:** Symptoms are often nonspecific and can include personality and behavioral changes, memory disturbance, increased intracranial pressure with headache and sometimes seizures.

#### **Incidence**

The incidence of this tumor varies by type.

#### **Cause**

Like many tumor types, the exact cause of glioma is not known.

#### **Treatment**

Treatment is based on tumor type:

- **Astrocytoma:** [Click here to learn more](#) about treatment for astrocytoma.
- **Ependymoma:** [Click here to learn more](#) about treatment for ependymoma.
- **Mixed Glioma (also called Oligoastrocytoma):** Treatment may include surgery followed by radiation therapy, particularly if the tumor is high-grade. Chemotherapy will also generally be used in high-grade tumors.
- **Oligodendroglioma:** [Click here to learn more](#) about treatment for oligodendroglioma.
- **Optic Glioma:** Careful observation may be an option for patients with stable or slow-growing tumors. Surgery might be recommended for a growing tumor which involves only the optic nerve. Radiation might be used for a tumor of the chiasm or other pathways. Local radiation and chemotherapy with radiation therapy are used for recurrent tumors. Patients with primary and/or recurrent tumors may wish to take part in a clinical trial.
- **Gliomatosis Cerebri:** Treatment is less well defined because this tumor is so rare. Surgical removal is generally not attempted, because it is so widespread. Radiation and chemotherapy may be considered.

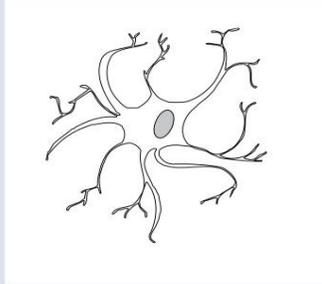
#### Astrocytoma:

Astrocytomas are tumors that arise from astrocytes—star-shaped cells that make up the “glue-like” or supportive tissue of the brain.

These tumors are “graded” on a scale from I to IV based on how normal or abnormal the cells look. There are low-grade astrocytomas and high-grade astrocytomas. Low-grade astrocytomas are usually localized and grow slowly. High-grade astrocytomas grow at a rapid pace and require a different course of treatment. Most astrocytoma tumors in children are low grade. In adults, the majority are high grade.

## ASTROCYTE

**Astrocytes are the cells that make up the “glue-like” or supportive tissue of the brain.**



Below are descriptions of the various grades of these tumors:

- **Pilocytic Astrocytoma** (also called *Juvenile Pilocytic Astrocytoma*)—These grade I astrocytomas typically stay in the area where they started and do not spread. They are considered the “most benign” (noncancerous) of all the astrocytomas. Two other, less well known grade I astrocytomas are cerebellar astrocytoma and desmoplastic infantile astrocytoma.
- **Diffuse Astrocytoma** (also called *Low-Grade or Astrocytoma Grade II*) Types: *Fibrillary, Gemistocytic, Protoplasmic Astrocytoma*—These grade II astrocytomas tend to invade surrounding tissue and grow at a relatively slow pace.
- **Anaplastic Astrocytoma**—An anaplastic astrocytoma is a grade III tumor. These rare tumors require more aggressive treatment than benign pilocytic astrocytoma.
- **Astrocytoma Grade IV** (also called *Glioblastoma, previously named “Glioblastoma Multiforme,” “Grade IV Glioblastoma,” and “GBM”*)— There are two types of astrocytoma grade IV—primary, or *de novo*, and secondary. Primary tumors are very aggressive and the most common form of astrocytoma grade IV. The secondary tumors are those which originate as a lower-grade tumor and evolve into a grade IV tumor.
- **Subependymal Giant Cell Astrocytoma**—Subependymal giant cell astrocytomas are ventricular tumors associated with tuberous sclerosis.

### Location

Astrocytomas can appear in various parts of the brain and nervous system, including the cerebellum, the cerebrum, the central areas of the brain, the brainstem, and the spinal cord.

### Description

- **Pilocytic Astrocytomas** generally form sacs of fluid (cysts), or may be enclosed within a cyst. Although they are usually slow-growing, these tumors can become very large.
- **Diffuse Astrocytomas** tend to contain microcysts and mucous-like fluid. They are grouped by the appearance and behavior of the cells for which they are named.
- **Anaplastic Astrocytomas** tend to have tentacle-like projections that grow into surrounding tissue, making them difficult to completely remove during surgery.
- **Astrocytoma Grade IV** (glioblastoma) may contain cystic material, calcium deposits, blood vessels, and/or a mixed grade of cells.

### Symptoms

Headaches, seizures, memory loss, and changes in behavior are the most common early symptoms of astrocytoma. Other symptoms may occur depending on the size and location of the tumor.

### **Incidence**

Pilocytic astrocytomas are typically seen in children and young adults. The other types tend to occur in males more often than females, and most often in people age 45 and over.

### **Cause**

Like many tumor types, the exact cause of astrocytoma is not known.

### **Treatment**

Treatment options depend on the type, size, and location of the tumor, if and how far it has spread, previous treatment received, and the patient's overall health. Treatment methods for the various types of astrocytomas are briefly explained below.

- **Pilocytic Astrocytoma:** These tumors are often removed by surgery alone. In adults and older children, radiation may follow surgery if the tumor cannot be completely removed. Or, the patient may be watched carefully for signs that the tumor has returned.
- **Diffuse Astrocytoma:** If the tumor is accessible and can be completely removed, the only additional care required is follow-up scans. In adults and older children, radiation may be suggested in addition to surgery. Radiation may also be used to treat an unremovable low-grade astrocytoma. The role of chemotherapy in treating these tumors is being investigated.
- **Anaplastic Astrocytoma:** The first step in treatment of anaplastic astrocytoma is surgery. Radiation is then used to treat the remaining tumor. Chemotherapy may be recommended immediately after radiation or when and if the tumor recurs.
- **Astrocytoma Grade IV:** The first treatment step is surgery to remove as much tumor as possible. Surgery is almost always followed by radiation. Chemotherapy is often given at the same time as radiation and may be used to delay radiation in young children.

### **Glioblastoma:**

Glioblastomas (GBM) are tumors that arise from astrocytes—the star-shaped cells that make up the “glue-like,” or supportive tissue of the brain. These tumors are usually highly malignant (cancerous) because the cells reproduce quickly and they are supported by a large network of blood vessels.

### **Location**

Glioblastomas are generally found in the cerebral hemispheres of the brain, but can be found anywhere in the brain or spinal cord.

### **Description**

Glioblastomas usually contain a mix of cell types. It is not unusual for these tumors to contain cystic mineral, calcium deposits, blood vessels, or a mixed grade of cells.

Glioblastomas are usually highly malignant—a large number of tumor cells are reproducing at any given time, and they are nourished by an ample blood supply. Dead cells may also be seen, especially toward the center of the tumor. Because these tumors come from normal brain cells, it is easy for them to invade and live within normal brain tissue. However, glioblastoma rarely spreads elsewhere in the body.

There are two types of glioblastomas:

- **Primary, or de novo:** These tumors tend to form and make their presence known quickly. This is the most common form of glioblastoma; it is very aggressive.
- **Secondary:** These tumors have a longer, somewhat slower growth history, but still are very aggressive. They may begin as lower-grade tumors which eventually become higher grade. They tend to be found in people 45 and younger, and represent about 10% of glioblastomas.

### Symptoms

Because glioblastomas can grow rapidly, the most common symptoms are usually caused by increased pressure in the brain. These symptoms can include headache, nausea, vomiting, and drowsiness. Depending on the location of the tumor, patients can develop a variety of other symptoms such as weakness on one side of the body, memory and/or speech difficulties, and visual changes.

### Incidence

This tumor represents about 15.4% of all primary brain tumors and about 60-75% of all astrocytomas. They increase in frequency with age, and affect more men than women. Only three percent of childhood brain tumors are glioblastomas.

### Cause

Like many tumor types, the exact cause of glioblastoma is not known.

### Treatment

Glioblastoma can be difficult to treat because the tumors contain so many different types of cells. Some cells may respond well to certain therapies, while others may not be affected at all. This is why the treatment plan for glioblastoma may combine several approaches.

The first step in treating glioblastoma is a procedure to make a diagnosis, relieve pressure on the brain, and safely remove as much tumor as possible through surgery. Because glioblastomas have finger-like tentacles, they are very difficult to completely remove. This is particularly true when they are growing near the parts of the brain that control important functions such as language and coordination.

Radiation and chemotherapy may be used to slow the growth of tumors that cannot be removed with surgery. Chemotherapy may also be used to delay the need for radiation in young children.

Learn more about different treatment options for brain tumors on our [Treatment page](#).

Some glioblastoma treatments are available through research studies called clinical trials. [Click here](#) to access Trial Connect™, the ABTA's clinical trial matching service.

### Prognosis

Prognosis is usually reported in years of "median survival." Median survival is the time at which *an equal number of patients do better and an equal number of patients do worse*. With standard treatment, median survival for adults with an anaplastic astrocytoma is about two to three years. For adults with more aggressive glioblastoma, treated with concurrent temozolamide and radiation therapy, median survival is about 14.6 months and two-year survival is 30%. However, a 2009 study reported that almost 10% of patients with glioblastoma may live five years or longer.

Children with high-grade tumors (grades III and IV) tend to do better than adults; five-year survival for children is about 25%.

In addition, glioblastoma patients who have had their MGMT gene shut off by a process called methylation also have prolonged survival rates. The MGMT gene is thought to be a significant predictor of response.

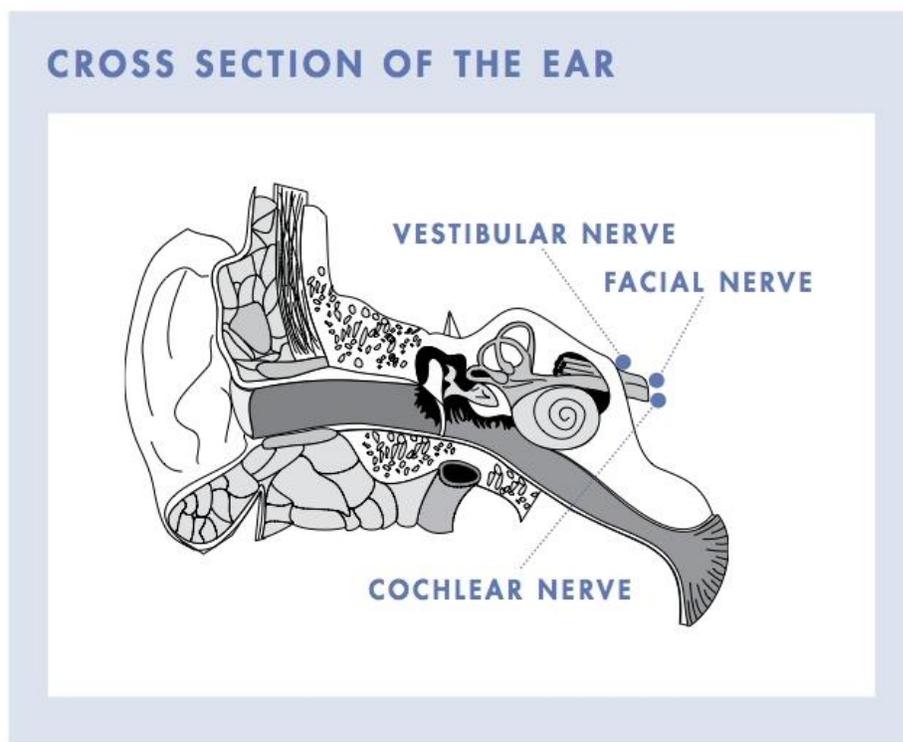
However, not all glioblastomas have the same biologic abnormalities. This may be the reason different patients respond differently to the same treatment and why different patients with the same tumor have different outcomes. Researchers continue to study the common characteristics of long-term brain tumor survivors, and how personalized and targeted treatments may be optimally used to treat brain tumor patients.

### Emerging Biomarkers in Glioblastoma

There are a number of biomarkers, or molecular signatures, which have the potential to contribute to diagnosis, prognosis and prediction of response to therapy in glioblastoma.

Schwannoma:

Schwannoma is a benign tumor of the nerve of hearing (the 8th cranial nerve, also known as the acoustic or vestibulocochlear nerve).



**Location**

Schwannomas are usually located in the angle between the cerebellum and the pons, in the back of the skull (the posterior fossa).

### **Description**

Schwannomas are usually very slow-growing.

### **Symptoms**

Common symptoms of Schwannoma are one-sided hearing loss and buzzing or ringing in the ear. Dizziness may also occur, although it is less common. If the tumor affects the facial nerve (the 7th cranial nerve, which is located next to the 8th cranial nerve), facial paralysis may occur. Other symptoms include difficulty in swallowing, impaired eye movement, taste disturbances, and unsteadiness.

### **Incidence**

Schwannomas account for about 8% of all primary brain tumors. They typically occur in middle-aged adults, and females are twice as likely as males to have this tumor.

### **Cause**

Like many tumor types, the exact cause of Schwannoma is not known. However, it is believed to occur when there is a defect in a gene that normally prevents tumors from forming.

### **Treatment**

Total removal using microsurgical techniques is often possible. Stereotactic radiosurgery may be used as an alternative to surgery in some patients.

Neurofibromas:

Neurofibromas are tumors of the nerve fibers. The term neurofibromatosis refers to two different genetic diseases characterized by skin abnormalities and nervous system tumors:

- **Neurofibromatosis type 1:** Also called NF-1 or Von Recklinghausen's disease.
- **Neurofibromatosis type 2:** Also known as NF-2.

### **Location**

Tumor location depends on the type of neurofibromatosis present.

**NF-1** can cause neurofibromas to appear throughout the body. These tumors often are visible underneath the skin. It can also cause skin discolorations called "café-au-lait" spots, as well as freckles in the armpits and groin.

Other nervous system tumors can be associated with NF-1; these occur in approximately 10% of patients and include optic pathway gliomas (usually pilocytic astrocytoma), cerebral hemisphere, posterior fossa (brain stem and cerebellum), and low-grade astrocytomas in the spinal cord.

**NF-2** Nervous system tumors associated with this type may include tumors of the hearing nerve (acoustic neuromas or vestibular Schwannoma), typically on both sides, meningiomas, schwannomas or the spinal root of nerves, and ependymomas (spinal cord or brain).

### **Description**

A neurofibroma is a tumor or growth located along a nerve or nervous tissue. Neurofibromatosis refers to two different genetic diseases characterized by skin abnormalities and nervous system tumors.

**Symptoms**

The symptoms of NF-1 and NF-2 present themselves in very different ways. One of the most common early signs of NF-1 are the skin discolorations referred to as “café-au-lait” spots. Because NF-2 tumors may involve the hearing nerve, unexplained hearing loss or ringing in the ears might be an early symptom.

**Incidence**

NF-1 is the more common form of neurofibroma, appearing in one of every 3000 or 4000 people worldwide. NF-2 is a little more rare, occurring in one of every 35,000-40,000.

**Cause**

The predisposition to tumor formation in both disorders is related to genetic abnormalities which interfere with a protein that normally regulates and prevents tumor formation.

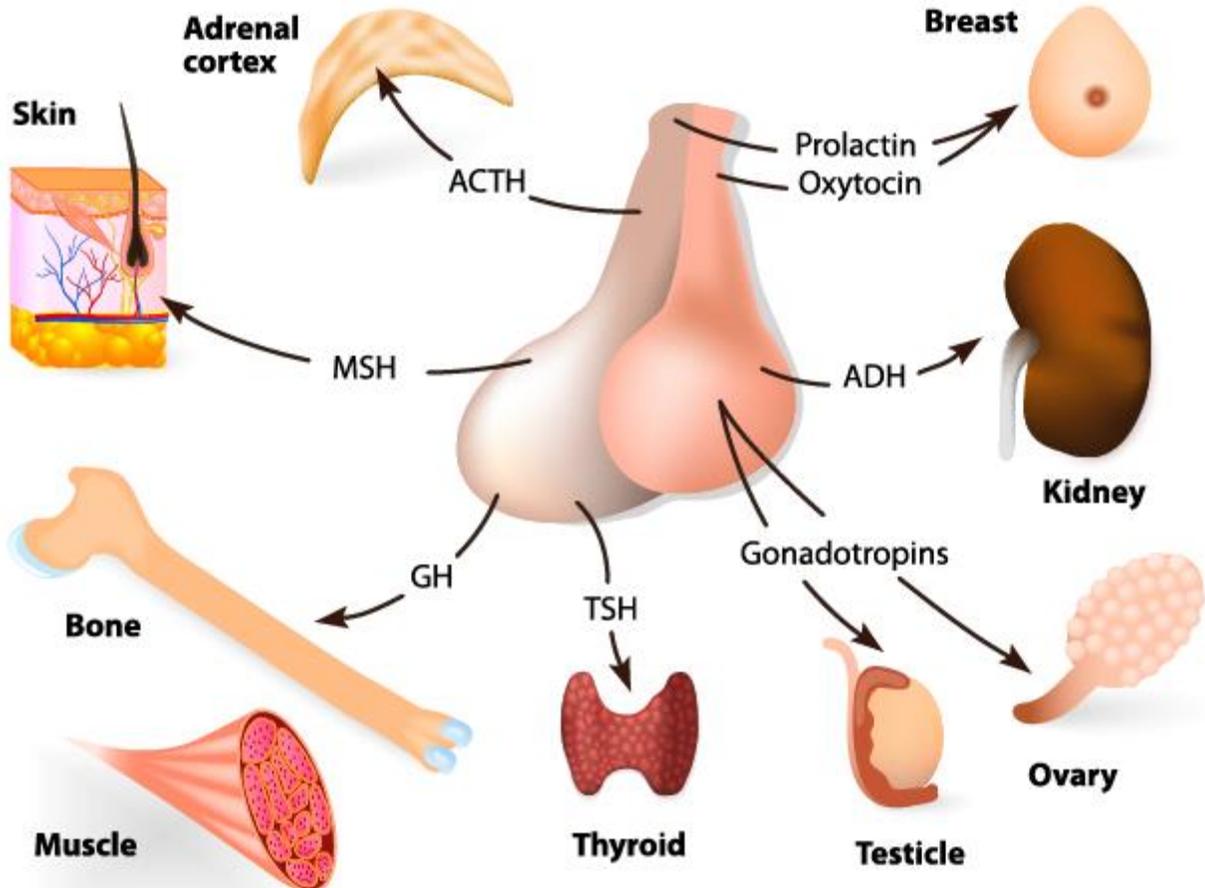
**Treatment**

Surgery is the most common form of treatment for neurofibroma. However, removal of the tumor can be tricky because these growths are often woven through the nerve structure.

Pituitary Tumors:

The pituitary gland is involved in the production of several essential hormones.

# PITUITARY GLAND



Tumors arising from the pituitary gland itself are called adenomas or carcinomas. Pituitary adenomas are benign, slow-growing masses that represent about 10% of primary brain tumors. Pituitary carcinoma is the rare malignant form of pituitary adenoma.

## Location

Most pituitary adenomas grow in the front two-thirds of the pituitary gland. These tumors are classified as “secreting” and “non-secreting.” A “secreting tumor” produces excessive amounts of hormones. Most pituitary tumors fall into this category; they are further classified by the type(s) of hormone they produce.

## Description

Pituitary adenomas are benign, slow-growing tumors. Pituitary carcinoma is the rare malignant form of pituitary adenoma. It is diagnosed only when there is proven spread (metastases) inside or outside the nervous system.

## Symptoms

Symptoms are caused when the growing tumor pushes on surrounding structures. This pressure can result in headache, visual impairment, and behavioral changes.

Tumors can also either produce excessive amounts of hormone or limit how much hormone is produced. The hormones most commonly affected include: growth hormone (regulates body height and structure), prolactin (controls lactation, or milk production), sex hormones (control the menstrual cycle and other sexual functions), thyroid gland hormones (control the thyroid gland), adrenal gland hormones, and vasopressin (a hormone involved in water and electrolyte balance).

Symptoms of pituitary adenoma and pituitary carcinoma are identical.

### **Incidence**

Pituitary tumors account for 9% to 12% of all primary brain tumors. They can occur at any age, but they are more common in older people. Women are more affected than men, particularly during the childbearing years.

