



Neurointerventional Surgery: An Introduction



Mini-Medical School
Delaware Academy of Medicine

5/4/2023

Thinesh Sivapatham, M.D.

Department of Neurointerventional Surgery
Christiana Care Health System

CCHS
NEUROSCIENCES



Objectives

- Describe the field of Neurointerventional Surgery and the path to get here
- Overview of common neurointerventional procedures
 - Intracranial aneurysm treatment
 - Endovascular stroke treatment



What is Neurointerventional Surgery?

A field of medicine encompassing minimally invasive, image-guided procedures to diagnose and treat diseases of the brain and spine.

The Path to Neurointerventional Surgery

- Bachelor's Degree (4 years)
 - Me: Bachelor of Arts in Biological Basis of Behavior at The University of Pennsylvania
- Medical School (4 years)
 - Me: University of Tennessee College of Medicine
- Residency (4-7 years, including Internship year)
 - Radiology (5 years)
 - Me: The Ohio State University
 - Neurology (4 years)
 - Neurosurgery (6-7 years)

The Path to Neurointerventional Surgery

- Bachelor's Degree (4 years)
 - Me: Bachelor of Arts in Biological Basis of Behavior at The University of Pennsylvania
- Medical School (4 years)
 - Me: University of Tennessee College of Medicine
- Residency (4-7 years, including Internship year)
 - Radiology (5 years)
 - Me: The Ohio State University
 - Neurology (4 years)
 - Neurosurgery (6-7 years)

- Fellowship (1-2 years)
 - Radiology:
 - Neuroradiology (1-2 years)
 - Me: University of Pennsylvania (1 year)
 - Neurology:
 - Vascular Neurology or Neurocritical Care (1-2 years)
 - Neurosurgery:
 - Usually do 1 year of Neurointerventional Surgery during residency
- Neurointerventional Surgery (1-2 years)
 - Me: Cleveland Clinic Foundation (2 years)

The Path to Neurointerventional Surgery

- Bachelor's Degree (4 years)
 - Me: Bachelor of Arts in Biological Basis of Behavior at The University of Pennsylvania
- Medical School (4 years)
 - Me: University of Tennessee College of Medicine
- Residency (4-7 years, including Internship year)
 - Radiology (5 years)
 - Me: The Ohio State University
 - Neurology (4 years)
 - Neurosurgery (6-7 years)

- Fellowship (1-2 years)
 - Radiology:
 - Neuroradiology (1-2 years)
 - Me: University of Pennsylvania (1 year)
 - Neurology:
 - Vascular Neurology or Neurocritical Care (1-2 years)
 - Neurosurgery:
 - Usually do 1 year of Neurointerventional Surgery during residency
- Neurointerventional Surgery (1-2 years)
 - Me: Cleveland Clinic Foundation (2 years)

Radiology pathway -> Interventional Neuroradiologist
Neurology pathway -> Interventional Neurologist
Neurosurgery pathway -> Endovascular Neurosurgeon

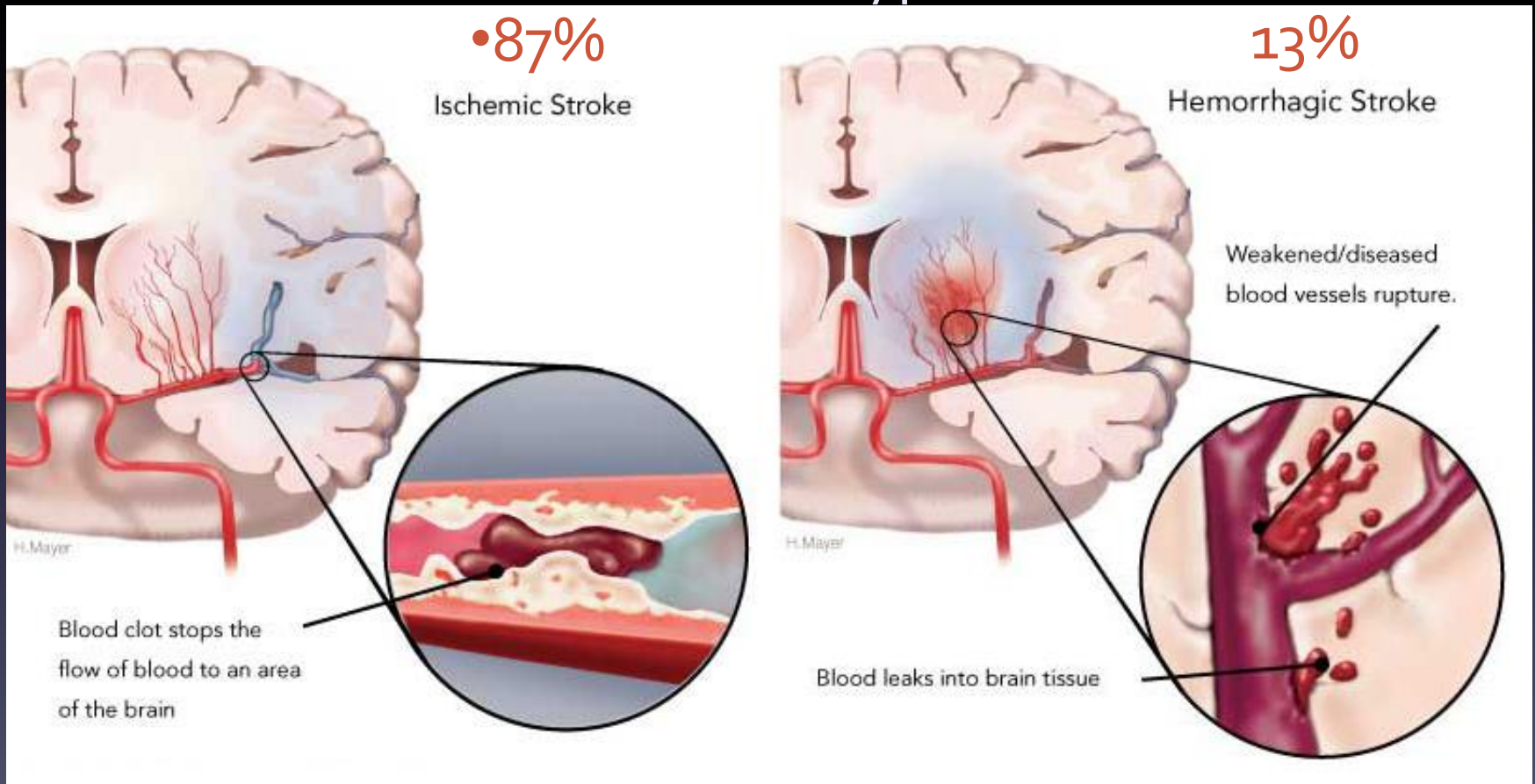


Neurointerventional
Surgeon

Spectrum of Neurointerventional Procedures

- Endovascular procedures of the brain and spine
 - Treatment of patients with stroke