### **Cause**

Like many tumor types, the exact cause of pituitary tumors is not known.

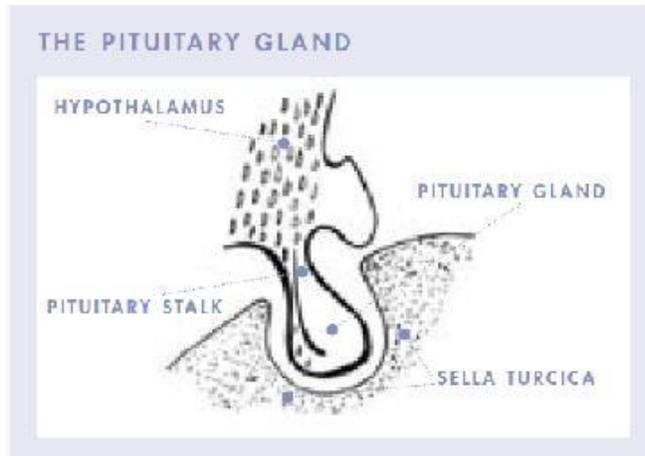
### **Treatment**

Because the pituitary gland impacts so many of the body's functions, a multi-disciplinary approach to tumor treatment is needed to ensure the best possible outcome.

Treatment of pituitary adenoma or carcinoma usually includes surgery to remove it. In some cases, however drug therapy may be used to reduce the size of the tumor without surgery. Radiation can be used to treat a persistent and/or recurring tumor that does not respond to medication, as long as the tumor is secreting hormone. For tumors that do not secrete hormone, radiation may be used following partial removal, or if the tumor was invasive. Replacement hormone therapy is often prescribed following surgery and/or radiation.

### **Craniopharyngioma:**

A craniopharyngioma is a benign (noncancerous) tumor arising from small nests of cells near the pituitary stalk.



Adamantinomatous (ordinary) craniopharyngioma occurs in children and tends to be less solid than papillary craniopharyngioma. Papillary craniopharyngioma occurs in adults and is a more solid tumor.

### Location

Craniopharyngiomas occur in the sellar region of the brain, near the pituitary gland. They often involve the third ventricle, optic nerve, and pituitary gland.

### Description

Craniopharyngiomas are localized tumors and become large before they are diagnosed. How malignant they are and how quickly they are likely to spread are unknown.

### Symptoms

Increased pressure within the brain causes many of the symptoms associated with this tumor. Other symptoms result from pressure on the optic tract and pituitary gland. Obesity, delayed development, impaired vision, and a swollen optic nerve are common.

### Incidence

Craniopharyngiomas represent 2-5% of all primary brain tumors, and 5-10% of all childhood brain tumors. This tumor tends to be found in two age groups—patients up to age 14 and patients over age 45. They are more common in African-American patients.

### Cause

Like many tumor types, the exact cause of craniopharyngioma is not known.

### Treatment

Surgery to remove the tumor is usually the first step in treatment. If hydrocephalus (excess water in the brain) is present, a shunt (drainage system) may be placed during surgery. The shunt will help remove excess cerebrospinal fluid from the brain and ease the pressure.

Radiation therapy may be suggested if all visible tumor cannot be removed. In children younger than 3, radiation may be delayed by the use of surgery or hormone therapies.

This tumor tends to be located close to the pituitary gland, which controls hormone balance in the body. To ensure the best outcome, an endocrinologist (a doctor trained to treat hormone imbalances) may work with the treatment team to develop a long-term care plan.

## Pineal Tumors:

These tumors originate from normal cells in the pineal gland. The pineal gland is located in the center of the brain and is involved in the secretion of specific hormones.

Tumor types occurring in the pineal region may or may not involve the pineal gland. True pineal cell tumors—pineocytoma, pineoblastoma, and mixed pineal tumors—are covered on this page.

Tumors that may occur in this region but are not necessarily pineal tumors include: germinoma, non-germinoma (eg, teratoma, endodermal sinus tumor, embryonal cell tumor, choriocarcinoma, and mixed tumors), meningioma, astrocytoma, ganglioglioma, and dermoid cysts. Information on these particular tumors can be found elsewhere on this site.

### Location

The pineal gland is located at the rear of the third ventricle, which is one of the fluid-filled cavities of the brain. Pineal tumors come from the normal cells of the pineal gland.

### Description

There are three types of pineal tumors:

- **Pineocytoma:** Slow-growing, grade II tumor.
- **Pineoblastoma:** More aggressive, grade IV, malignant tumor. A grade III intermediate form has also been described.
- **Mixed Pineal Tumor:** Contains a combination of cell types.

### Symptoms

Symptoms are most often caused by blockage of the cerebrospinal fluid flow and problems with the eye movement pathways. Headache, nausea and vomiting, and double vision are common.

### Incidence

Pineal region tumors represent less than 1% of all primary brain tumors; however, 3% to 8% of childhood brain tumors occur in this area. These tumors tend to occur in young adults between 20 and 40 years old. About 10% to 20% of the tumors, particularly pineoblastoma, have the potential to spread through the cerebrospinal fluid. This usually occurs late in the disease. The tumors, however, rarely spread elsewhere in the body.

### Cause

Like many tumor types, the exact cause of pineal cell tumors is not known. However, scientists have identified chromosomal abnormalities which may play a role in the development of these tumors.

### Treatment

Standard treatment for these kinds of tumors is radiation therapy. Radiation of the entire brain and spinal cord is recommended in patients with pineoblastoma. Chemotherapy may also be considered, particularly if the tumor has spread or if it regrows.

Surgery may be possible in some individuals to determine the tumor type and remove part of the tumor. In some cases, placement of a shunt (similar to a drain) is used to relieve pressure caused by buildup of cerebrospinal fluid.

#### Metastatic Cancer:

A metastatic, or secondary, brain tumor is formed by cancer cells from a primary cancer elsewhere in the body that have spread to the brain.

##### **Location**

The locations of metastatic brain tumors varies.

##### **Description**

Cancers that frequently spread to the brain include lung cancer, breast cancer, melanoma (a malignant form of skin cancer), colon cancer, and kidney cancer.

##### **Symptoms**

Symptoms depend on the size and location of the tumor.

##### **Incidence**

People are surviving cancer longer than ever before. As a result, it is likely that the incidence of metastatic brain tumors will rise in the years to come.

##### **Cause**

Metastatic brain tumors are caused by cancer that has spread from another part of the body.

##### **Treatment**

Treatment consists of radiation and/or chemotherapy.

#### Medulloblastoma:

Medulloblastoma is a fast-growing, high-grade tumor. The various types of medulloblastoma include:

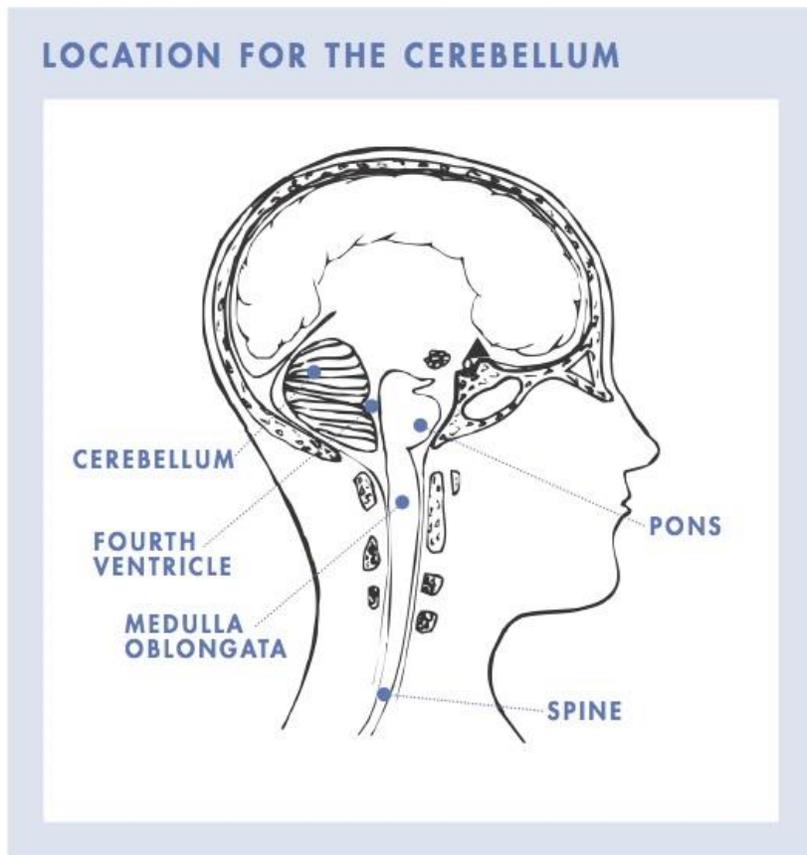
- classic medulloblastoma
- desmoplastic nodular medulloblastoma
- large-cell or anaplastic medulloblastoma
- medulloblastoma with neuroblastic or neuronal differentiation
- medulloblastoma with glial differentiation

- medulloblastoma
- melanotic medulloblastoma

Each type of medulloblastoma is described in our Medulloblastoma publication, which can be downloaded at the bottom of the page.

### Location

Medulloblastoma is always located in the cerebellum—the lower, rear portion of the brain. It is unusual for medulloblastomas to spread outside the brain and spinal cord.



### Description

Medulloblastoma is a fast-growing, high-grade tumor. It is the most common of the embryonal tumors—tumors that arise from “embryonal” or “immature” cells at the earliest stage of their development.

### Symptoms

The most common symptoms of medulloblastoma include behavioral changes, changes in appetite, symptoms of increased pressure on the brain (eg, headache, nausea, vomiting, and drowsiness, as well as problems with coordination). Unusual eye movements may also occur.

### Incidence

Medulloblastoma is relatively rare, accounting for less than 2% of all primary brain tumors and 18% of all pediatric brain tumors. More than 70% of all pediatric medulloblastomas are diagnosed in children under age 10. Very few occur in children up to age 1.

Medulloblastoma in adults is less common, but it does occur. About one-third of all medulloblastomas diagnosed in the United States are found in adults between the ages of 20-44. The incidence in adults sharply decreases in frequency after age 45, with very few older adults having this tumor. Medulloblastoma occurs more often in men than in women.

### **Cause**

Like many tumor types, the exact cause of medulloblastoma is not known. However, scientists are making significant strides in understanding its biology. Changes have been identified in genes and chromosomes (the cell's DNA blueprints) that may play a role in the development of this tumor. There are also a few rare, genetic health syndromes that are associated with increased risk for developing this tumor.

### **Treatment**

Treatment consists of surgical removal of as much tumor as possible, radiation, and then chemotherapy (in older children and adults). Learn more about different treatment options for brain tumors on our [Treatment page](#).

New approaches to treatment are currently in development. These new therapies are offered in organized research studies called clinical trials. [Click here](#) to access TrialConnect®, the ABTA's clinical trial match service.

### **Prognosis**

How well a patient responds to treatment is affected by the age they are at the time of diagnosis, the size and extent of the tumor, the amount of mass that can be removed safely, and the level of metastatic disease.

Overall, the Central Brain Tumor Registry of the United States reports about 57%-60% of adults (age 20+) with medulloblastoma are alive at five years following diagnosis, and 44% at 10 years. It is important to realize these statistics do not reflect the differences in outcome between low risk and high risk groups (since high risk groups may not do as well), differences in patient characteristics, nor differences in patient responses to treatment. And "10 year survival" means the patients were followed for only 10 years; we do not know how well they did beyond that length of time.

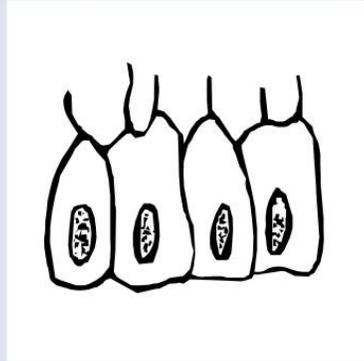
With current therapies, 70% - 80% of children with average-risk medulloblastoma can be expected to be alive and free of disease five years from diagnosis. Even in those children with high-risk disease, effective therapy is possible and results in long-term disease control in as high as 60% - 65% of patients. Outcome for infants is poorer, but for those infants with localized disease at the time of diagnosis, survival rates in the 30% - 50% range are being seen.

Ependymoma:

Ependymomas arise from the ependymal cells that line the ventricles of the brain and the center of the spinal cord.

## EPENDYMOMA

**Ependymal cells line the ventricles of the brain and the center of the spinal cord.**



These tumors are divided into four major types:

- **Subependymomas (grade I):** Typically slow-growing tumors.
- **Myxopapillary ependymomas (grade I):** Typically slow-growing tumors.
- **Ependymomas (grade II):** The most common of the ependymal tumors. This type can be further divided into the following subtypes, including cellular ependymomas, papillary ependymomas, clear cell ependymomas, and tancytic ependymomas.
- **Anaplastic ependymomas (grade III):** Typically faster-growing tumors.

### Location

The various types of ependymomas appear in different locations within the brain and spinal column. Subependymomas usually appear near a ventricle. Myxopapillary ependymomas tend to occur in the lower part of the spinal column. Ependymomas are usually located along, within, or next to the ventricular system. Anaplastic ependymomas are most commonly found in the brain in adults and in the lower back part of the skull (posterior fossa) in children. They are rarely found in the spinal cord.

### Description

Ependymomas are soft, grayish, or red tumors which may contain cysts or mineral calcifications.

### Symptoms

Symptoms of an ependymoma are related to the location and size of the tumor. In babies, increased head size may be one of the first symptoms. Irritability, sleeplessness, and vomiting may develop as the tumor grows. In older children and adults, nausea, vomiting, and headache are the most common symptoms.

### Incidence

Ependymomas are relatively rare tumors in adults, accounting for 2-3% of primary brain tumors. However, they are the sixth most common brain tumor in children. About 30% of pediatric ependymomas are diagnosed in children younger than 3 years of age.

**Cause**

Like many tumor types, the exact cause of ependymomas is not known.

**Treatment**

The first step of ependymoma treatment is to remove as much of the tumor as possible. Radiation is usually recommended for older children and adults following surgery, in some cases even if the tumor was completely removed.

The role of chemotherapy in treating newly diagnosed ependymomas is not clear. However, it may be used to treat tumors that have grown back after radiation therapy, or to delay radiation in infants and very young children.

Learn more about different treatment options for brain tumors on our [Treatment page](#).

New approaches to treatment are currently in development. These new therapies are offered in organized research studies called clinical trials.

### **Tumor Grading:**

Medical professionals assign tumors “grades” to help your healthcare team communicate better, plan treatment, and predict outcomes. The grades (1-4) assess how cancerous the tumor cells are. A grade 1 tumor is the slowest growing and easiest to treat. A grade 4 tumor is the most cancerous and can be difficult to treat.

- Grade 1 tumors are the least cancerous and are usually associated with long-term survival. The tumors grow slowly and have an almost normal cellular appearance when viewed through a microscope. Surgery alone might be an effective treatment for this grade of tumor. Pilocytic astrocytoma is an example of a grade 1 tumor.
- Grade 2 tumors are relatively slow-growing and have a slightly abnormal cellular microscopic appearance. Some can spread into nearby normal tissue and reproduce themselves, and can become a higher grade tumor. Examples are grade 2 oligodendroglioma and grade 2 astrocytoma.
- Grade 3 tumors are by definition malignant (cancerous.) The cells of a grade 3 tumor are actively reproducing abnormal cells which grow into nearby normal brain tissue. These tumors tend to recur, or reproduce themselves, and may recur as a grade 3 or change to a grade 4. A cancer recurrence is defined as a return of cancer after treatment and after a period of time during which the cancer cannot be detected.
- Grade 4 are the most cancerous brain tumors. They reproduce rapidly, can have a bizarre cellular appearance when viewed under the microscope and easily grow into surrounding normal brain tissue. These tumors form new blood vessels so they can maintain their rapid growth. They also have areas of dead cells in their center. Glioblastoma is the most common example of a grade 4 tumor.

A single tumor may contain several grades of cells. The highest or most cancerous grade of cell determines the tumor grade, even if most of the cells are a lower grade. Some tumors undergo changes. A lower-grade tumor might recur as a higher-grade tumor. Your doctor can tell you if your tumor might have this potential.

**APPENDIX:**

Figure 1: Examples of Locations and different types of brain tumors

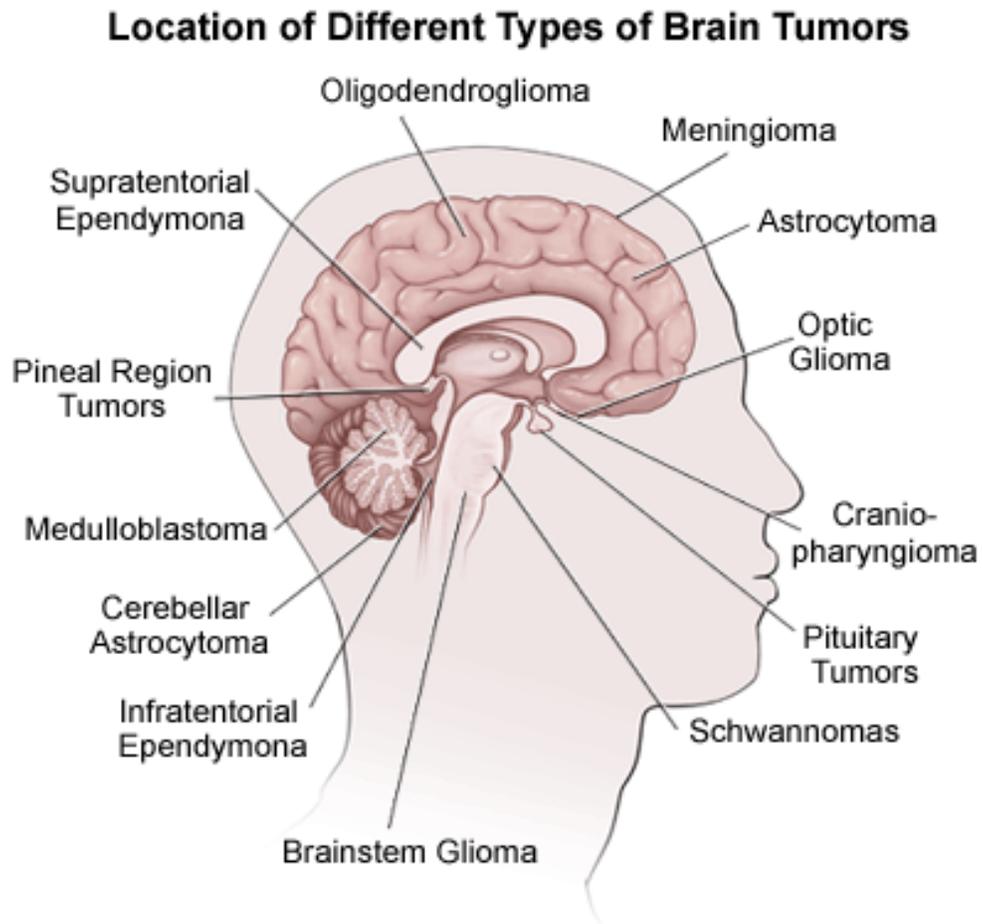


Figure 2: Neuronavigation system: GPS like system used during surgery to guide the surgeon to the target and avoid important structures.



Figure 3: Eloquent Areas of the Brain on the Dominant Hemisphere (the side that controls speech which is typically the left). These are areas of the brain of critical importance, involving motor function, speech and sight. Motor function and vision are also present on the non-dominant hemisphere (typically the right).

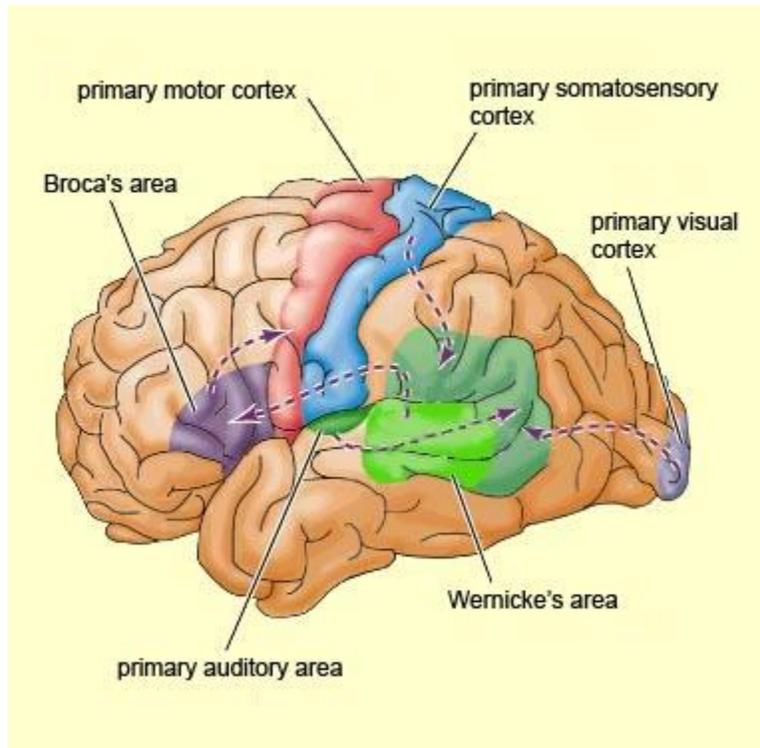


Figure 4: World Health Organization Grading of Tumors

World Health ORGANIZATION (WHO) GRADING SYSTEM	
<b>Grade 1 Tumor</b> <ul style="list-style-type: none"><li>• <i>Slow-growing cells</i></li><li>• <i>Almost normal appearance under a microscope</i></li><li>• <i>Least malignant</i></li><li>• <i>Usually associated with long-term survival</i></li></ul>	<b>Grade 3 Tumor</b> <ul style="list-style-type: none"><li>• <i>Actively reproducing abnormal cells</i></li><li>• <i>Abnormal appearance under a microscope</i></li><li>• <i>Infiltrate adjacent normal brain tissue</i></li><li>• <i>Tumor tends to recur, often as a higher grade</i></li></ul>
<b>Grade 2 Tumor</b> <ul style="list-style-type: none"><li>• <i>Relatively slow-growing cells</i></li><li>• <i>Slightly abnormal appearance under a microscope</i></li><li>• <i>Can invade adjacent normal tissue</i></li><li>• <i>Can recur as a higher grade tumor</i></li></ul>	<b>Grade 4 Tumor</b> <ul style="list-style-type: none"><li>• <i>Abnormal cells which reproduce rapidly</i></li><li>• <i>Very abnormal appearance under a microscope</i></li><li>• <i>Form new blood vessels to maintain rapid growth</i></li><li>• <i>Areas of dead cells (necrosis) in center</i></li></ul>

# Comprehensive Level 4 Epilepsy Surgery Program

## Kaiser Permanente Northern California

### Kaiser Permanente – Redwood City [RWC] (650) 299 - 2290

- John Duncan, MD, PhD: Neurosurgeon, Chief of Pediatric Neurosurgery, Kaiser Santa Clara, Director of Epilepsy surgery, Northern California Kaiser Permanente (Pediatric clinic and pediatric surgeries SCH, adult clinic and adult surgeries RWC)
- Everett Austin, MD: Neurologist, epileptologist (Clinic in RWC and San Rafael)
- Josiah Ambrose, MD: Neurologist, epileptologist
- Mark Sedrak, MD: Neurosurgeon, Director of Functional Neurosurgery, Northern California Kaiser Permanente
- Patrick Pezeshkian, MD: Neurosurgeon, Functional Neurosurgeon
- Cam Tran, MD: Neuroradiologist
- Tina Nguyen, MD: Neurologist, Neuromonitoring specialist
- Dorris Luong, NP: Nurse Practitioner for Epilepsy Program
- Diana Bruce, PA: Physician Assistant in Functional Neurosurgery
- Ivan Bernstein, PA: Physician Assistant in Functional Neurosurgery
- Eric Sabelman, PhD: Bioengineer in Functional Neurosurgery
- Siddharth Srivastava, PhD: Bioengineer in Functional Neurosurgery
- Brenda Melconian, RN, Redwood City Program Coordinator/Scheduler
- Nancy Mendelsohn: Neuroscience Research coordinator

### Locations of Regional Epilepsy Sites



Outlined Red are surgical sites, others are medical  
 Filled Blue are Pediatric  
 Filled Gray are Adult

**Kaiser Permanente – San Francisco [SFO] (415) 833 - 4625**

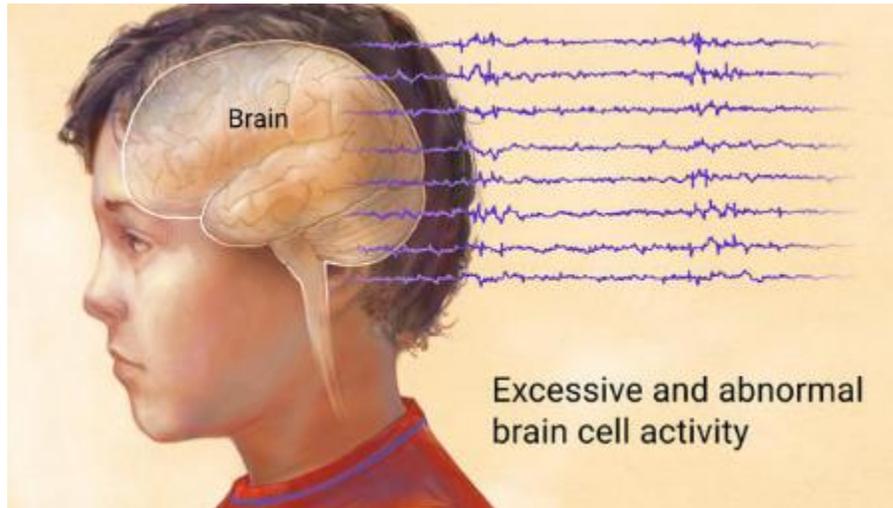
- Sharon McDaniel, MD: Pediatric Neurologist, epileptologist (Clinic/EMU in SFO, Surgery SCH)
- John Kuratani, MD: Pediatric Neurologist, epileptologist (Clinic in SFO/SCH, EMU SFO/SCH, Surgery SCH)
- Wendy Lewis, Psy.D: neuropsychologist

**Kaiser Permanente – Santa Clara [SCH] (408) 851 - 1240**

- John Duncan, MD, PhD: Neurosurgeon, Chief of Pediatric Neurosurgery, Kaiser Santa Clara, Director of Epilepsy surgery, Northern California Kaiser Permanente (Pediatric clinic and pediatric surgeries SCH, adult clinic and adult surgeries RWC)
- Sharon McDaniel, MD: Pediatric Neurologist, epileptologist (Clinic/EMU in SFO, Surgery SCH)
- John Kuratani, MD: Pediatric Neurologist, epileptologist (Clinic in SFO/SCH, EMU SFO/SCH, Surgery SCH)
- Kevin Chao, MD: Pediatric Neurosurgeon

**Kaiser Permanente – Sacramento [SAC] (916) 973 – 5175**

- Leo Chen, MD: Neurologist, epileptologist
- Ning Zhong, MD: Neurologist, epileptologist
- Lupe Kimble, NP: Nurse Practitioner for Epilepsy program



*(Epilepsy: A disorder in which nerve cell activity in the brain is disturbed, causing seizures)*

## What is Epilepsy?

Epilepsy is a chronic disorder characterized by recurrent, unprovoked seizures. These seizures occur as a result of activation of clusters of abnormal neurons/cells in the brain. When these clusters of abnormal neurons become activated, many problems can occur which is often related to the actual location of that cluster and its spread to other parts of the brain. It's notable that there are many types of seizures, which depend on various factors, and only some of these are amendable to surgery.

## How To Become Eligible for Epilepsy Surgery?

Most patients are initially managed by their local neurologist for their epilepsy. If a patient becomes refractory, or the case becomes complicated, a referral can be made to an epileptologist, who is a specialty neurologist located at several sites across Northern California Kaiser Permanente. The epileptologist will evaluate the patient, decide on possibly further advanced medical management strategies, which, if the patient's symptoms are refractory, may be considered for a more in depth evaluation. It's notable that there are many seizure types that are not amendable to epilepsy surgery, please consult your neurologist for further information. This evaluation typically includes an MRI and long-term surface EEG (Phase I study), but may also include: WADA testing, Neuropsychological testing, specialized MRI imaging (e.g., functional MRI, DTI), PET imaging, MEG imaging, and Ictal SPECT imaging. If the site of the seizures are still unknown, the patient may be considered for invasive EEG. Invasive EEG is a surgical procedure where electrodes are inserted into the brain to better evaluate the source of the seizures.

WADA testing is often an important component in the workup of epilepsy. This procedure involves a procedure called an angiogram, where a catheter is inserted through an artery in the groin, the catheter is brought all the way up to the carotid artery and a medication (amytal) is injected which shuts down that half of the brain. During that time, the patient is unable to move that whole side of the body

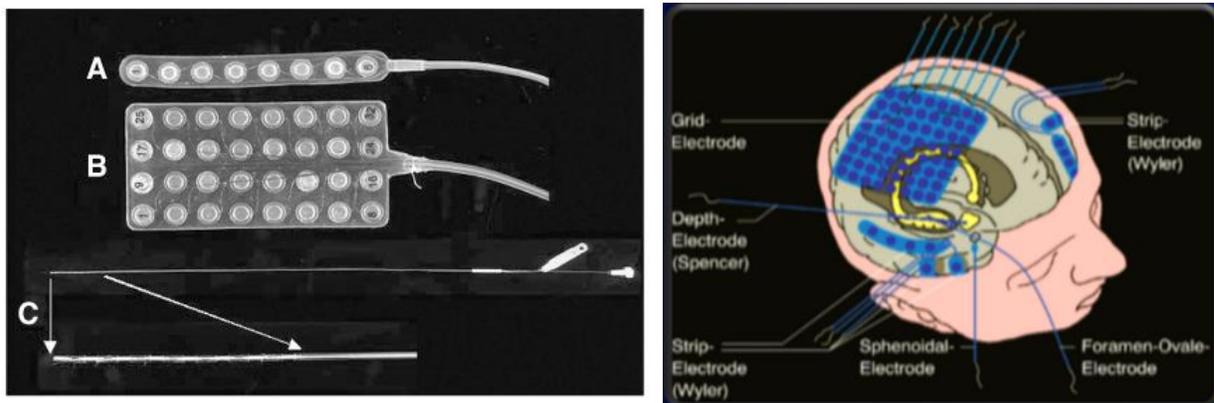
and the patient undergoes testing of speech and memory. The procedure is then repeated on the opposite side. Based off of this information, we are able to identify the brain hemisphere where speech is located and derive some information as to where memory is encoded. This helps in planning for a surgical procedure.

## What is Epilepsy Surgery?

When a patient is deemed to have refractory epilepsy despite at least 2-3 medication trials, appears to have focal epilepsy, that patient may be presented at a regional epilepsy board for next possible steps. If a patient is approved for surgery there are two main categories of epilepsy surgery, those addressing the location of the seizures and those used to treat the seizures.

### *Lateralization/Localization Surgery (Phase II):*

Often times, all the non-invasive methods to evaluate the actual location of the seizures do not give enough information to identify the seizure focus. Because of this, patients often undergo placement of invasive EEG to better identify the focus. There are many types of electrode implants, the main: subdural strips (A), grids (B), and depth electrodes (C). The type of electrodes inserted would depend on the seizure type, the information gathered from the surface EEG, MRI and other studies.



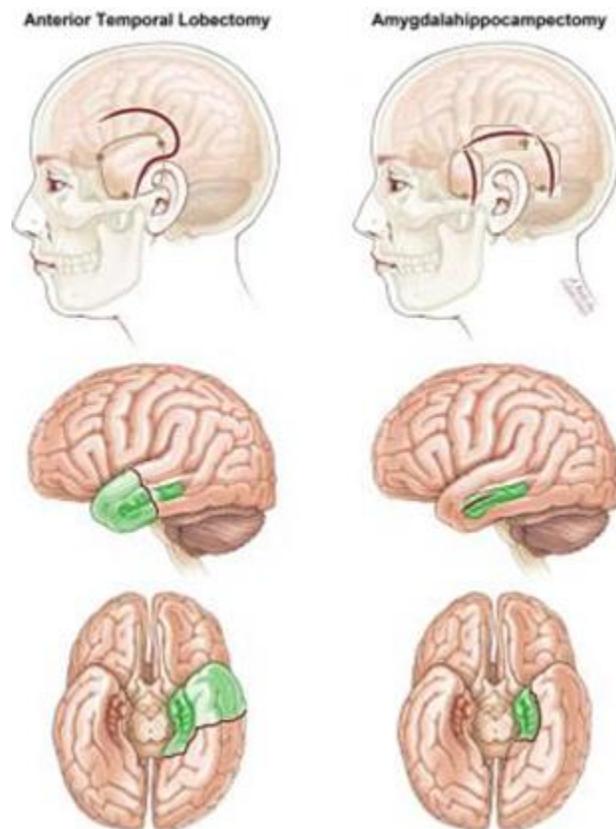
These invasive EEG electrodes are temporarily implanted as a part of a “Phase II” study, typically about 1 week long, but will depend on the findings. Patients are in the hospital after these implants in the Epilepsy Monitoring Unit (EMU), while the team awaits seizures. Oftentimes, medications are reduced and occasionally stopped, VNS machines may be turned down or off, patients are also often sleep deprived and whatever triggers the seizures can be encouraged. The team often wants to have approximately 3 or more seizures of the type the patient normally would experience. Once enough information has been acquired, the leads can be removed and, possibly, a second operation planned. Depth electrodes can often be removed at the bedside, but the other electrodes require removal in the operating room.

***Treatment Surgery:***

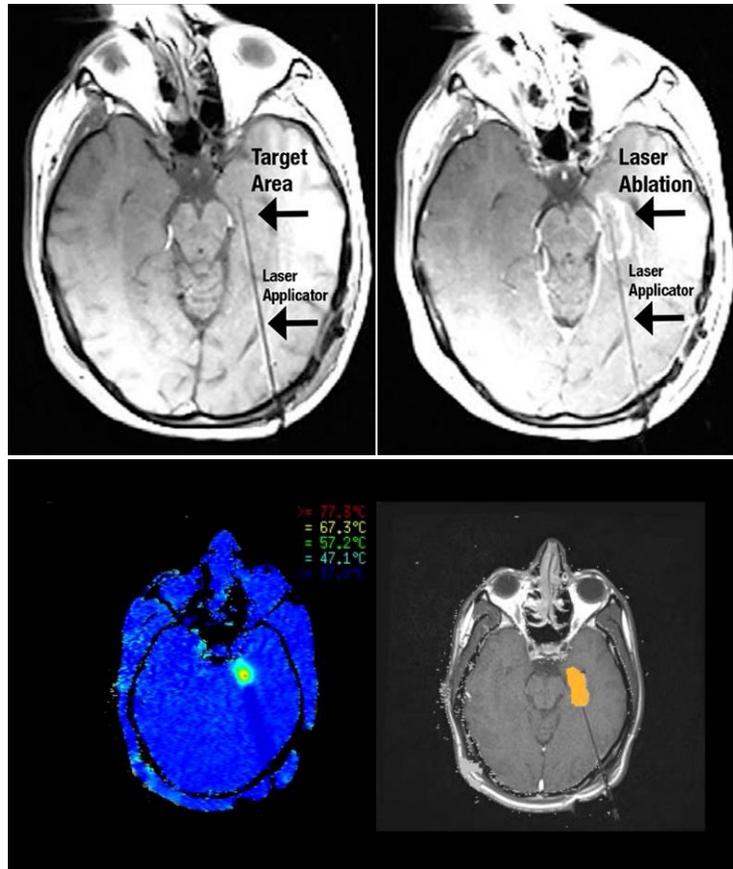
After there is enough information gathered regarding the epilepsy location, treatment surgeries can then be discussed with the comprehensive epilepsy group, led by your epileptologist(s) and surgeon(s). There are many types of epilepsy surgery, which are in two broad categories: excision/ablation (includes “topectomy”) or device implantation.

**Excision/Ablation:**

The most common adult type of surgical epilepsy involves a region of the brain called the temporal lobe. In particular, a region of the brain called the hippocampus is often the cause of the refractory seizures. There are two main types of excisional of temporal lobe operations: selective amygdalohippocampectomy (A+H) and complete anterior temporal lobectomy (ATL). In essence, a selective procedure is geared towards removing a smaller portion of brain tissue called the amygdala and hippocampus. The selective procedure is often the procedure of choice on the dominant (speech) side of the brain when the disease is thought to be “mesial”, or on that inner side of the temporal lobe. The ATL procedure is a more complete excision of the region of interest in the temporal lobe. Depending on the prior information gathered from a patient’s workup, speech center, and anatomy, the A+H or ATL procedure can be decided. It’s notable that temporal lobe operations, overall, have the highest chance of developing seizure freedom.



There is another form of treatment used for mesial temporal lobe epilepsy (MTE) called Laser-Induced Thermal Therapy (LITT). This procedure involves implanting a laser applicator probe in the area causing the seizures, while patients are asleep under anesthesia. This is often performed using what's called stereotaxis, which is a procedure that helps pinpoint targets within the brain. A small incision is placed at the entry point, then after the probe is inserted, the patient is taken to the MRI where laser energy is delivered, causing the tissue to heat up, thereby rendering that calculated region of brain to be dead or non-functional.



### *Topectomy:*

Many times, seizures are found outside of the temporal lobe. These are called “extratemporal neocortical”. When there is no obvious focus on the MRI, the case is deemed “non-lesional”, meaning that there is no clear anatomical cause of the seizures. There are often microscopic causes, however, such as a malformation called cortical dysplasia, of which there are varying degrees. Sometimes, the MRI does show an abnormality and we call this “lesional”. Often times, the lesion, or abnormality is a malformation/dysplasia or a tumor. A similar procedure, called a craniotomy, is performed where a window of bone is opened over that region of interest. The area is mapped and removed if surgically accessible and safe. Oftentimes, a seizure focus may be close to or involve important areas of the brain (called “eloquent” regions). These eloquent regions include speech, motor, and visual zones. If the seizure focus is near or potentially involving these eloquent zones, the surgery may need to be performed

awake, or with neuro-monitoring (a specialty service in the operating room), or perhaps the zone may need to be addressed by surgical excision. When the later occurs, other surgical options can be considered that involve implanted devices, such as neuropace or vagal nerve stimulation.

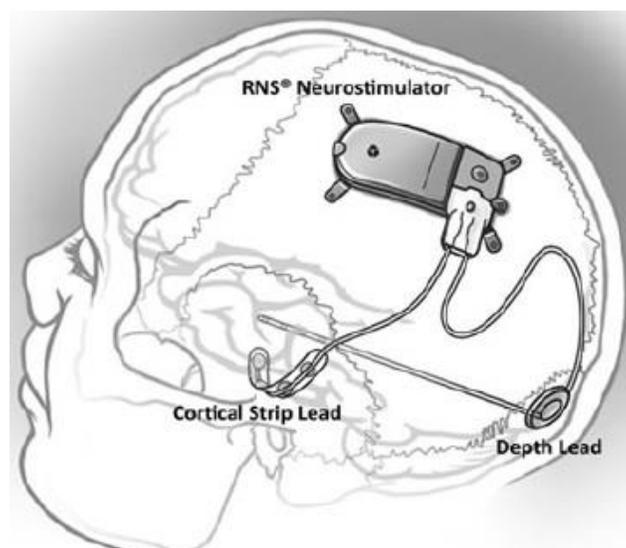
In addition to topectomies, pediatric epilepsy procedures include corpus callosotomy as well as hemispherectomy, both anatomic and functional. Like other epilepsy operations, these procedures depend on the clinical problem and findings during the evaluation.

### Device Implantation:

There are now several devices that can be utilized for the treatment of refractory epilepsy. These include: neuropace, vagal nerve stimulation, and deep brain stimulation. Typically with these treatments, seizures can be successfully treated, but only rarely cured. Also, the benefit from these treatments are often slow, and start to accrue months after implantation and may even continue 5 years or more afterwards.