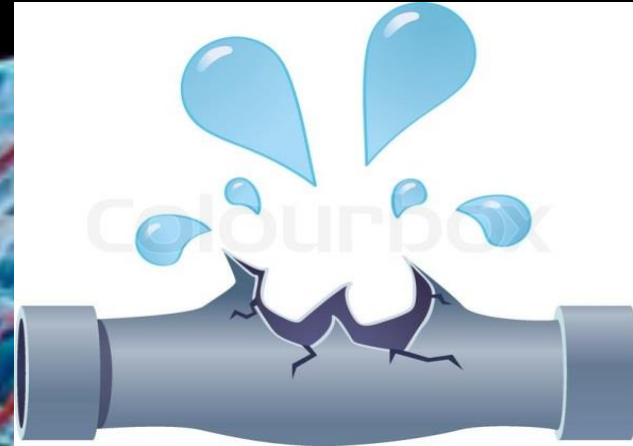
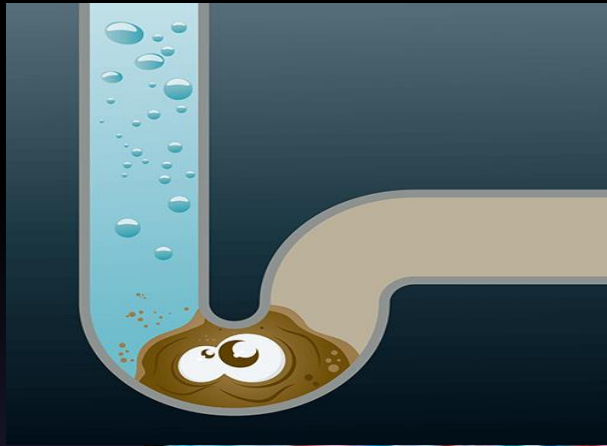
Stroke Subtypes



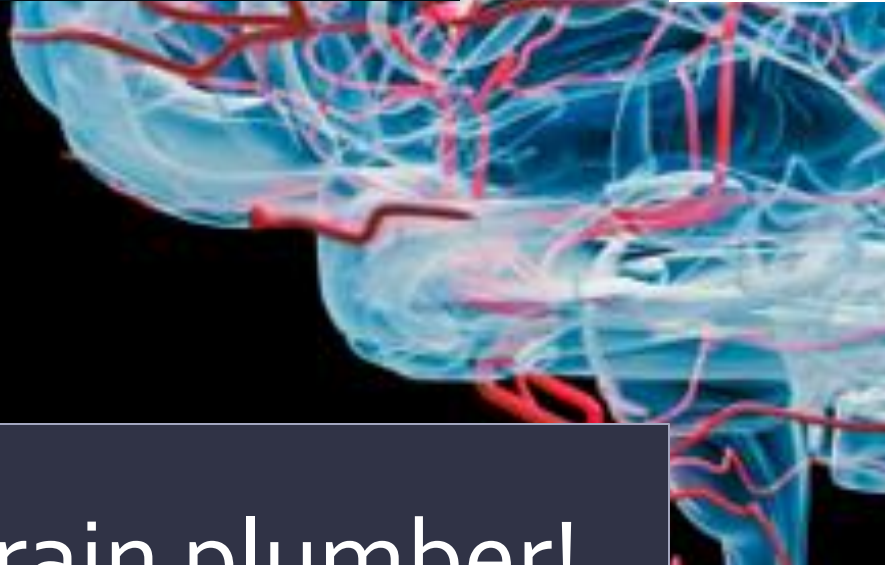
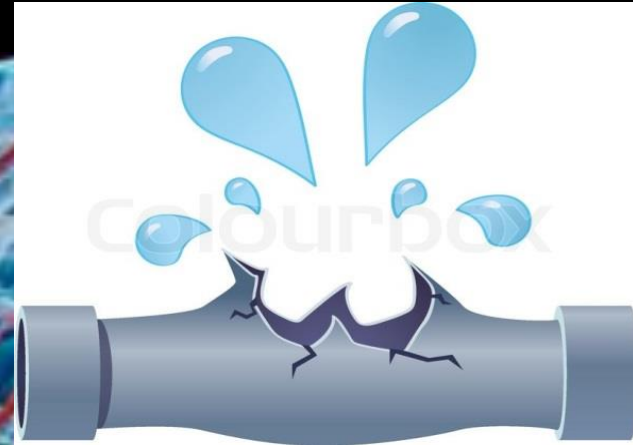
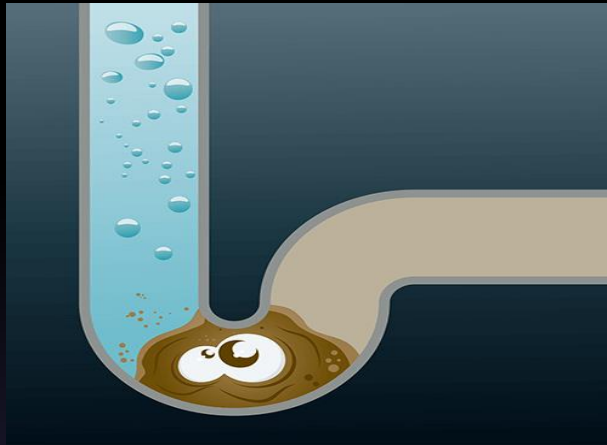
What is a Neurointerventionalist?



What is a Neurointerventionalist?



What is a Neurointerventionalist?



Brain plumber!

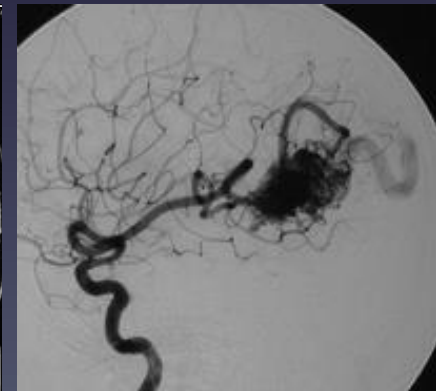
Spectrum of Neurointerventional Procedures

- Endovascular procedures of the brain and spine
- Minimally invasive spine procedures
- Other image guided procedures

Spectrum of Neurointerventional Procedures

- Endovascular

- Cerebral angiography
- Mechanical thrombectomy for acute ischemic stroke
- Intracranial/extracranial angioplasty/stenting (Carotid)
- Intracranial embolization
 - Aneurysm treatment
 - AVM/AVF embolization
- Extracranial embolization
 - Epistaxis treatment
 - Tumor embolization
 - Carotid blowout
 - Trauma
 - Head/Neck cancer
- Vasospasm treatment
- Spinal angiography/embolization
- Venous procedures
 - Thrombectomy for dural venous sinus thrombosis
 - Venous angioplasty/stenting
- Balloon test occlusion
- Wada testing