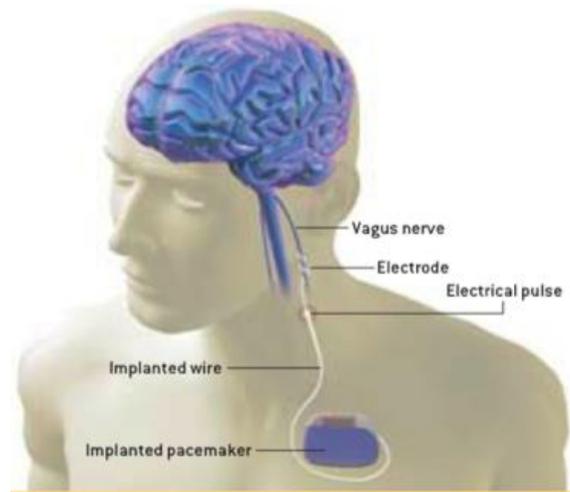
### *Neuropace*

Neuropace, also called Responsive Neuro-Stimulation (RNS), is a device that's implanted in a region of the brain geared towards treatment refractory seizures. This type of implant is often used when a patient has multifocal epilepsy (multiple areas causing the seizures) that cannot be removed, or when the seizure focus is located in or too close to an eloquent/important structure within the brain. This device is similar to invasive EEG, in that both depth and strip electrodes can be utilized. However, those electrodes are in this case implanted in or around the brain, a small portion of bone is removed and a battery is implanted in the skull which is connected to those electrodes. The device can then both monitor for seizures, but it can also deliver electricity to the brain in response to the detection of a seizure. Typically, after the device is implanted, a patient would undergo monitoring with the device for about 1 month, before the device is programmed to deliver electricity.



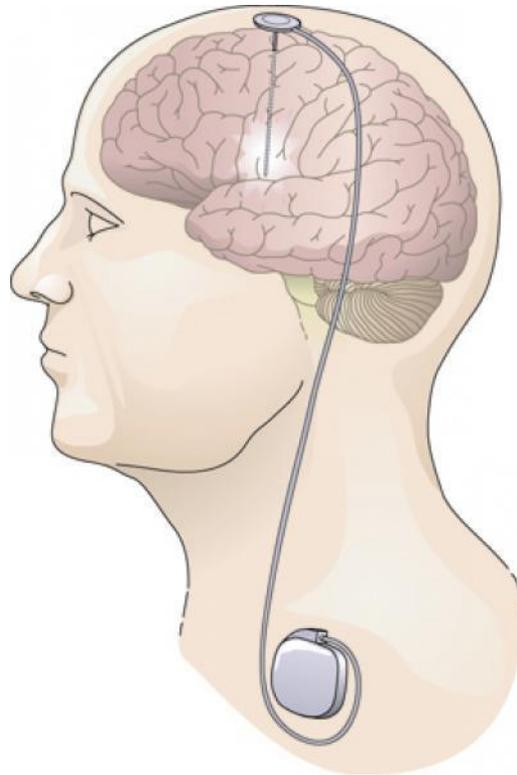
### *Vagal Nerve Stimulation:*

Vagal Nerve Stimulation (VNS) is one of the most common implants used to treat epilepsy and is the broadest reaching for seizure type. VNS involves placement of wires on the vagal nerve in the neck, which is then connected to a battery in the chest below the collar bone. Electrical impulses are delivered using the device to the vagal nerve, which then is relayed to the brain.



### *Deep Brain Stimulation:*

Deep Brain Stimulation (DBS) is a procedure where electrodes are implanted in the brain and connected to a battery in the chest, below the collar bone. Unlike VNS, DBS electrodes are implanted physically in the brain tissue at target areas. Further, unlike RNS, DBS involves stimulation that is non-responsive, utilizing higher energy and typically physically located in different strategic targets. DBS can be utilized for both multifocal epilepsy or generalized epilepsy.



### **Multimodality Team Approach:**

The Kaiser Permanent Epilepsy Center team consists of outstanding physicians who were trained at the country's top medical schools and are driven to have the best clinical results. The clinicians are outcome driven and actively involved in multiple research studies. Our approach in Northern California Kaiser Permanente has been to take advantage of the system and integrate a full team approach for treating our epilepsy patients. A comprehensive team of epilepsy neurologists, epilepsy neurosurgeons, neuroradiologists, neuropsychologists, dietitians, nurse practitioners, physician assistants review all patient data and formulate your comprehensive epilepsy treatment plan. This group decides who will most likely have a significant benefit from surgery and who may not, who may be high risk and who should be able to tolerate the surgery without a problem. In addition, we have a group in the operating room of anesthesiologists, nurses, operating room technicians, and circulators all specifically dedicated to epilepsy surgeries. This team approach adds another layer of clinical excellence to the overall program.



## Appendix:

Figure 1: Example of Surface EEG and the Epilepsy Monitoring Unit (EMU). The EMU is a hospital bed where patients have long-term EEG and video recordings to capture seizure activity. This helps your doctors understand the location of the seizures, clinical manifestation (what it looks like or “semiology”), and the seizure type (e.g., focal or generalized).

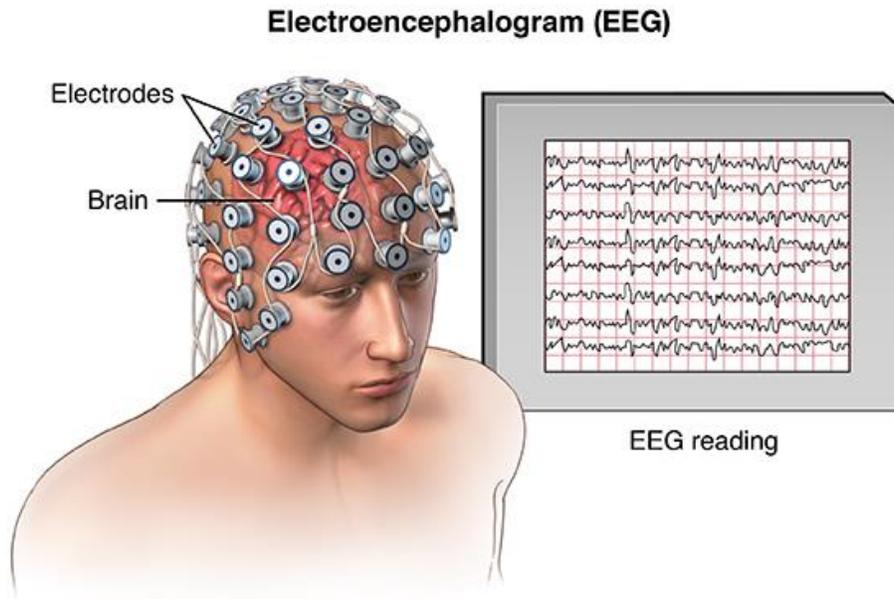


Figure 2: Depiction of WADA testing, used to evaluate the side of the brain that controls speech (most often left) and memory encoding. A catheter is inserted through an artery in the groin and brought all the way up to the carotid artery, where amytal is injected (a). Testing is then performed for including verbal responses to test speech (b), and to test object recognition and memory (c).

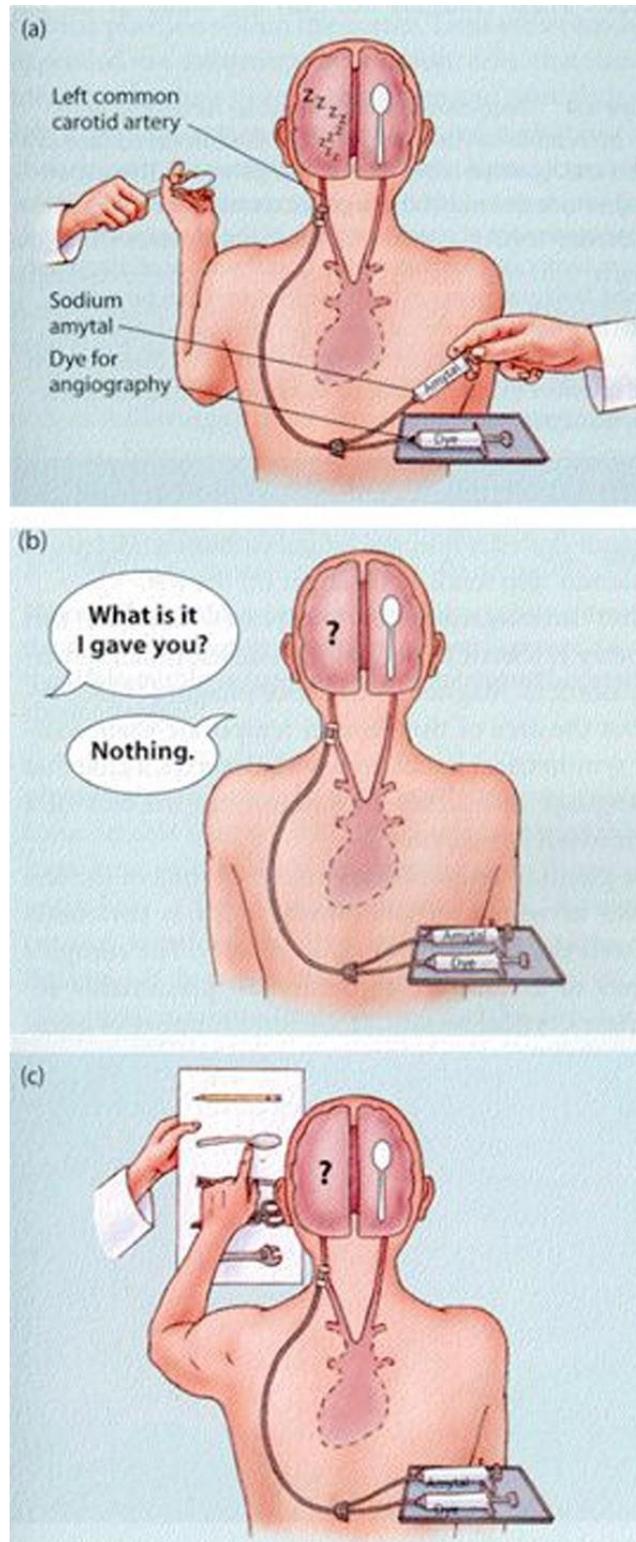


Figure 3: Diffusion Tensor Imaging. This type of imaging allows us to image the physical tracts within the brain, which give us an understanding of the connections

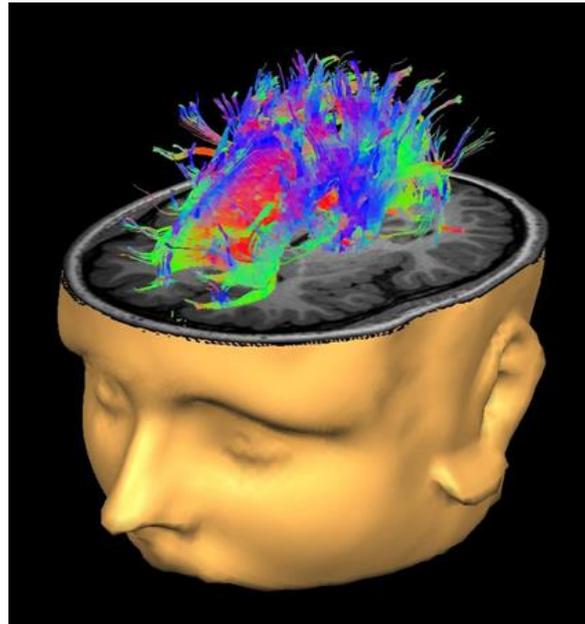


Figure 4: PET imaging. This type of imaging involves using tagged glucose (fluorine-18/fluorodesoxyglucose) to evaluate changes in metabolism in the brain. Often times we try to observe a reduced area of metabolism suggestive of the seizure focus, such as that seen in figures C and D (red arrows)

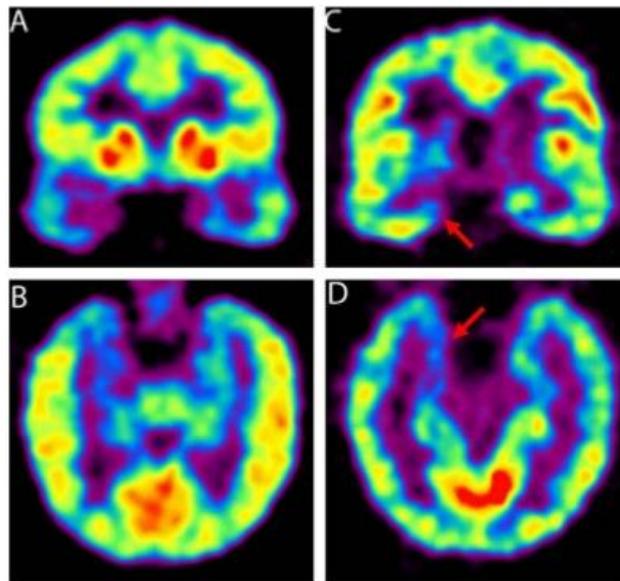


Figure 5: Invasive EEG. These are electrode systems implanted in or around the brain to evaluate the physical location of the seizures.

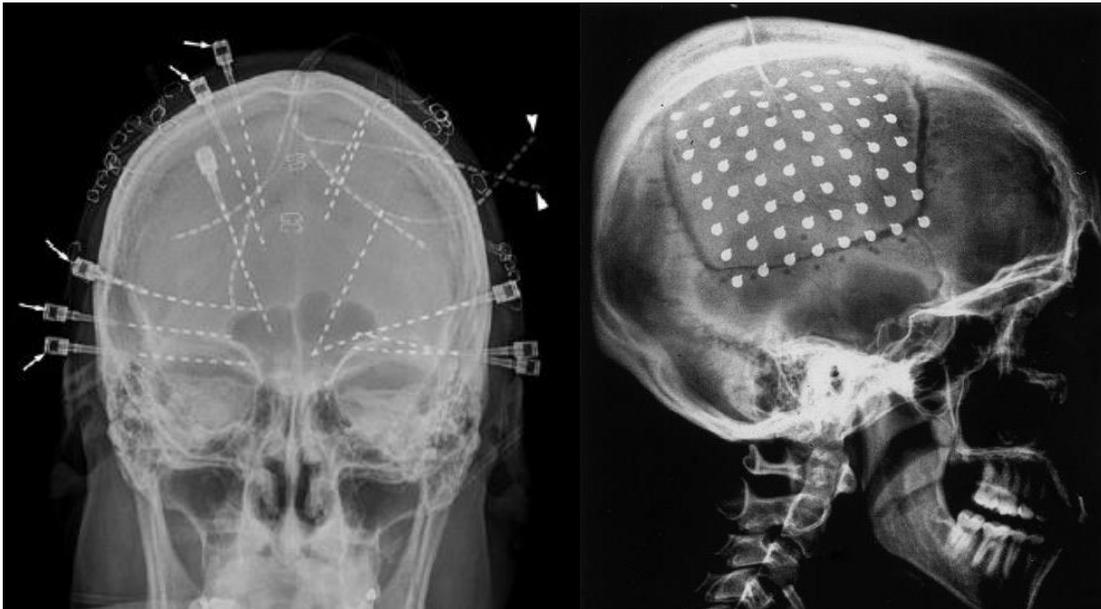


Figure 6: Eloquent Areas of the Brain on the Dominant Hemisphere (the side that controls speech which is typically the left). These are areas of the brain of critical importance, involving motor function, speech and sight. Motor function and vision are also present on the non-dominant hemisphere (typically the right).

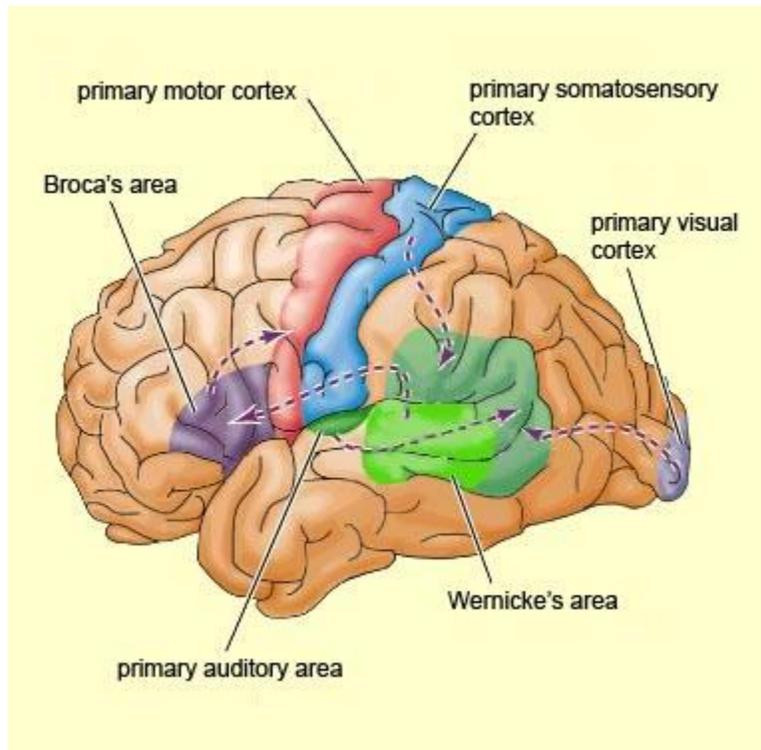
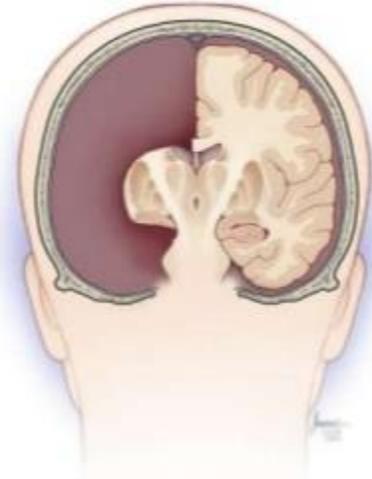


Figure 7: Hemispherectomy; Anatomic versus Functional, which describe degree of abnormal brain removed, which depend on clinical condition.

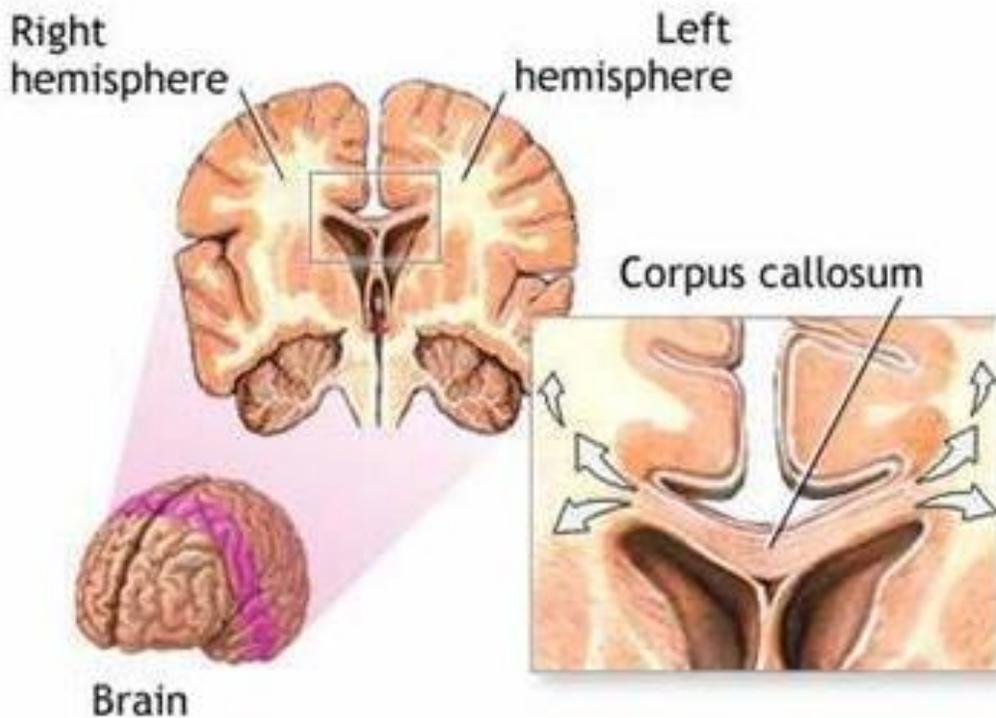
**Anatomic Hemispherectomy**



**Functional Hemispherectomy**



Figure 8: Corpus Callosotomy: a procedure where the corpus callosum, the portion of the brain that connects the two hemisphere's, is sectioned, typically to reduce “drop attacks” related to epilepsy.



## Deep Brain Stimulation Program – Kaiser Permanente Redwood City

### Parkinson's Disease

#### Redwood City Personnel (650) 299 - 2290:

- Mark Sedrak, MD: Director of Functional Neurosurgery, Northern California Kaiser Permanente\*
- Patrick Pezeshkian, MD: Functional Neurosurgeon
- Ramon Quesada, MD: Physical Medicine and Rehabilitation (PMR) Physician
- William T Wong, MD: Interventional Psychiatrist
- Diana Bruce, PA: Physician Assistant in Functional Neurosurgery\*
- Ivan Bernstein, PA: Physician Assistant in Functional Neurosurgery, Surgery Scheduling Supervisor
- Eric Sabelman, PhD: Senior Bioengineer in Functional Neurosurgery
- Siddharth Srivastava, PhD: Bioengineer in Functional Neurosurgery
- Julie Perez: Medical Assistant to Functional Neurosurgery

#### Redwood City Associated Sites:

### Locations of Movement Disorders Team Red are surgical sites



#### Kaiser Permanente – San Leandro (510) 454-3180

- Han Lee, MD: Movement Disorder Neurologist
- Carol Evans, NP: Movement Disorder Nurse Practitioner

#### Kaiser Permanente – San Francisco (415) 833 - 4555

- Rima Ash, MD: Movement Disorder Neurologist\*

#### Kaiser Permanente – Walnut Creek (925) 295 - 6953

- Jeff Klingman, MD: Movement Disorder Neurologist, Chief of Neurology in Northern California Kaiser Permanente
- Heidi Shale, MD: Movement Disorder Neurologist

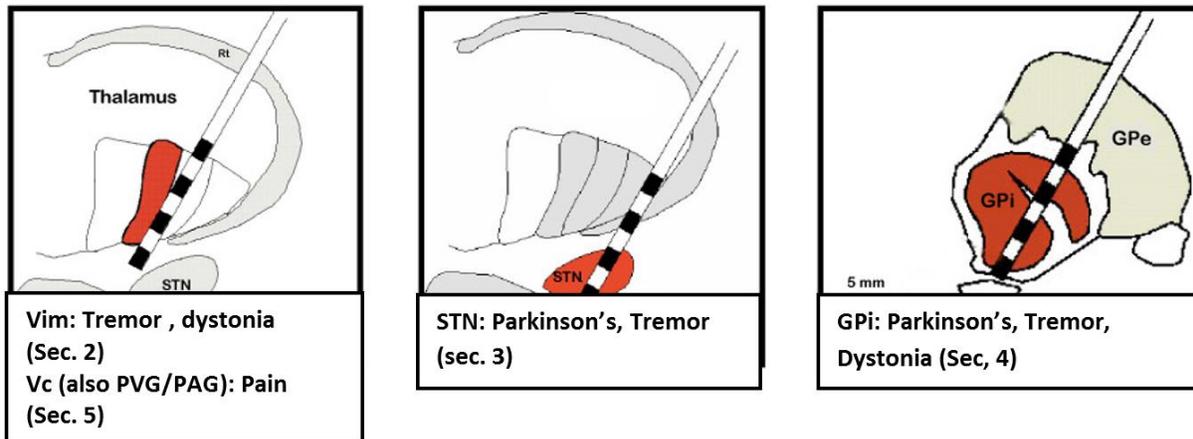
- Robin Bon, NP: Movement Disorder Nurse Practitioner
- Stacey Rohrer, Phd: Neuropsychologist
- Maia del Fierro-Lemon, MHCA: Consultant
- Susan Bodell, RN: Regional Program Coordinator for the Movement Disorders Deep Brain Stimulation Program

**Other Regional Site:**

Kaiser Permanente – Sacramento (925) 295 - 7848

- Conrad Pappas, MD, Phd: Functional Neurosurgeon
- Suketu Khandhar, MD: Movement Disorder Neurologist, Director of Movement Disorders Program\*
- Dawn Levine, Phd: Neuropsychologists
- Steven Jinks, Phd: Clinical Neuroscientist/Neurophysiologist
- May J Kim, Phd: Neuropsychologist
- Catherine Nitifan-Young, FNP: Movement Disorders Nurse Practitioner

**\*Involved with INTREPID Boston Scientific Study**



### How To Become Eligible for Deep Brain Stimulation?

Most patients are initially managed by their local neurologist for their movement disorder (Parkinson's Disease, Dystonia, or Essential Tremor). If a patient becomes refractory, or the case becomes complicated, a referral can be made to the movement disorder specialist, who is a Neurologist at 4 sites across Northern California Kaiser Permanente. The movement disorder specialist will evaluate the patient, decide on possibly further advanced medical management strategies, which, if the patient's symptoms are refractory, may be considered for deep brain stimulation. There are complicated and strict criteria that need to be met for a patient to become eligible. The first depends on a patient's symptoms, which for Parkinson's Disease, only some components are treatable with DBS (including motor fluctuations/ON/OFF swings, dystonia, tremor, rigidity). Certain symptoms with Parkinson's Disease are less likely to respond, including gait dysfunction (walking difficulty). Medication response with PD is important and may predict DBS outcome. Lastly, cognitive dysfunction or significant psychiatric disease may contraindicate the surgery. These are typically formally assessed using neuropsychological evaluation (s). A screening MRI is typically performed at the home facility to identify any obvious structural abnormalities or issues that may make surgery difficult or dangerous.

If there are no clear contraindications to surgery, the case file is brought to the Movement Disorders Board, which is a panel that meet approximately every 6 weeks. During this meeting, the entire case is reviewed, history, medication trials, videos of patient (ON/OFF for PD), neuropsychological evaluation, and MRI/Imaging. A group consensus needs to be made for patient to continue on meeting the surgical team. Also, during this meeting, a decision about the target is typically made. For essential tremor, the target is the thalamus (Ventral Intermediate Nucleus of the Thalamus). For dystonia, the target is typically the globus pallidus interna (GPi). For Parkinson's disease, there are multiple possible targets, but most commonly subthalamic nucleus (STN) and globus pallidus interna (GPi). In PD, STN may be favored by our group if patient doesn't have significant psychiatric comorbidities, impulse control problems, if there is tremor dominance, and to maximize medication reduction. The literature is essentially split between these two targets, but STN is a smaller target that requires higher precision than GPi and STN has a slightly faster response time (figure 1). Lastly, there is usually a decision about staging an operation (2 surgeries instead of 1) and also about different battery types (Activa PC, dual channel non-rechargeable; Activa SC, single channel non-rechargeable, or Activa RC, dual channel rechargeable). The advantage of the dual channel devices, is that the patient would only require 1 general

anesthesia event (during the time of tunneling to the chest). However, in comparing the SC to the PC, the SC has about 30% more battery life. SC's and PC's typically last about 3-6 years and require replacement surgery which is an outpatient local anesthetic procedure. The RC requires charging, typically about 20-30 minutes every 1-2 days, but if well maintained will last 9 total years. For surgeries that require high output (GPi), the RC may be advantageous to avoid frequent battery replacement operations.

If a patient is approved for surgery they will meet with the surgical team either in Redwood City or Sacramento typically after a phone appointment with a member of the team. During that time, the surgery will be discussed in greater detail and a decision to proceed or not can be made at that time. Typically, if a patient agrees to surgery, they will come back within 1 month of the operation and have a specific meeting with one of the PA's for a History and Physical, the Pre-operative Medical Clinic (POM), a special MRI will be obtained and specific instructions around the time of surgery will be discussed (including stopping Parkinson's medications 48 hours prior to each operation.)

### **How we do it at Kaiser Permanente-Redwood City**

Deep brain stimulation (DBS) is a high tech surgical procedure, geared towards improving symptoms of neurological origin by manipulating circuits within the brain. This technology progressed after historical destructive procedures were fraught with complications and high frequency stimulation was found to produce similar clinical features to those destructive procedures with the added features of being reversible and adjustable.

There are many ways these surgeries can be performed and you will see many advertisements with various techniques. The "gold" standard operation contains three key elements: image guidance, microelectrode recordings, and intraoperative testing. I'm proud to say that we, at Redwood City Kaiser, utilize all three of these elements to provide the best possible patient outcome every time.

#### **Image Guidance:**

We all may know that CT and MRI scans give us images containing anatomical information about the internal structure of our body. These images acquired are in 2-dimensional slices. When aimed at the brain, these techniques provide images of the various structures in the brain, including the targets of interest for DBS surgeries. There is much discussion in the world of functional neurosurgery attempting to understand where each and every target is physically located not only in 2D space, but more importantly in 3D. How do we exactly know where the targets are? Do MRI's actually show the subthalamic nucleus (or other targets) and surrounding structures in enough detail? Although special MRI sequences can demonstrate where various structures seem to be located, these targets used for movement disorder surgeries are tiny and ambiguous even with the best of systems.

We do two special things in our program with regards to image guidance: specialized MRI diffusion tensor imaging/colored fractional anisotropy (DTI/FA), susceptibility weighted imaging (SWI), and a calibrated XR technique for real-time imaging in the operating room. The DTI/FA method, the technique on which we have published, gives us patient specific information about the structural organization of fiber/axonal tracts in the brain, which are pathways for the diffusion of water (i.e, high FA) in the brain, and which also connects various brain structures together. Hence, in addition to providing anatomical information, DTI/FA also provide information about the relative connectivity of brain areas. . Using computational techniques, the direction of water diffusion, and the amount of diffusion in that direction is combined in a spectacular color map. When used in combination with the classical MRI, it provides an enhanced information about the anatomical localization of the small DBS targets also in relation to the

fiber tracts, and the pattern of water diffusion in their proximity. Secondly, we use an amazing technique developed at Stanford that utilizes XR machines set up in the operating room, calibrated to a very specific fixated point, which gives our bioengineer the ability to calculate positions in the brain in real-time. We uniquely have the ability to calculate even the position of the microelectrode recordings in addition to the DBS electrode. These can be calculated relative to each other or relative to referential structures in the brain, the actual landmarks used for MRI/CT guidance. In addition, this method is the most accurate method of calculating positions that is known in the world (accurate to 0.6mm or better)! It is more accurate than intraoperative MRI, intraoperative CT, fluoroscopy, or frameless systems. In addition, it is notable that MRI and CT systems have a theoretical problem of depth/angular measurement error as a result of software “smoothing” called interpolation. The XR system we use, does not have this problem. So at the end of our surgeries, we are quite certain about our stereotactic location.

### **Microelectrode Recordings:**

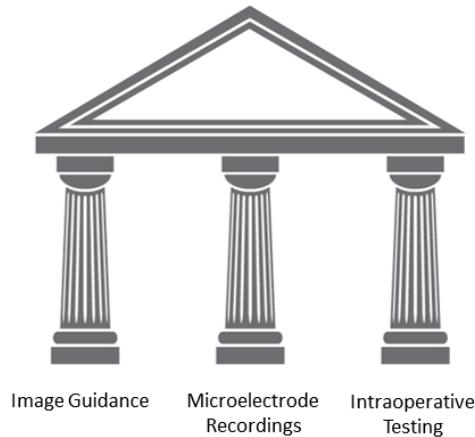
It is amazing to think that we now have the ability to measure electrical activity (action potentials) created by single neurons and a small cluster of neurons in the brain. This ability to visualize brain activity at the level of a single neuron has led to the discovery of many structures within the brain, hinting at their role in understanding the functional organization of this extremely complex organ. This method has become a very useful tool for neurosurgeons to identify many of the key targets during deep brain stimulation. During the time we measure these actual “action potentials” (actual neurons firing!), we can induce activity by manipulating the arm, the leg, or sometimes by flashing light in the eyes and many other maneuvers. The target areas of the brain become very active when patients are awake and off of their medications (typically 1-2 days). This is a second layer of assurance that have identified the proper position in the brain. We perform an XR when we identify the target and ensure that the DBS electrode eventually will make it to the same exact spot we want, with the help of our calibrated XR technique.

In addition to these MER’s, we’ve recently started utilizing what are called “local field potential” recordings. This method is similar to what many know as EEG/ECOG, where pools of neurons are sampled for their electrical activity. However, we are measuring these fields of neurons deep within the brain rather than on the surface. It turns out that many of the LFP signals may in fact help us understand the overall activity in a certain portion of the brain. This information is typically not utilized during the procedure, but can be analyzed when recorded afterwards.

### **Intraoperative Testing:**

The last and final test is one of the most important. “What happens when we introduce electricity in the brain at a specific target?”. This is a very critical step during the surgery. Patients do receive much local anesthesia at incision site (like numbing medication at dentist) in addition to having an anesthesiologist who administers some meds that won’t interfere with surgery, allowing some sedation (some patients even sleep). The awake testing can yield very critical information to the surgeon. For example, occasionally we can map the area we think is the best target utilizing MER, have our image guidance to get us to where we want to be, and we find that with stimulation at that precise target, we induce effects that suggest we are too close to surrounding structures. When this occurs, our knowledge of the mapped area and our image guidance help steer us away from these surrounding areas, giving our patients the best possible outcome and allowing our programmers the greatest degree of flexibility.

## Three Pillars to Successful DBS Operation



### **Staging Each Side of the surgery:**

We stage each side of the surgery for essentially 3 reasons. First, we have found that when both sides of the brain are exposed, patients tend to have more post-operative confusion. When each side is done individually, patients typically only require one night hospital stay. Second, we have noticed increased inaccuracy when both sides are done simultaneously, and our technique has demonstrated increased brain shift when this is done. Third, the physiology in the target site may actually be affected by the first site of implant. There is evidence that these regions are interconnected, both right and left. This interference seems to dissipate in a few weeks. We typically implant a dual channel implantable pulse generator (IPG; Activa PC or Activa RC) at the end of the second surgery under general anesthesia. If we implant single channel IPG's (Activa SC), we typically implant each generator at the end of each individual surgery. It is notable that we can do the surgeries in this format, which is our preference, because we are not under reimbursement practices as a result of Medicare and other insurers.

### **Activation of Device and Titration of Medications**

Typically after the entire system is implanted surgically, the device is off. Some patients notably have a "microlesioning" effect, where symptoms may improve slightly over hours, days, or weeks and then return to baseline. We allow this effect and any small amount of swelling in the brain to improve before turning on the device. This programming is typically done by the referring specialized movement disorder neurologist or associated personnel, about 2-4 weeks after surgery completion. Final effects from the DBS system, which has thousands of settings, may not be present for 6-12 months.

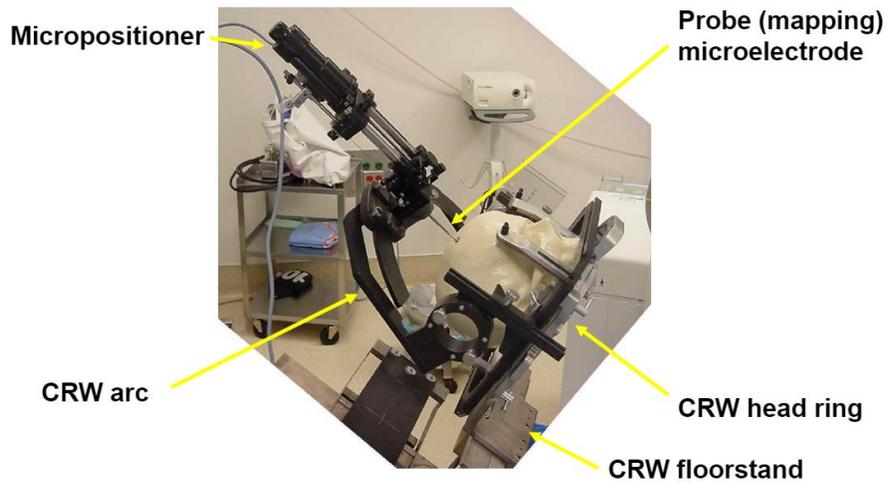
### **Team Approach:**

It is important to realize that the physicians of Kaiser are truly outstanding individuals, many of which are excellent at what they do, graduating top of their respective classes, and from top universities around the country. A major benefit of being a part of Kaiser, is that these physicians are truly driven to have the best clinical results. The clinicians are outcome driven, not income driven. Our approach in Northern California Kaiser, has been to take advantage of the system and integrate a full team approach for treating our movement disorders patients. With this in mind, a board was created, incorporating: functional neurosurgeons, movement disorder neurologists, neuropsychologists, bioengineers, physician assistants, nurse practitioners, nurses, and administrators who all take part in creating a consensus decision for each patient. This is an organized meeting where patients are formally presented, they are videotaped in "On" and "Off" medication states, formal UPDRS-III (Parkinson's Scale) scores are tabulated, MRI's are reviewed, neuro-psychological evaluations are discussed. With all this information in mind, the board decides who will most likely have a significant benefit and who may not, who may be high risk and who

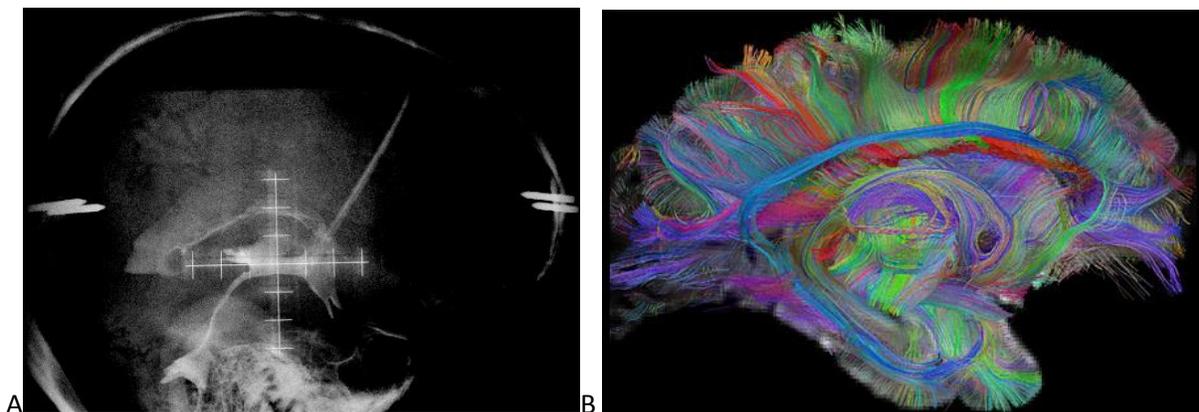
should be able to tolerate the surgery without a problem. This type of board meeting is very unique. Most institutions simply work using “hallway conversations” or simple consultations/referrals for this type of advanced surgery. In addition, we have a dedicated group in the operating room, anesthesiologists, nurses, operating room technicians, circulators, all specifically dedicated to DBS surgeries. This team approach adds another layer of clinical excellence to our overall program.

## Appendix:

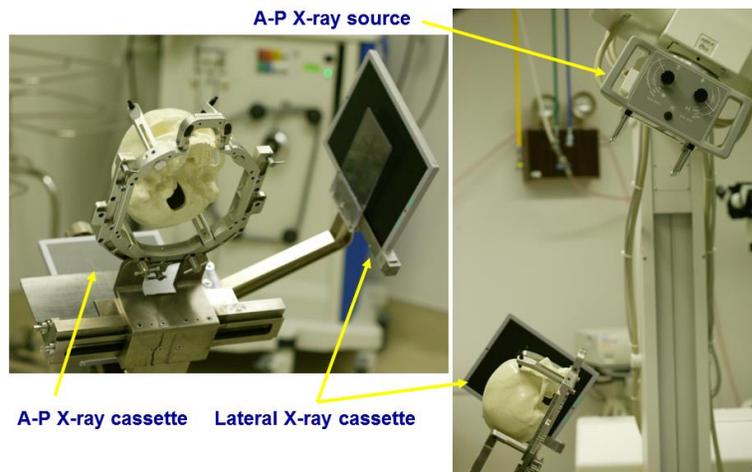
Picture 1: Example of Stereotactic Frame and equipment



Picture 2: A: Ventriculogram. XRay taken after injected contrast is delivered in the brain, allowing for internal landmarks to be imaged and direct ultra-precise calculations to be measured. B: Diffusion Tensor Imaging (DTI) showing actual tracts within the brain, helping the surgeons pinpoint patient specific regions within the brain itself.