Spectrum of Neurointerventional Procedures

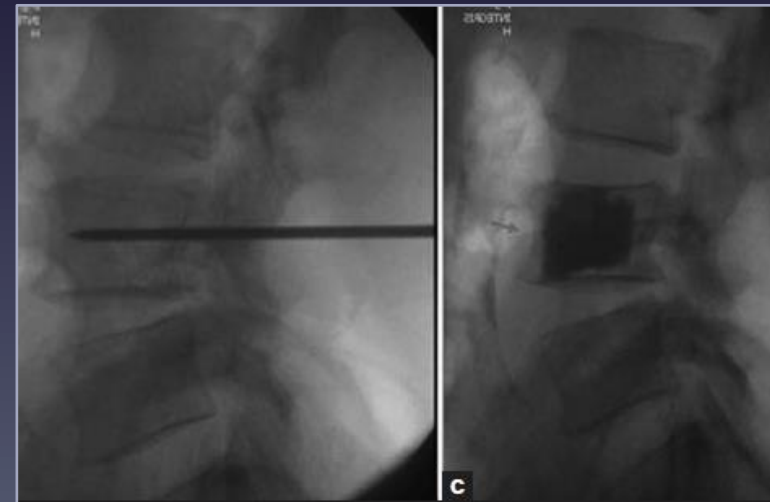


- Spine

- Vertebral augmentation
 - Vertebroplasty/kyphoplasty
- Pain injections
 - Epidural steroid injections
 - Selective nerve root blocks
 - Facet joint injections
 - Lumbar sympathetic blocks
- Biopsy
 - Spine/disc
 - Paraspinal masses
- Lumbar puncture
- Myelography
- Blood patch
- Lumbar drains

- Other image guided procedures

- Biopsy of head/neck masses



Neuro Endovascular Procedures

- Digital subtraction angiography (DSA)
 - Inject dye into blood vessel through catheter
 - Computer “subtracts” bone so we can see blood vessels better
- Biplane fluoroscopy
 - Radiation based image-guided procedures
 - Biplane = 2 views at the same time



Neuro Endovascular Procedures

- Digital subtraction angiography (DSA)
 - Inject dye into blood vessel through catheter
 - Computer “subtracts” bone so we can see blood vessels better
- Biplane fluoroscopy
 - Radiation based image-guided procedures
 - Biplane = 2 views at the same time



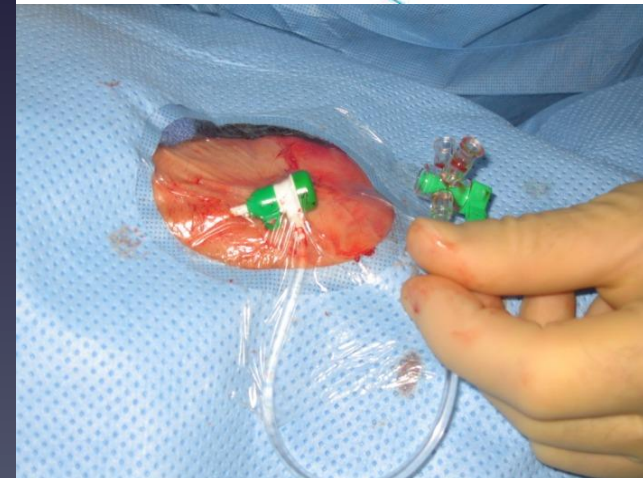
Neuro Endovascular Procedures

- Digital subtraction angiography (DSA)
 - Inject dye into blood vessel through catheter
 - Computer “subtracts” bone so we can see blood vessels better
- Biplane fluoroscopy
 - Radiation based image-guided procedures
 - Biplane = 2 views at the same time



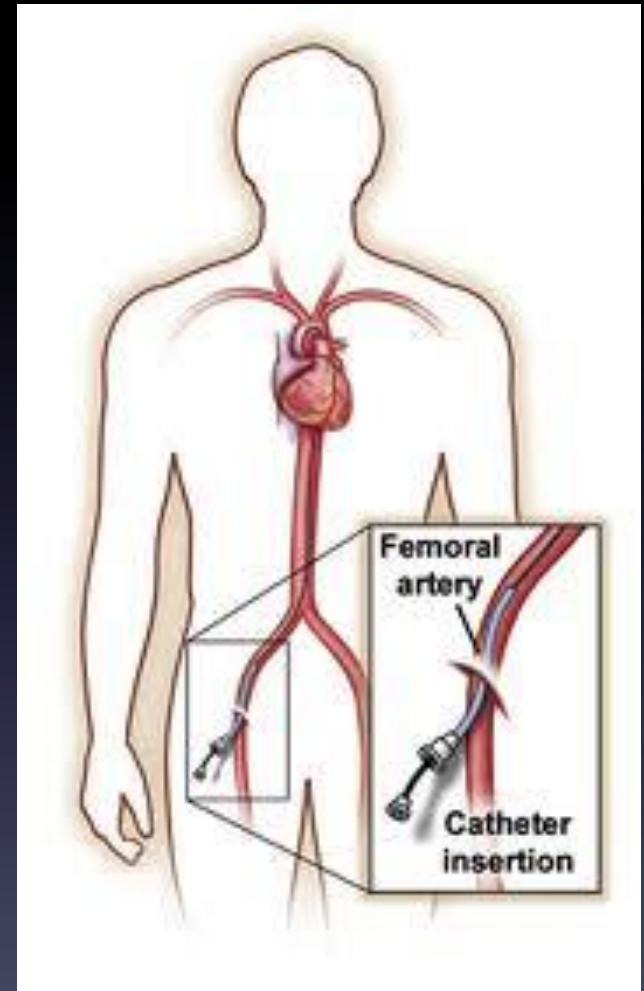
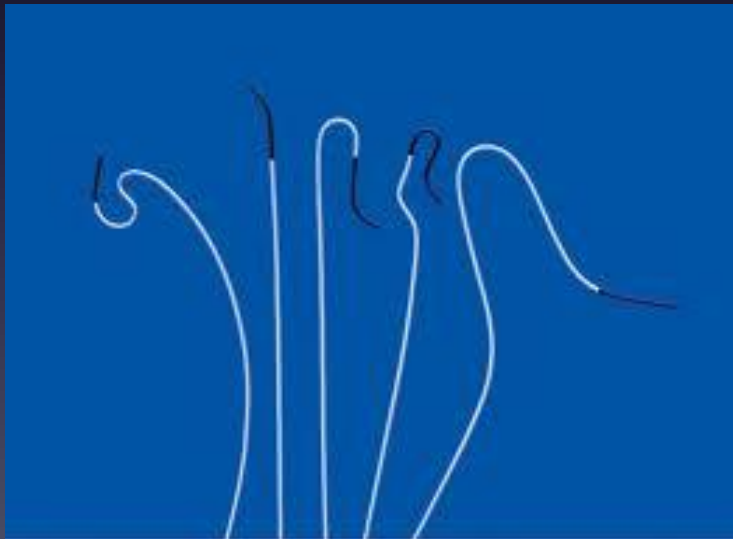
Neuro Endovascular Procedures

- Arterial access
 - Typically common femoral artery (usually right)
 - Crease of the leg near groin region
 - Alternate routes:
 - Radial (wrist), brachial (upper arm), and rarely carotid (neck) arteries
 - Local anesthetic/lidocaine
 - Numbing medicine for skin
 - Small skin incision (3-5 mm)
 - Small needle placed into artery
 - Needle exchanged over a wire for sheath
 - Small tube that maintains access to artery



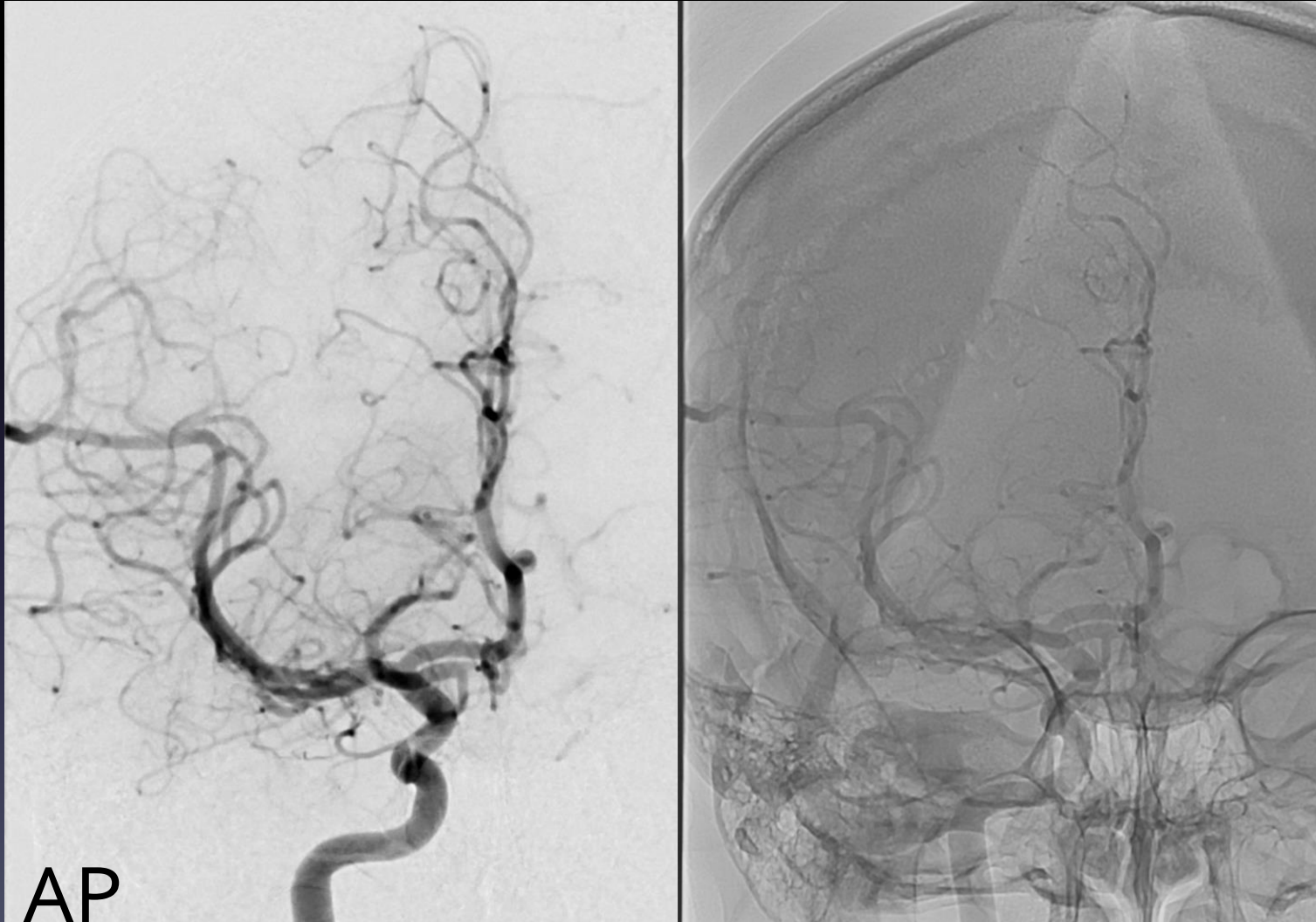
Neuro Endovascular Procedures

- Catheter advanced over a wire into aortic arch and vessels selected
 - Catheters are plastic tubes through which we can inject dye to take pictures
 - Catheters also provide access to deliver treatment devices to the brain
 - Come in different shapes and sizes