Picture 3: X-Ray setup, with to both AP and Lateral Image Sets



Picture 4: Demonstration of “curving” of a lead in the operating room. Despite this movement, we are able to calculate a very precise location.

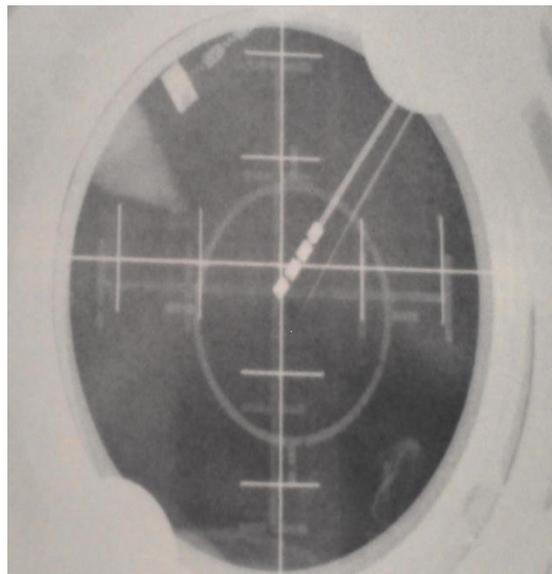


Figure 5: Microelectrode recordings are performed, measuring single cell and multiunit activity in the brain.

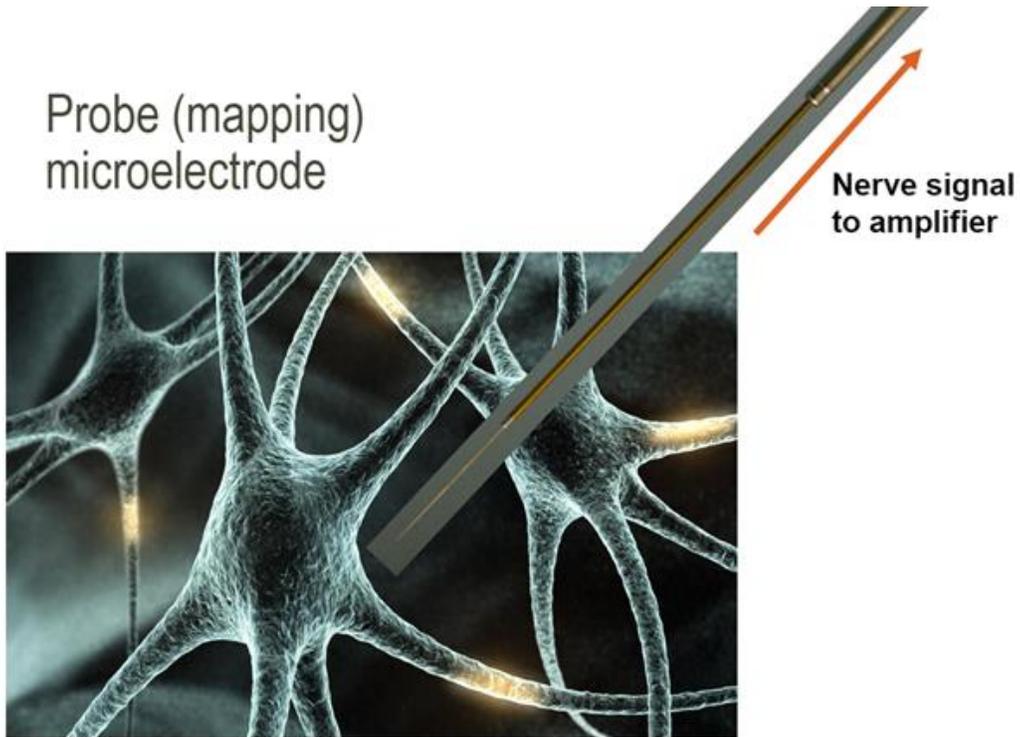


Figure 6: Microelectrode recordings demonstrate key findings in different parts of the brain. Image on left is for STN, right is GPi.

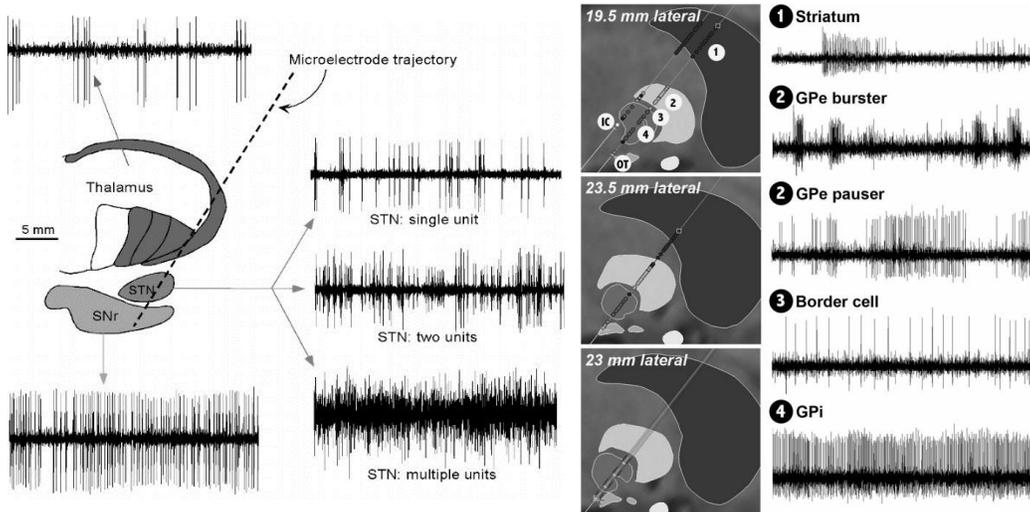


Figure 7: Navigus cap, which mounts the electrode lead to the skull

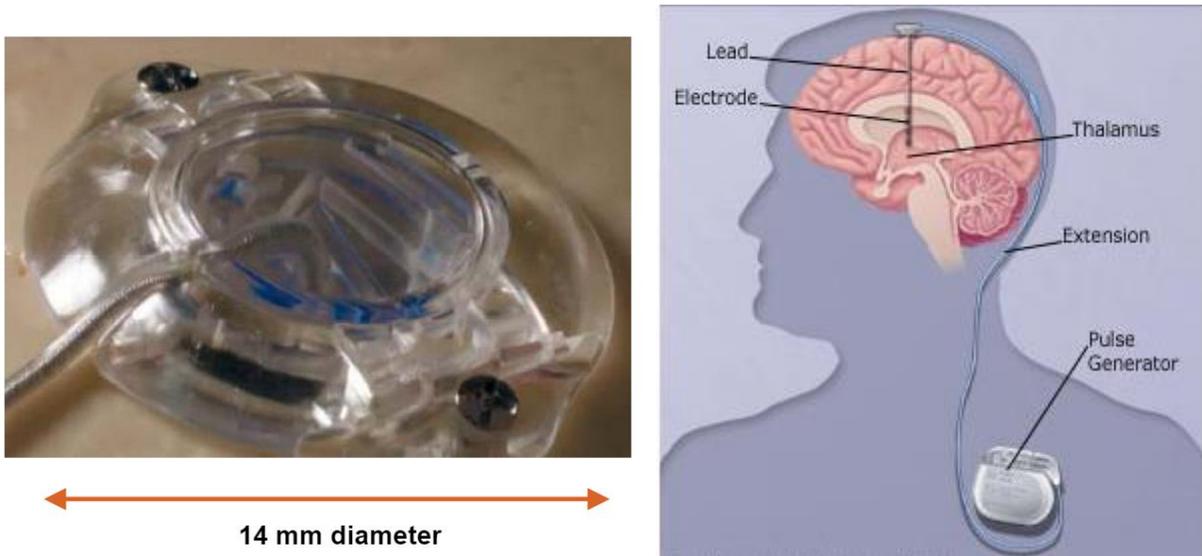


Figure 8: Shows the gradual improvement of the UPDRS III scale in Parkinson’s patients. Note that the improvement takes about 6 months and is slightly faster with STN stimulation than GPi, but the net outcome is the same.

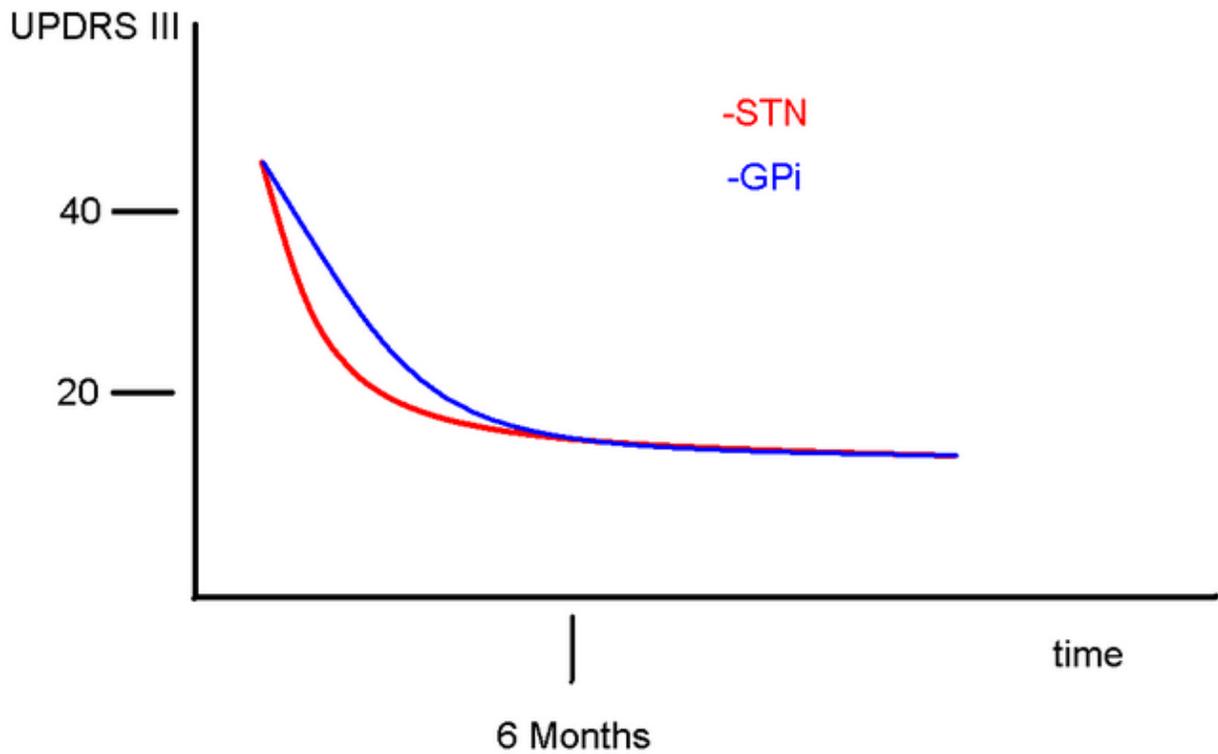


Figure 9: The narrowed therapeutic window in Parkinson's Disease is a disabling feature, causing motor fluctuations to ON/OFF throughout a given day. After DBS, these fluctuations are typically less prominent and the PD symptoms are overall under better control.

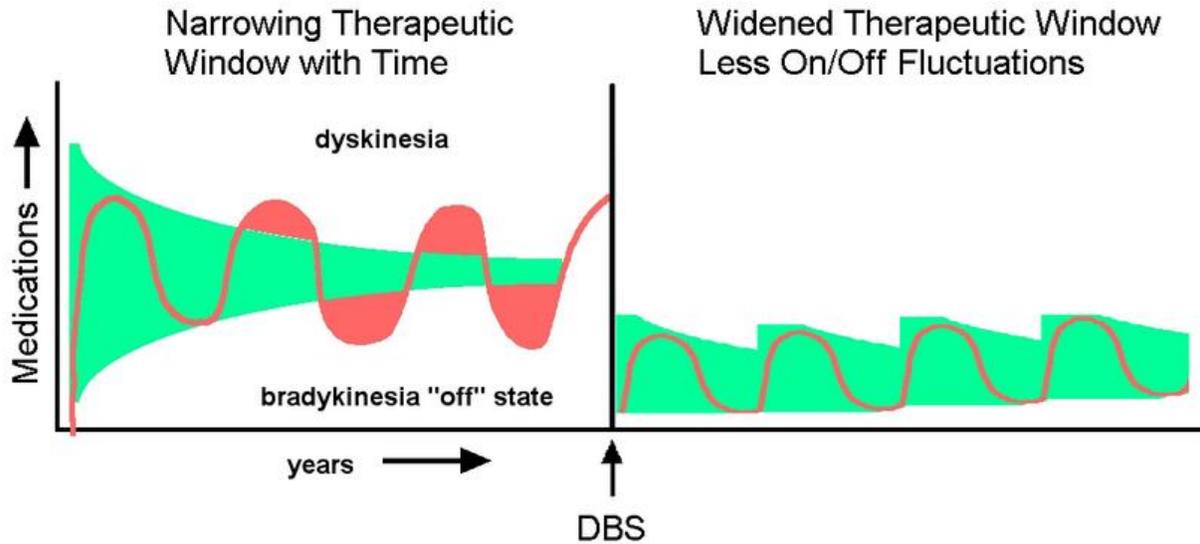
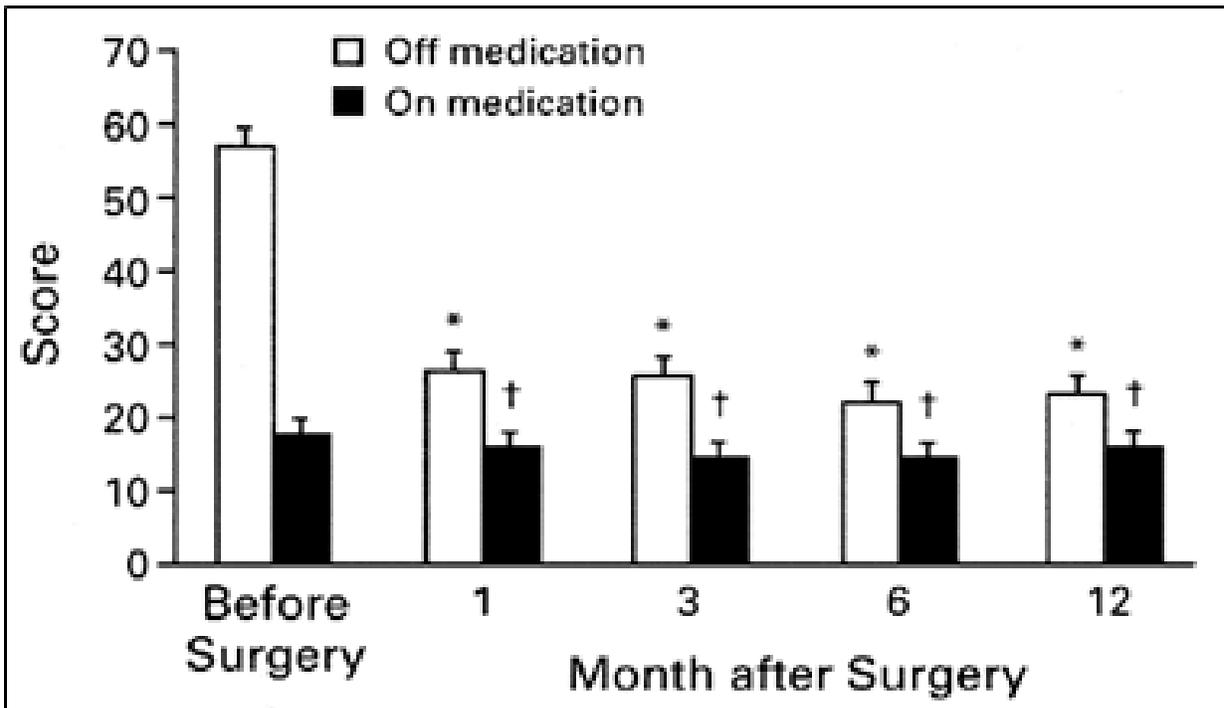


Figure 10: Outcomes from DBS Surgery, Bilateral STN, Score is UPDRS-III



## Deep Brain Stimulation Program – Kaiser Permanente Redwood City

### Essential Tremor

#### Redwood City Personnel (650) 299 - 2290:

- Mark Sedrak, MD: Director of Functional Neurosurgery, Northern California Kaiser Permanente
- Patrick Pezeshkian, MD: Functional Neurosurgeon
- Ramon Quesada, MD: Physical Medicine and Rehabilitation (PMR) Physician
- William T Wong, MD: Interventional Psychiatrist
- Diana Bruce, PA: Physician Assistant in Functional Neurosurgery
- Ivan Bernstein, PA: Physician Assistant in Functional Neurosurgery, Surgery Scheduling Supervisor
- Eric Sabelman, PhD: Senior Bioengineer in Functional Neurosurgery
- Siddharth Srivastava, PhD: Bioengineer in Functional Neurosurgery
- Julie Perez: Medical Assistant to Functional Neurosurgery

#### Locations of Movement Disorders Team Red are surgical sites



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- Han Lee, MD: Movement Disorder Neurologist
- Carol Evans, NP: Movement Disorder Nurse Practitioner

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- Rima Ash, MD: Movement Disorder Neurologist

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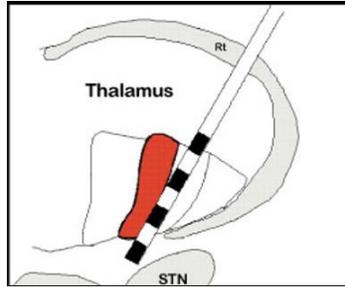
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**Other Regional Site:**

Kaiser Permanente – Sacramento (925) 295 - 7848

- Conrad Pappas, MD, Phd: Functional Neurosurgeon
- Suketu Khandhar, MD: Movement Disorder Neurologist, Director of Movement Disorders Program
- Dawn Levine, Phd: Neuropsychologists
- Steven Jinks, Phd: Clinical Neuroscientist/Neurophysiologist
- May J Kim, Phd: Neuropsychologist
- Catherine Nitifan-Young, FNP: Movement Disorders Nurse Practitioner



*(Ventral Intermediate Nucleus (VIM) of the Thalamus)*

## How To Become Eligible for Deep Brain Stimulation?

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If there are no clear contraindications to surgery, the case file is brought to the Movement Disorders Board, which is a panel that meet approximately every 6 weeks. During this meeting, the entire case is reviewed, history, medication trials, videos of patient, neuropsychological evaluation, and MRI/Imaging. A group consensus needs to be made for patient to continue on meeting the surgical team. Also, during this meeting, a decision about the target is typically made. For essential tremor, the target is the thalamus (Ventral Intermediate Nucleus of the Thalamus). For dystonia, the target is typically the globus pallidus interna (GPi). For Parkinson’s disease, there are multiple possible targets, but most commonly subthalamic nucleus (STN) and globus pallidus interna (GPi). In PD, STN may be favored by our group if patient doesn’t have significant psychiatric comorbidities, impulse control problems, if there is tremor dominance, and to maximize medication reduction. The literature is essentially split between these two targets, but STN is a smaller target that requires higher precision than GPi and STN has a slightly faster response time (figure 1). STN can also be used in difficult/complex essential tremor patients as a secondary resort. Lastly, there is usually a decision about staging an operation (2 surgeries instead of 1) and also about different battery types (Activa PC, dual channel non-rechargeable; Activa SC, single channel non-rechargeable, or Activa RC, dual channel rechargeable). The advantage of the dual channel devices, is that the patient would only require 1 general anesthesia event (during the time of tunneling to the chest). However, in comparing the SC to the PC, the SC has about 30% more battery life. SC’s and PC’s typically last about 3-6 years and require replacement surgery which is an outpatient local anesthetic procedure. The RC requires charging, typically about 20-30minutes every 1-2 days, but if

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We all may know that CT and MRI scans give us images containing anatomical information about the internal structure of our body. These images acquired are in 2-dimensional slices. When aimed at the brain, these techniques provide images of the various structures in the brain, including the targets of interest for DBS surgeries. There is much discussion in the world of functional neurosurgery attempting to understand where each and every target is physically located not only in 2D space, but more importantly in 3D. How do we exactly know where the targets are? Do MRI's actually show the subthalamic nucleus (or other targets) and surrounding structures in enough detail? Although special MRI sequences can demonstrate where various structures seem to be located, these targets used for movement disorder surgeries are tiny and ambiguous even with the best of systems.