Cerebral angiography

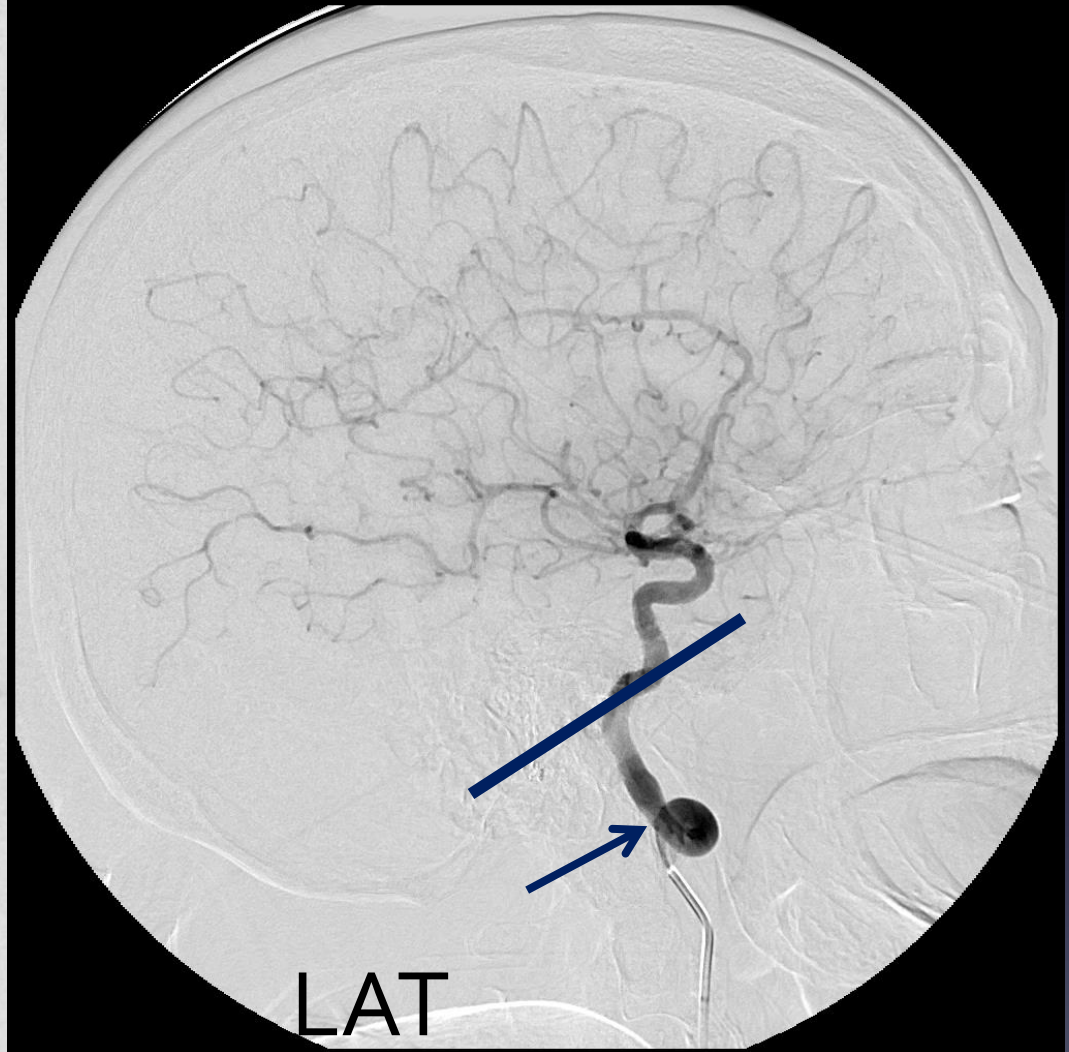
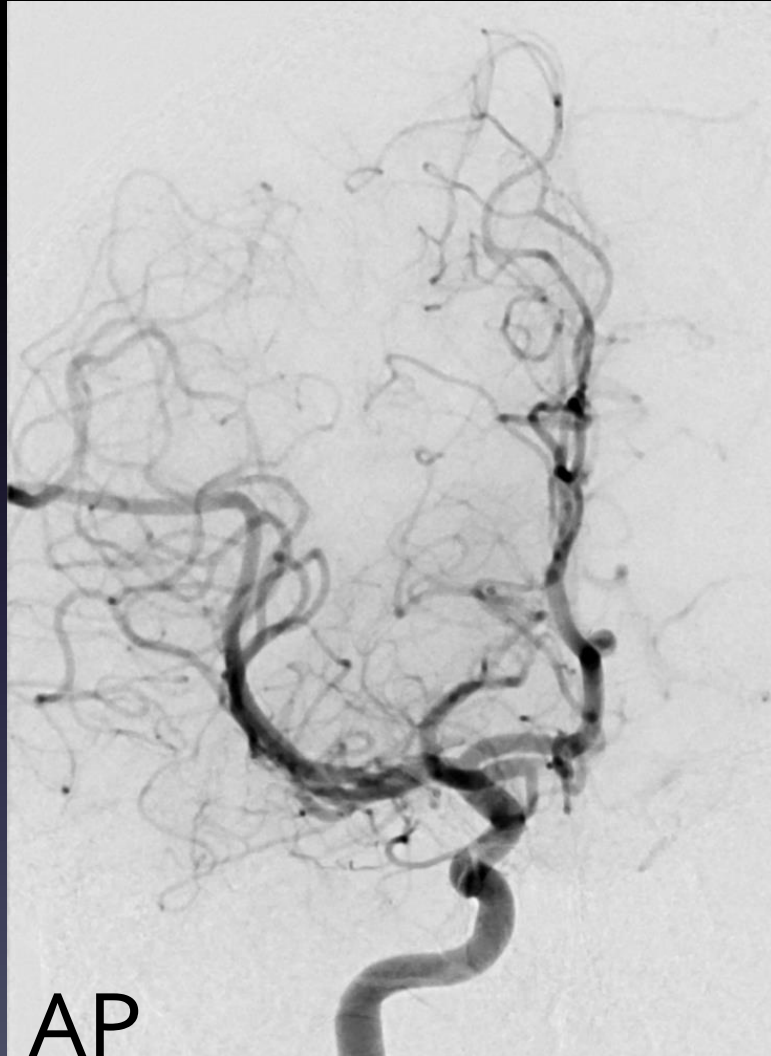
Right internal carotid artery



Digital subtraction angiography (DSA)

Cerebral angiography

Right internal carotid artery



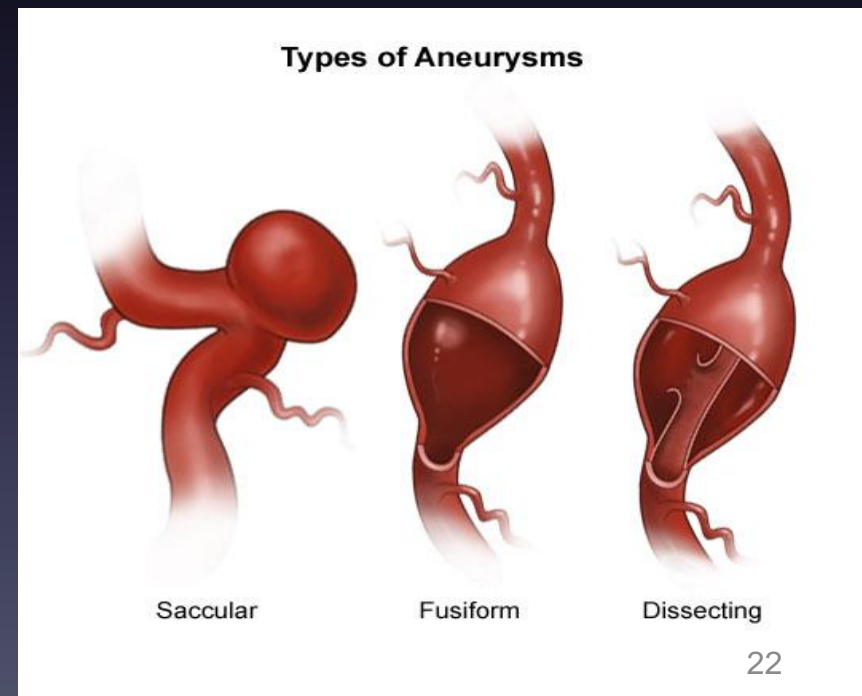
Digital subtraction biplane angiography

Endovascular Treatment of Intracranial Aneurysms



What is an aneurysm?

- Abnormal dilation of an artery
 - Generally due to weakening of artery wall
- Can occur anywhere in the body, but more common in arteries of the brain
 - Intracranial arteries have thinner walls
- Different types
 - Saccular
 - Fusiform
 - Dissecting

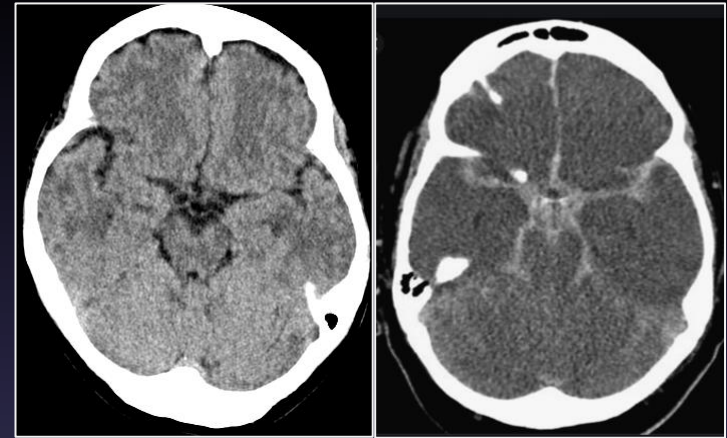


Intracranial Aneurysms

- Prevalence of intracranial aneurysms ~ 3%
- Not all aneurysms are the same, and not all aneurysms need to get treated
 - Probably only ~ 1-2% of intracranial aneurysms rupture
 - Annual rupture risk can range from < 1% to > 10%
 - Depends on size, shape, location of aneurysm and individual risk factors
 - Need to weigh risk of the aneurysm bleeding over the course of the patient's lifetime vs. the risk of treatment

Subarachnoid Hemorrhage (SAH)

- Bleeding into the cerebrospinal fluid (CSF) spaces around the brain (subarachnoid space)
- Most common causes:
 - Trauma
 - Aneurysm rupture
 - most common cause of non-traumatic SAH



Morbidity and Mortality of SAH

- Mortality of aneurysmal SAH can be up to 40-50%
 - 15% before reaching hospital
- Of survivors, an additional 40-50% will be disabled or have permanent neurologic deficits
- Only about 30% of patients who suffer aneurysmal SAH will return to functional independent living

Complications of SAH

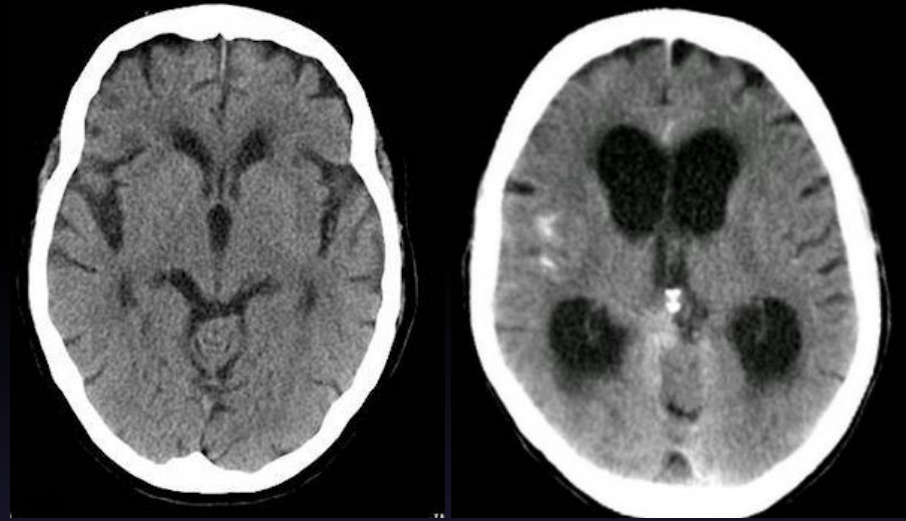
- Rebleeding of the aneurysm
 - If untreated, 2-4% risk per day for the first 10 days
 - 30% risk during first 30 days
 - 2-4% per year thereafter
 - Ruptured aneurysms are always treated if feasible

- Seizures
 - Occur in about 8% of patients

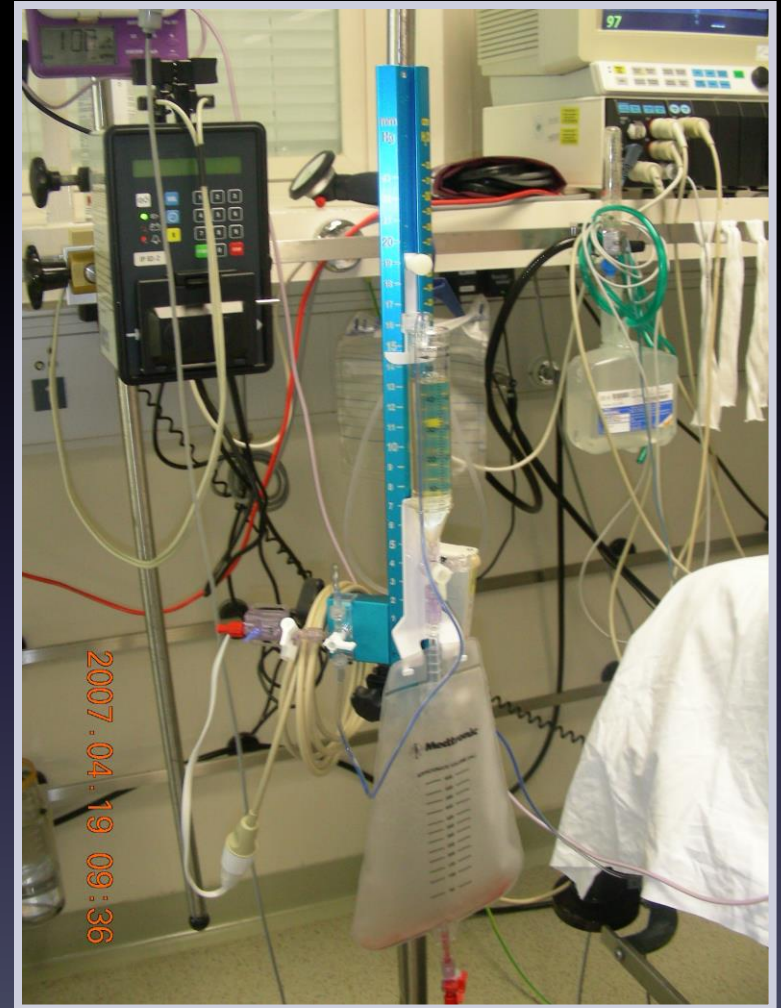
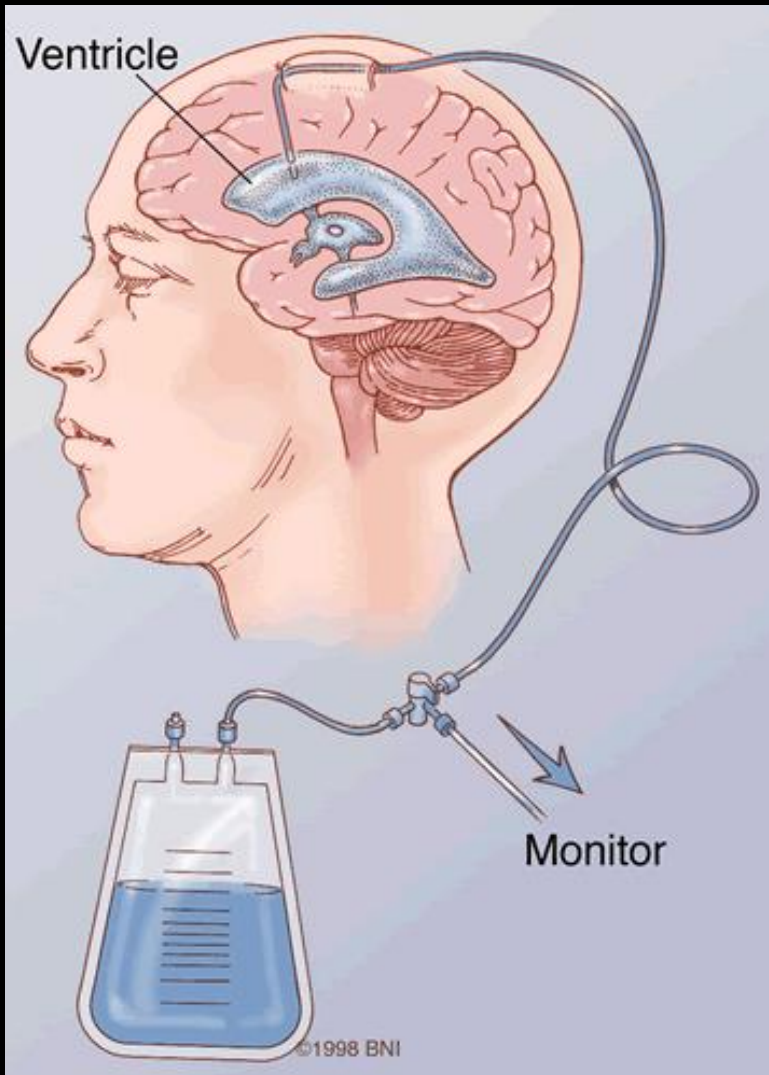
Complications of SAH