We do two special things in our program with regards to image guidance: specialized MRI diffusion tensor imaging/colored fractional anisotropy (DTI/FA), susceptibility weighted imaging (SWI), and a calibrated XR technique for real-time imaging in the operating room. The DTI/FA method, the technique on which we have published, gives us patient specific information about the structural organization of fiber/axonal tracts in the brain, which are pathways for the diffusion of water (i.e, high FA) in the brain, and which also connects various brain structures together. Hence, in addition to providing anatomical information, DTI/FA also provide information about the relative connectivity of brain areas. . Using computational techniques, the direction of water diffusion, and the amount of diffusion in that direction is combined in a spectacular color map. When used in combination with the classical MRI, it provides an enhanced information about the anatomical localization of the small DBS targets also in relation to the fiber tracts, and the pattern of water diffusion in their proximity. Secondly, we use an amazing technique developed at Stanford that utilizes XR machines set up in the operating room, calibrated to a very specific fixated point, which gives our bioengineer the ability to calculate positions in the brain in real-time. We uniquely have the ability to calculate even the position of the microelectrode recordings in addition to the

DBS electrode. These can be calculated relative to each other or relative to referential structures in the brain, the actual landmarks used for MRI/CT guidance. In addition, this method is the most accurate method of calculating positions that is known in the world (accurate to 0.6mm or better)! It is more accurate than intraoperative MRI, intraoperative CT, fluoroscopy, or frameless systems. In addition, it is notable that MRI and CT systems have a theoretical problem of depth/angular measurement error as a result of software “smoothing” called interpolation. The XR system we use, does not have this problem. So at the end of our surgeries, we are quite certain about our stereotactic location.

### **Microelectrode Recordings:**

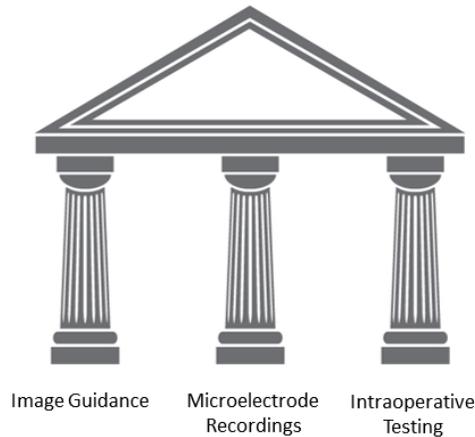
It is amazing to think that we now have the ability to measure electrical activity (action potentials) created by single neurons and a small cluster of neurons in the brain. This ability to visualize brain activity at the level of a single neuron has led to the discovery of many structures within the brain, hinting at their role in understanding the functional organization of this extremely complex organ. This method has become a very useful tool for neurosurgeons to identify many of the key targets during deep brain stimulation. During the time we measure these actual “action potentials” (actual neurons firing!), we can induce activity by manipulating the arm, the leg, or sometimes by flashing light in the eyes and many other maneuvers. The target areas of the brain become very active when patients are awake and off of their medications (typically 1-2 days). This is a second layer of assurance that have identified the proper position in the brain. We perform an XR when we identify the target and ensure that the DBS electrode eventually will make it to the same exact spot we want, with the help of our calibrated XR technique.

In addition to these MER’s, we’ve recently started utilizing what are called “local field potential” recordings. This method is similar to what many know as EEG/ECOG, where pools of neurons are sampled for their electrical activity. However, we are measuring these fields of neurons deep within the brain rather than on the surface. It turns out that many of the LFP signals may in fact help us understand the overall activity in a certain portion of the brain. This information is typically not utilized during the procedure, but can be analyzed when recorded afterwards.

### **Intraoperative Testing:**

The last and final test is one of the most important. “What happens when we introduce electricity in the brain at a specific target?”. This is a very critical step during the surgery. Patients do receive much local anesthesia at incision site (like numbing medication at dentist) in addition to having an anesthesiologist who administers some meds that won’t interfere with surgery, allowing some sedation (some patients even sleep). The awake testing can yield very critical information to the surgeon. For example, occasionally we can map the area we think is the best target utilizing MER, have our image guidance to get us to where we want to be, and we find that with stimulation at that precise target, we induce effects that suggest we are too close to surrounding structures. When this occurs, our knowledge of the mapped area and our image guidance help steer us away from these surrounding areas, giving our patients the best possible outcome and allowing our programmers the greatest degree of flexibility.

## Three Pillars to Successful DBS Operation



### **Staging Each Side of the surgery:**

We stage each side of the surgery for essentially 3 reasons. First, we have found that when both sides of the brain are exposed, patients tend to have more post-operative confusion. When each side is done individually, patients typically only require one night hospital stay. Second, we have noticed increased inaccuracy when both sides are done simultaneously, and our technique has demonstrated increased brain shift when this is done. Third, the physiology in the target site may actually be affected by the first site of implant. There is evidence that these regions are interconnected, both right and left. This interference seems to dissipate in a few weeks. We typically implant a dual channel implantable pulse generator (IPG; Activa PC or Activa RC) at the end of the second surgery under general anesthesia. If we implant single channel IPG's (Activa SC), we typically implant each generator at the end of each individual surgery. It is notable that we can do the surgeries in this format, which is our preference, because we are not under reimbursement practices as a result of Medicare and other insurers.

### **Activation of Device and Titration of Medications**

Typically after the entire system is implanted surgically, the device is off. Some patients notably have a “microlesioning” effect, where symptoms may improve slightly over hours, days, or weeks and then return to baseline. We allow this effect and any small amount of swelling in the brain to improve before turning on the device. This programming is typically done by the referring specialized movement disorder neurologist or associated personnel, about 2-4 weeks after surgery completion. Final effects from the DBS system, which has thousands of settings, may not be present for 6-12 months.

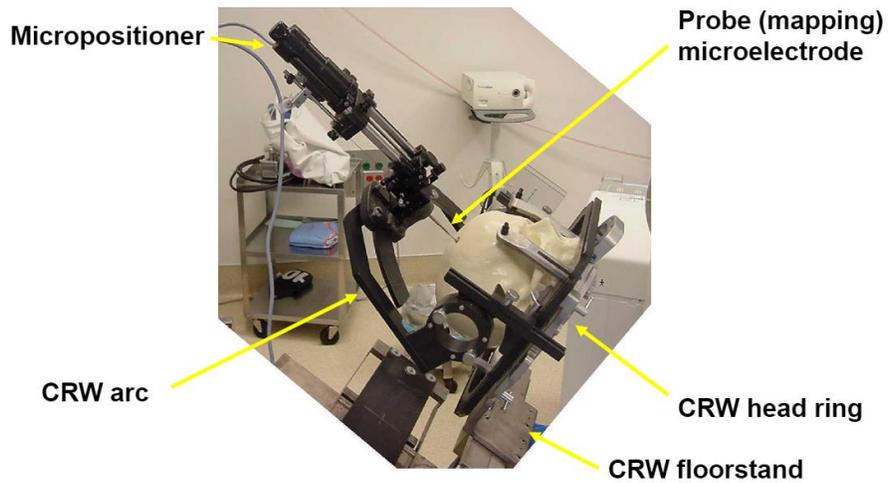
### **Team Approach:**

It is important to realize that the physicians of Kaiser are truly outstanding individuals, many of which are excellent at what they do, graduating top of their respective classes, and from top universities around the country. A major benefit of being a part of Kaiser, is that these physicians are truly driven to have the best clinical results. The clinicians are outcome driven, not income driven. Our approach in Northern California Kaiser, has been to take advantage of the system and integrate a full team approach for treating our movement disorders patients. With this in mind, a board was created, incorporating: functional neurosurgeons, movement disorder neurologists, neuropsychologists, bioengineers, physician assistants, nurse practitioners, nurses, and administrators who all take part in creating a consensus decision for each patient. This is an organized meeting where patients are formally presented, they are videotaped in “On” and “Off” medication states, formal UPDRS-III (Parkinson’s Scale) scores are tabulated, MRI’s are reviewed, neuro-psychological evaluations are discussed. With all this information in mind, the board decides who will most likely have a significant benefit and who may not, who may be high risk and who

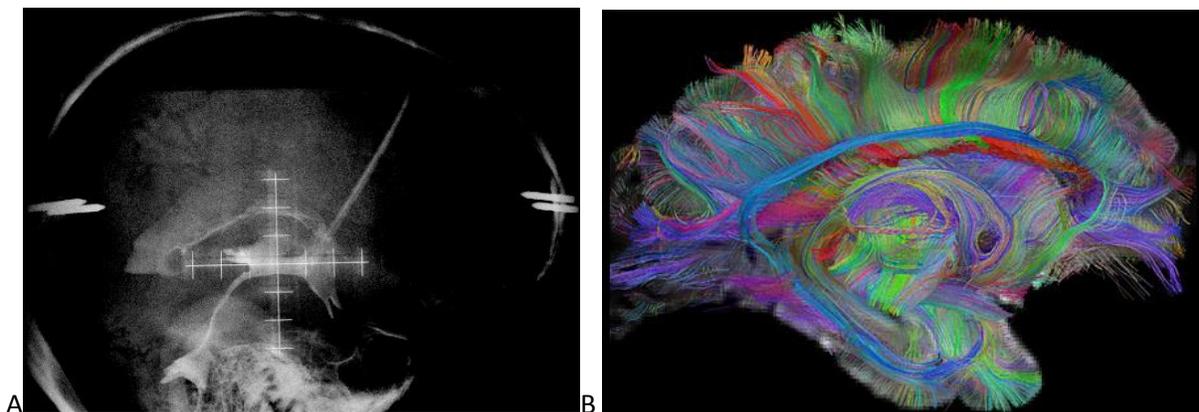
should be able to tolerate the surgery without a problem. This type of board meeting is very unique. Most institutions simply work using “hallway conversations” or simple consultations/referrals for this type of advanced surgery. In addition, we have a dedicated group in the operating room, anesthesiologists, nurses, operating room technicians, circulators, all specifically dedicated to DBS surgeries. This team approach adds another layer of clinical excellence to our overall program.

## Appendix:

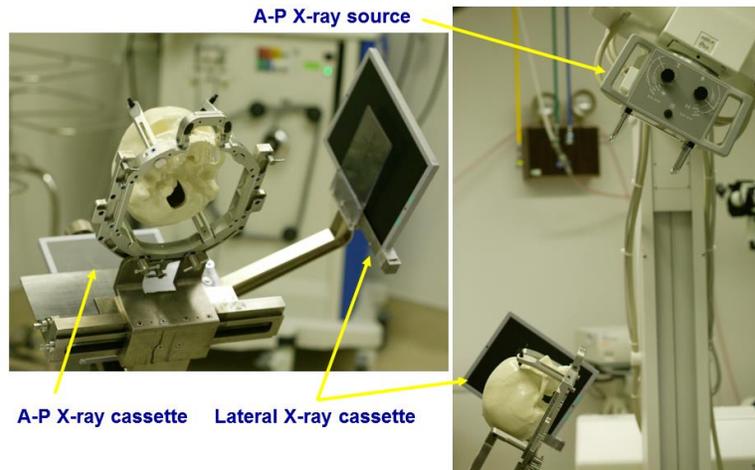
Picture 1: Example of Stereotactic Frame and equipment



Picture 2: A: Ventriculogram. XRay taken after injected contrast is delivered in the brain, allowing for internal landmarks to be imaged and direct ultra-precise calculations to be measured. B: Diffusion Tensor Imaging (DTI) showing actual tracts within the brain, helping the surgeons pinpoint patient specific regions within the brain itself.



Picture 3: X-Ray setup, with to both AP and Lateral Image Sets



Picture 4: Demonstration of “curving” of a lead in the operating room. Despite this movement, we are able to calculate a very precise location.

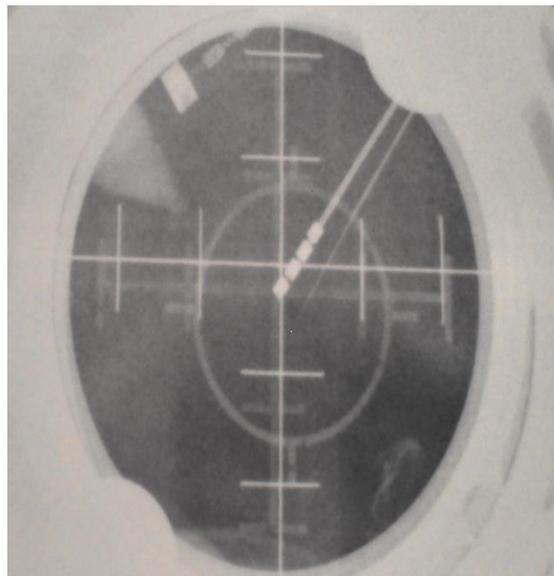


Figure 5: Microelectrode recordings are performed, measuring single cell and multiunit activity in the brain.

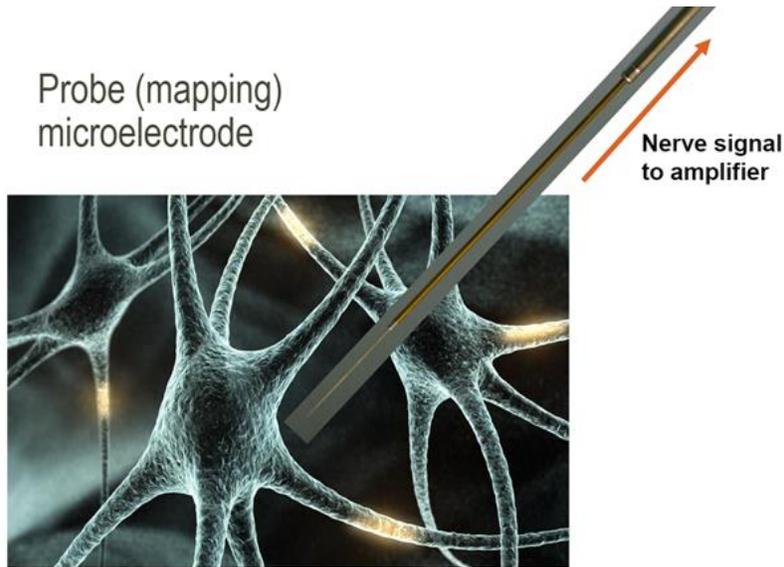


Figure 6: Microelectrode recordings demonstrate key findings in different parts of the brain

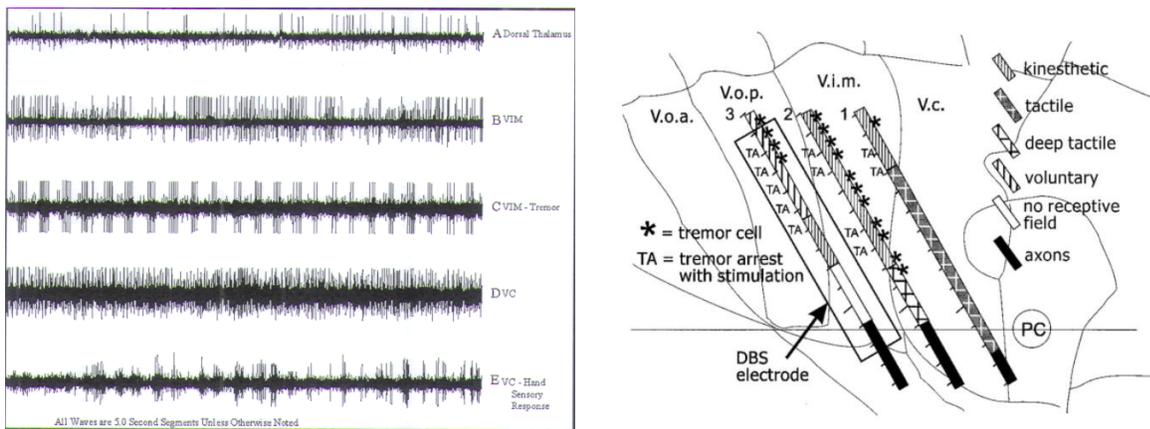


Figure 7: Navigus cap, which mounts the electrode lead to the skull

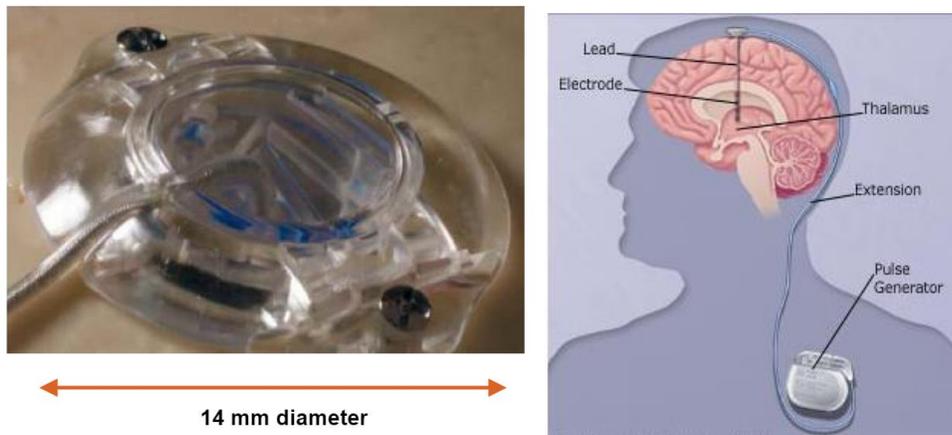


Figure 8: Depiction of preoperative tremor (A) and post-operative with DBS on (B)