- Hydrocephalus

- Dilated ventricles due to obstruction of normal CSF flow by blood
- May cause decreased level of consciousness and increased intracranial pressure
- May require CSF drainage with ventriculostomy (EVD or external ventricular drain) – placed by neurosurgeon

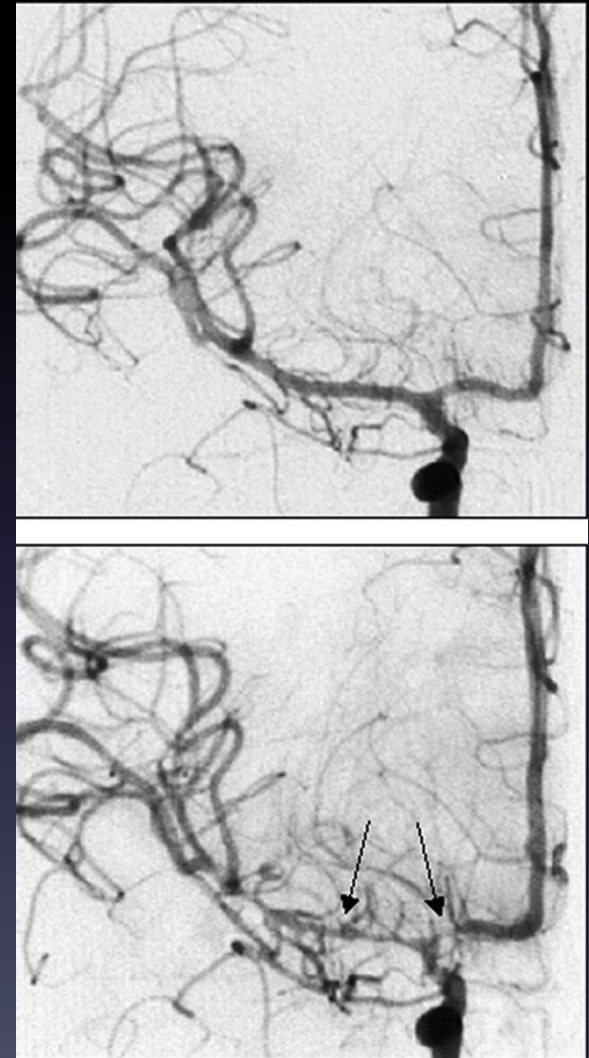


External Ventricular Drainage



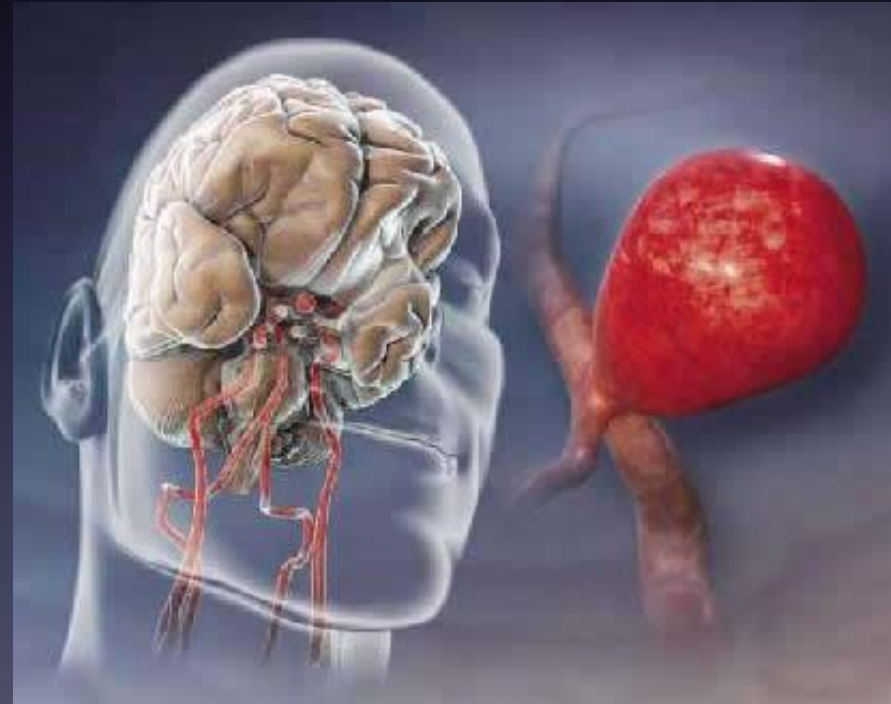
Complications of SAH

- Vasospasm
 - Narrowing of intracranial arteries after SAH
 - Typically occurs days 3-14 after SAH
 - Can result in stroke if not treated
 - Leading cause of death and disability in SAH patients who survive initial bleed
 - Medical management: fluids, induced HTN
 - Possible intra-arterial vasodilator infusion or angioplasty



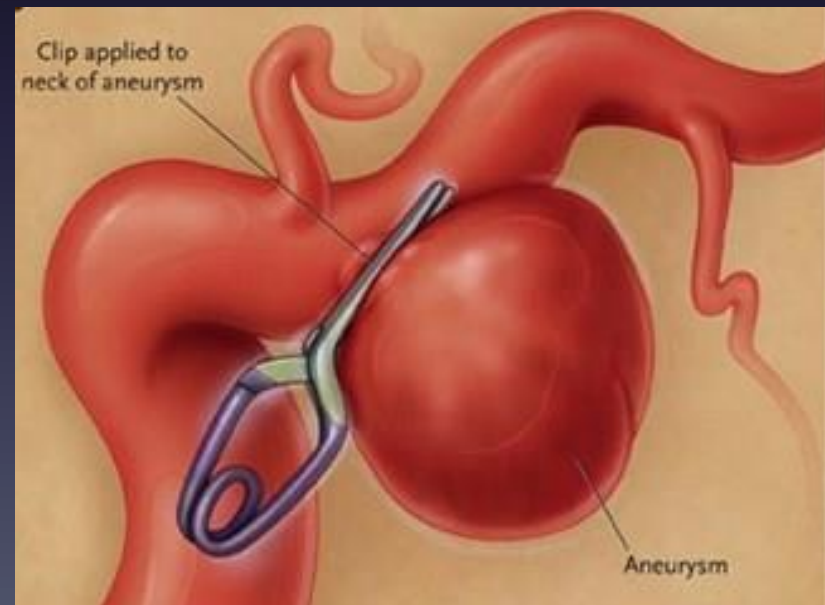
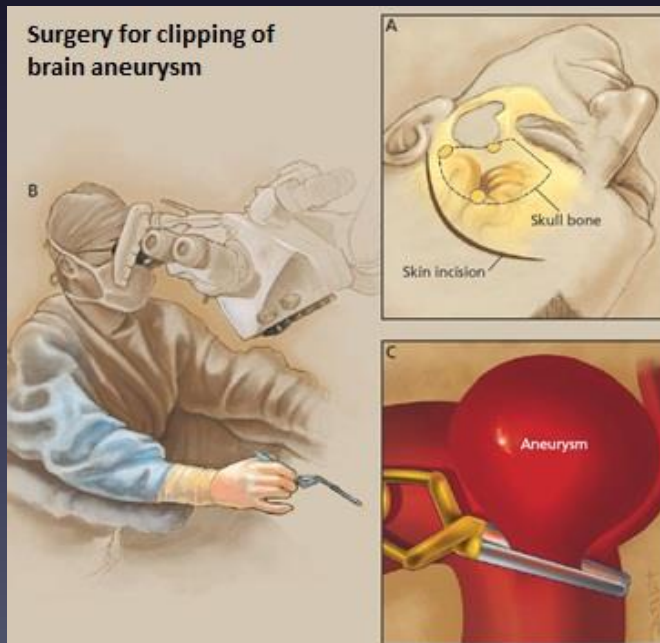
Aneurysm Treatment