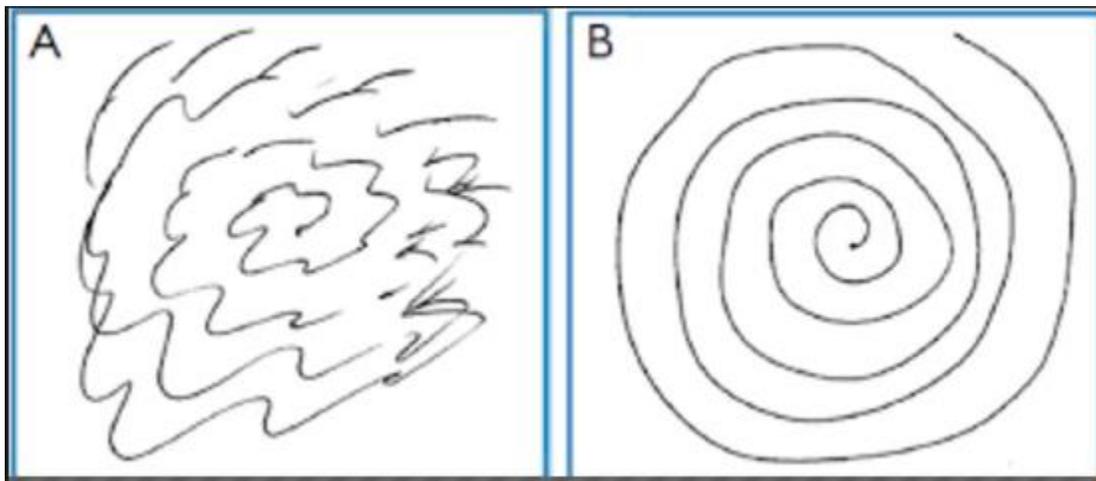
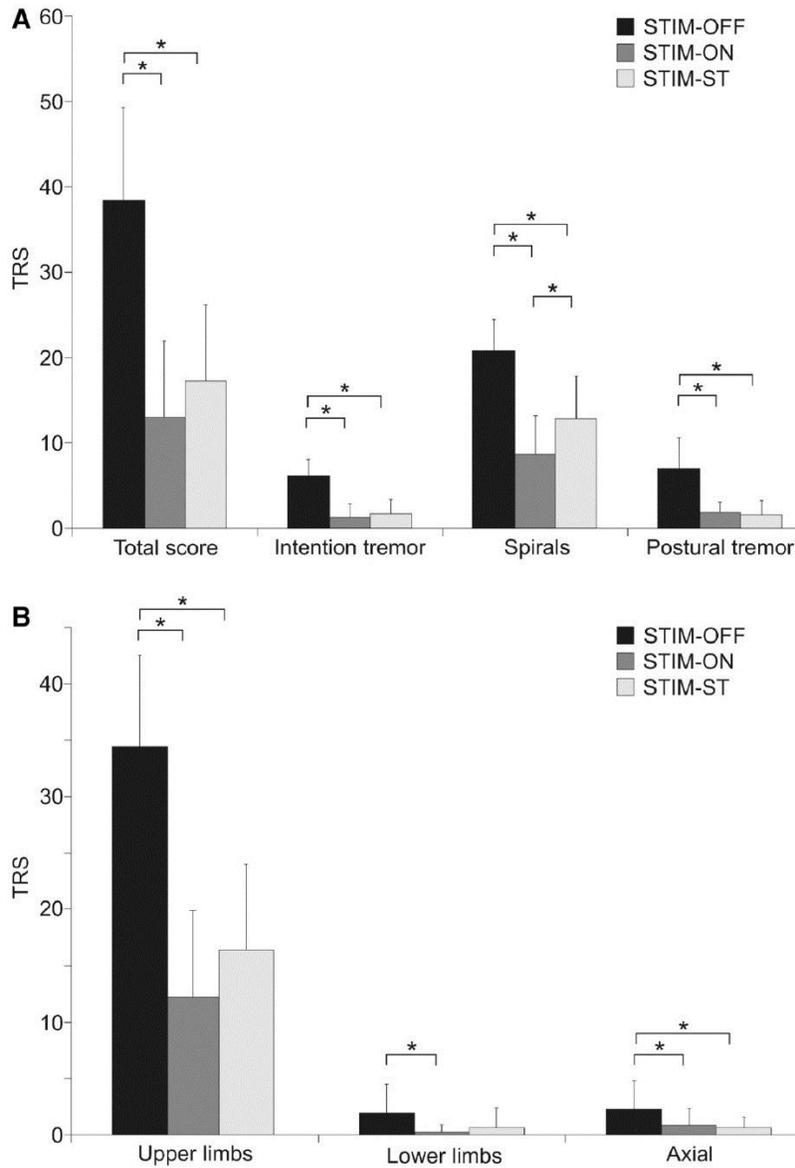


Figure 9: Thalamic DBS either using postoperatively optimized therapeutic stimulation parameters (STIM-ON) or supra-therapeutic stimulation (STIM-ST) was highly effective in reducing tremor when compared with no stimulation (STIM-OFF). Both types of stimulation significantly reduced the Tremor Rating Scale (TRS) total score and all subscores (tremor location-severity and drawings) except for the lower limbs during supra-therapeutic stimulation (STIM-ST). Supra-therapeutic stimulation effect did not significantly differ from stimulation on (STIM-ON) except for the drawing (spiral) scores. \* $P < 0.05$ . (TRS=Fahn-Tolosa-Marin Tremor Rating Scale)



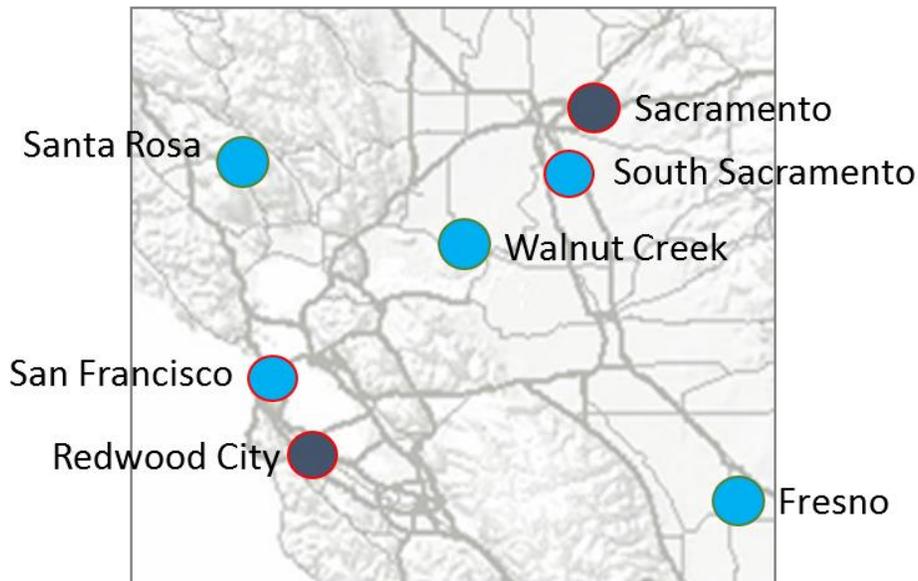
## Comprehensive Level 4 Interventional Pain Program

### Kaiser Permanente Redwood City

#### Redwood City Personnel (650) 299 - 2290:

- Taissa Cherry, MD: Anesthesiologist, Interventional Pain
- Mark Sedrak, MD: Director of Functional Neurosurgery, Northern California Kaiser Permanente
- Patrick Pezeshkian, MD: Functional Neurosurgeon
- Diana Bruce, PA: Physician Assistant in Functional Neurosurgery
- Ivan Bernstein, PA: Physician Assistant in Functional Neurosurgery, Surgery Scheduling Supervisor
- Eric Sabelman, Phd: Senior Bioengineer in Functional Neurosurgery
- Siddharth Srivastava, Phd: Bioengineer in Functional Neurosurgery
- Julie Perez: Medical Assistant to Functional Neurosurgery

## Locations of Regional Implant Pain Programs



Outlined **Red** Filled **Gray** are implant surgical sites

Outlined **Red** Filled **Blue** are trial and management sites

Outlined **Green** Filled **Blue** are medical management sites

Intrathecal Pain Pump Management at San Francisco, Redwood city and South Sacramento

## **Kaiser Permanente – Northern California Service Areas**

### **DIABLO Service Area (WCR, MTZ, ANT) 925-372-1741**

#### **DIABLO 1 ANS Epidural Clinic**

Dr Angela Chiang                      Dr Cynthia Rahn  
Dr Mark Rahn                              Dr Sabrina Martinez  
Dr Prakash Raygor                      Dr Mark Moore

### **DIABLO 2 ANS Interventional Pain Clinic 925-372-1283**

Dr Andrew Maher  
Dr James Mura  
Dr Darko Vodopich  
Dr. Norm Aleks

### **DIABLO 3 PMR/SPINE CLINIC (925) 313-4740**

Dr. Eric Alexander

### **Fresno (559) 448-4555**

Dr. Eugene Huang (ANS)  
Dr. Jonathan Grossman (PMR/SPINE CLINIC)  
Dr. Rupinder Singh (ER)  
Dr. Marta Bator (ANS - Pool)

### **Modesto & Stockton Chronic Pain & Interventional Pain 209-735-3255**

Dr Tanja Frey - ans  
Dr Brandon Valine  
Dr. Raul Calderon

**Petaluma Intervention Pain Clinic PMR/SPINE CLINIC** 415-444-2988

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Dr Vitto

Dr Tabitha Washington

**Redwood City 1 of 2– ANS/NSG** 650-299-5454

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Dr. Mark Sedrak (NSG)

Dr. Patrick Pezeshkian (NSG)

PA Ivan Bernstein

PA Diana Bruce

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Dr Ray Lai

Dr Maratukulam

Dr Nguyen

Dr Treinen

**Richmond PMR/SPINE CLINIC** 510-307-1661

Dr John H Lim PMR/SPINE CLINIC

Dr Angelita Balbas PMR/SPINE CLINIC

**Roseville PMR/SPINE CLINIC** 916-771-6611

Dr William Fenton - ANS

Dr Mark Tyburski

Dr Ryan Carver

**Sacramento (916) 973-5490**

Conrad Pappas, MD (Neurosurgery)

**San Francisco Pain Interventional Center- ANS** 415-833-0095

Dr Justin McKendry ANS

Dr Taissa Cherry ANS

Dr Salman Dasti

**San Leandro (Union City) books appts/epidurals are done in Fremont PMR/SPINE CLINIC** (510) 675-3070

Dr Eunice Lau (chief) - PMR/SPINE CLINIC

Dr Sergiy Rybiy

Dr Raghu Katragadda ANS

**San Jose (Santa Theresa) Interventional Pain ANS** 408-972-6283

Dr Darshan Patel

Dr Samuel Park

Dr Shabeen Tharani

Dr Prasad Movva

Dr Laurence Won

Dr Vital Kandula

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Dr Murphy

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Dr. Tabitha Washington (ANS)

**South Sacramento Pain Clinic (ANS)** (916) 688-6353

Dr Mike Bicocca

Dr Rod Youssefi

Dr Kegang Hu

Dr Sabina Tahera

**South San Francisco ANS Pain Services** 650-742-2395

Dr Eddie Busracamwongs ANS

Dr. Hamid Motamed

Dr. Tin-Na Kan

Dr. Ali Abdollahi-Fard

**Santa Clara PMR/SPINE CLINIC** 408-851-9200

Dr Richard Kim

Dr Kevin Wang

Dr Dhiruj Kirpalani

**Vallejo – PMR/SPINE CLINIC (707) 651-1025**

Dr. Linda Cho (PMR/SPINE CLINIC)

## SPINAL CORD STIMULATION, PERIPHERAL NERVE STIMULATION

Spinal Cord Stimulation (SCS) or Dorsal Column Stimulation (DCS) is a treatment for primarily for limb pain, chronic regional pain syndrome (CRPS). This technology uses a low- voltage current to block nerve impulses in the spinal cord traveling from a troubled area to the brain. Peripheral Nerve Stimulation (PNS) uses the same technology, with targeted nerves and nerve bundles. PNS is useful in some headaches, facial pain, pelvic and groin pain. These technologies are not cures for these various pain syndromes, but sometimes can alleviate pain. Stimulation typically induces a smooth tingling sensation in the area of interest. The amount of pain relief varies for each person.

### ***Trial Period***

While SCS and PNS can be helpful in a number of people, it does not work in everybody. To help decide in whom this may or may not work, almost all patients have a trial implant to test the effectiveness. Typically for this week long trial period, we are looking for a substantial amount of ongoing pain relief, for specific areas of the stimulators which are contributing to pain relief, and in the end or a significant functional improvement in a patient's level of function and daily living. Some patients have some pain relief, but not enough to qualify for implant. Furthermore, some patients have no pain relief and likewise do not qualify.

The SCS trial begins with the surgical implant of the leads, usually done via a needle puncture, where the leads are placed along the back portion of your spinal cord. In the case of PNS, the leads are placed via needle puncture along the area in question as determined by the surgeon based on your description of location.

Little numbing medication is used during the insertion of the trial stimulator, in order to be able to test proper placement during the surgical procedure. You will be made comfortable for the surgery by the anesthesiologist ("twilight anesthesia"), but will remain awake so that the surgeon can determine if the lead placement is correct for your symptoms. Your feedback is important as you know where your pain is. We are looking for tingling in the area of the pain. We want to know during the procedure if we are inducing tingling in the area of interest and if we are covering it completely or if we are missing a particular area.

The tails leads are external, sutured and taped in place, and you will go home with the leads connected to a special box that will behave just as the implanted device would.

In the recovery room, and/or post-operative period, a representative from the company your doctor has chosen will do some programming and teach you how to use the patient remote control. Most people leave the hospital on the day of surgery. You may not shower for the entire period of the trial.

You will return on several occasions during the 7-10 period to have programming, working closely with the rep to achieve the best coverage and pain reduction possible. It is critically important during this trial period to keep a meticulous LOG of your pain levels, the program that

you are using, and to try different programs and turning device on and off to make sure it is functioning well for you.

The trial will end either when it is determined it is a successful trial or maximum on day 10. The leads are then pulled in the clinic at the bedside. This is a relatively painless procedure and you may shower the next day.

Occasionally, the trial period is performed using a full implanted electrode, which is buried underneath the skin like a permanent lead. This permanent lead is connected to temporary extensions and brought externally for a trial period. In this type of situation, the end of the trial results in either a full implant with a battery, or removal of the buried leads. Either way, this requires open surgery.

### ***Permanent Implant***

For those who have a successful trial, a permanent full implantation may be the next step. This surgery is typically a much bigger procedure than the trial, involving larger incisions. Patients may also be in the hospital at least overnight after a permanent implant. You may have the full implant surgery as early as three weeks after your lead pull, but sometimes a bit longer.

The surgery will go much the same as the trial with the addition of the IPG or generator placement. Most people choose this to be at the upper buttocks/flank, abdomen, or upper chest and you will have discussed this with your surgeon in advance.

You will have programming done similarly to the trial period. You will receive wound care instructions before you go home.

### ***Programming/Adjustment***

About 1- 2 weeks after your surgery you may return for programming. You will have post-operative care and can use those opportunities to have programming done by making arrangements both with the company's representative at the clinic where you are being seen. You can request additional sessions when you think your stimulation is not exactly where you need it. This can be done at any Kaiser facility, but must be under the supervision of a medical doctor, and must be coordinated with the provider and the company representative.

## **Intrathecal Pump Therapy**

Intrathecal pump therapy (ITP) is a pump device with a catheter that utilizes pain medications for infusion. ITP are useful for low back pain and cancer pain and are often used as a second line to stimulation therapy. The advantage of ITP is that it can afford a continuous infusion of pain medicine and can work for axial pain and cancer pain. The disadvantage of the therapy is that it required physical filling of the pump with a needle procedure every 6 weeks to 3 months and carries more long-term risk, especially of withdrawal problems. The amount of pain relief varies for each person.

### ***Trial Period***

While ITP can be helpful in a number of people, it does not work in everybody. To help decide in whom this may or may not work, almost all patients have a trial to test the effectiveness.

Typically for this week long trial period, we are looking for a substantial amount of ongoing pain relief, typically more than 50%.

### ***Permanent Implant***

For those who have a successful trial, a permanent full implantation may be the next step. This surgery is typically a much bigger procedure than the trial, involving larger incisions. Patients may also be in the hospital at least overnight after a permanent implant. You may have the full implant surgery as early as three weeks after your catheter trial, but sometimes a bit longer.

The surgery will go much the same as the trial with an incision in the back and in the abdomen on the left or right side. You will have discussed this with your surgeon in advance.

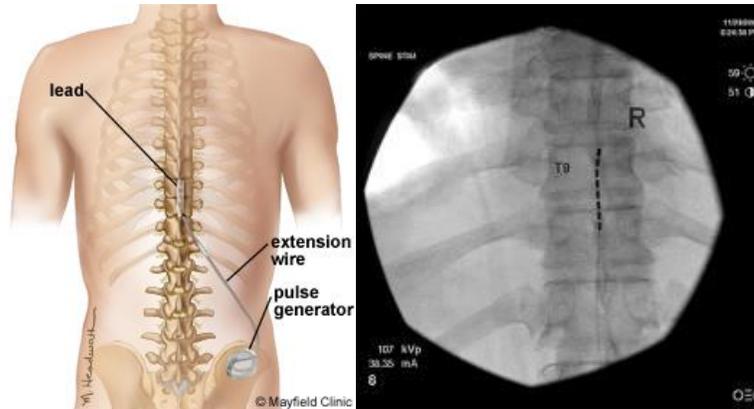
Your infusion will initially be set at a very low dose to avoid over-infusion problems. Over the next several months and years, the device can be programmed to optimally achieve therapy. You will receive wound care instructions before you go home.

### ***Programming/Adjustment***

Shortly after your surgery you may return for programming. You will have post-operative care and can use those opportunities to have programming done by making arrangements with the care management team, typically at either San Francisco, Redwood City, or South Sacramento facilities. You can request additional sessions when you think you're not exactly where you need to be for pain control. It is notable that not only can the infusion rate be adjusted with the device, but the actual formulation of the medications can be changed during each refill period, offering nearly innumerable possibilities.

## Appendix

Figure 1: Spinal cord stimulation



Spinal cord Stimulator as implanted    X-ray of a single lead in place

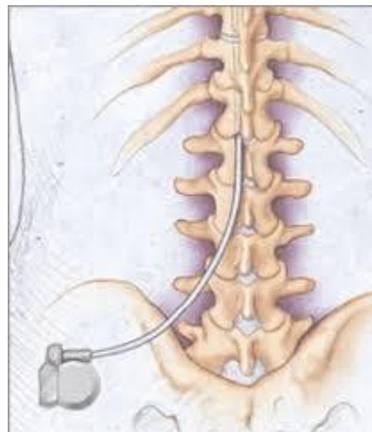


Figure 2: Peripheral Nerve stimulation, occipital and supraorbital locations



Figure 3: Different Companies offering therapy, including: Medtronic, St. Jude, Boston Scientific, Nevro, and Stimwave. Medtronic offers therapy that can be MRI compatible, monopolar compatible. St. Jude offers upgradable software, which may be able to accommodate “burst” stimulation in future. Boston Scientific offers the largest paddle’s and utilizes “independent current driver” technology. Nevro stimulates at 10,000 hertz, which offers paresthesia free stimulation. All of these technologies require an implanted battery, such as a pacemaker, except for Stimwave, which is wireless. With Stimwave, there is an external system that needs to be close by that will inductively stimulate the internal wire, with no implanted battery.



Figure 4: Differences between percutaneous and paddle leads, percutaneous are wire and cylindrical, whereas paddles are flat like a spatula

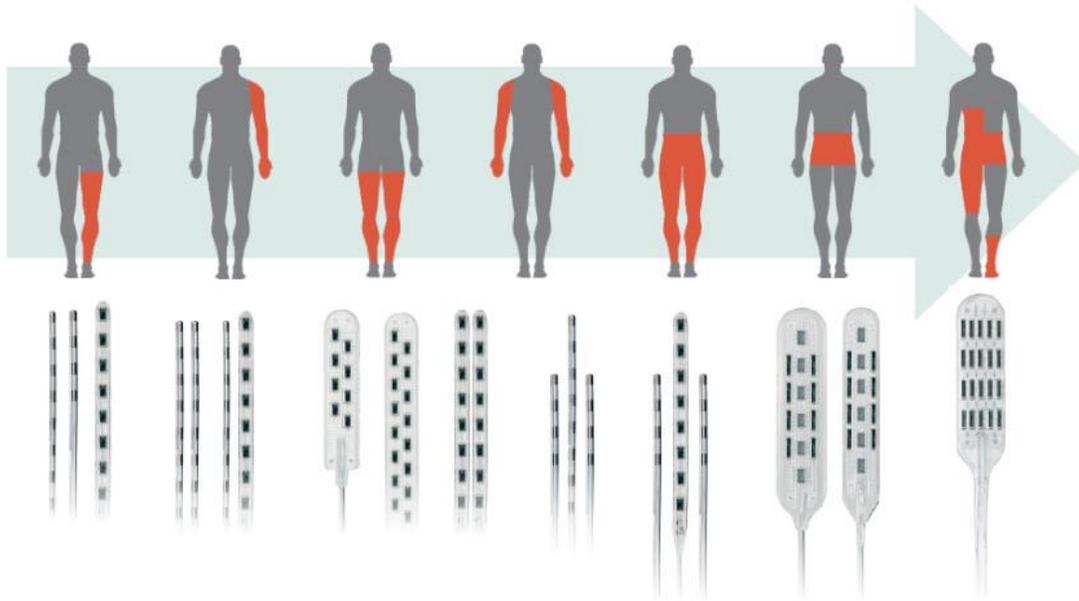


Figure 5: Intrathecal Pump, Medtronic Synchronomed II, there are 20cc and 40cc options