- Surgical Clipping
- Endovascular Treatment
 - Coil embolization
 - Flow diversion

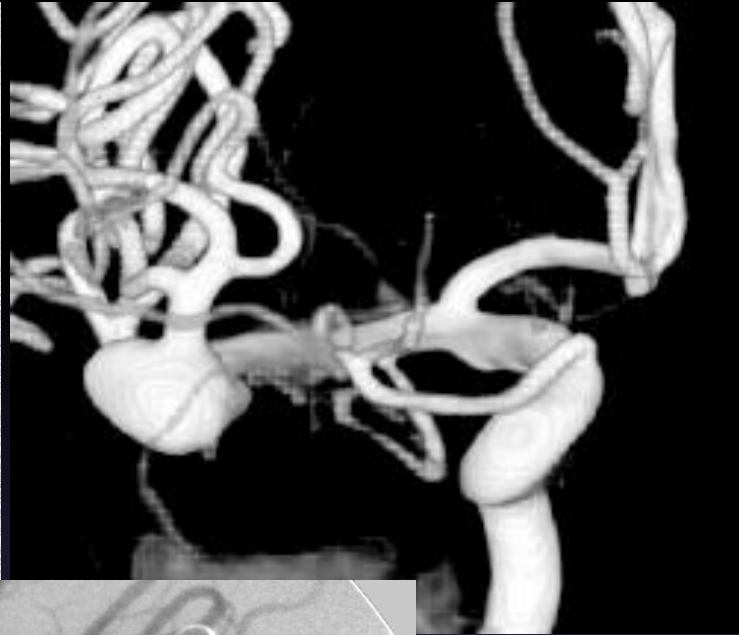
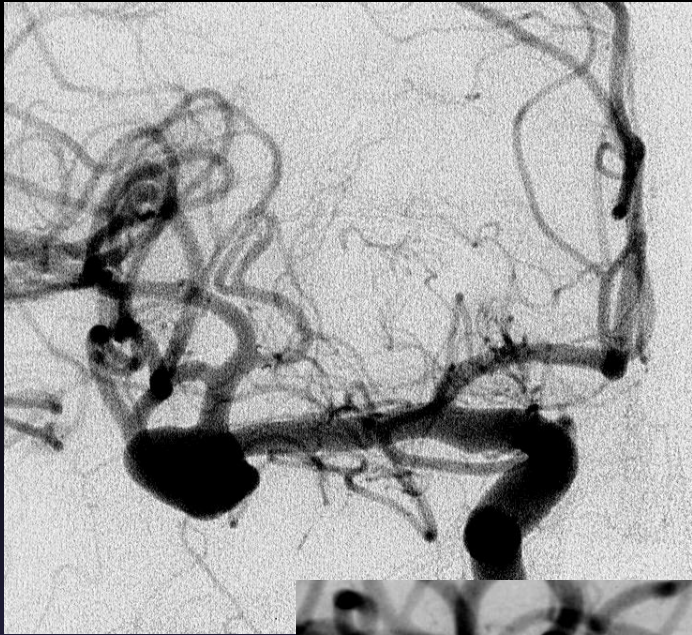


Aneurysm Clipping

- Open surgical procedure performed by neurosurgeon
- Been around since 1930s
- Longer recovery times
 - Several days in hospital for unruptured aneurysms
 - Weeks to months before returning to 100%
- Durable treatment, little chance of aneurysm recurrence

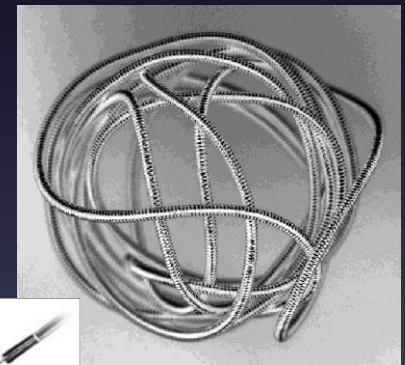
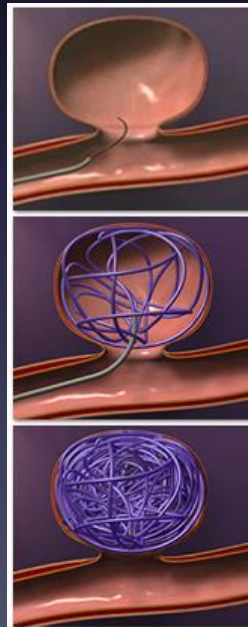
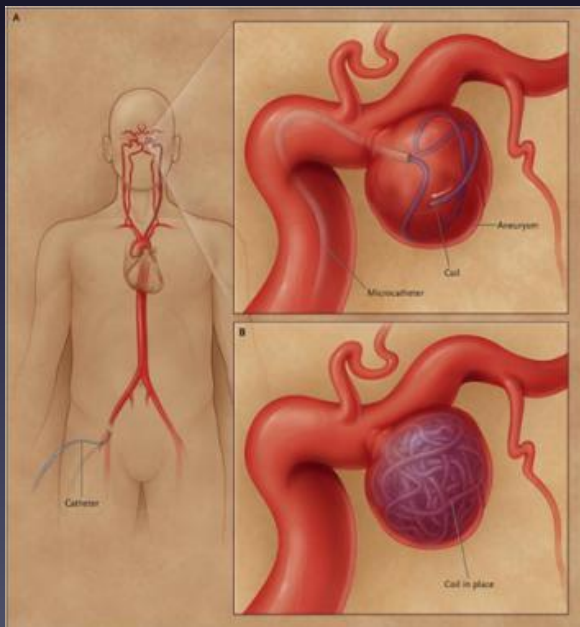


Aneurysm Clipping Case

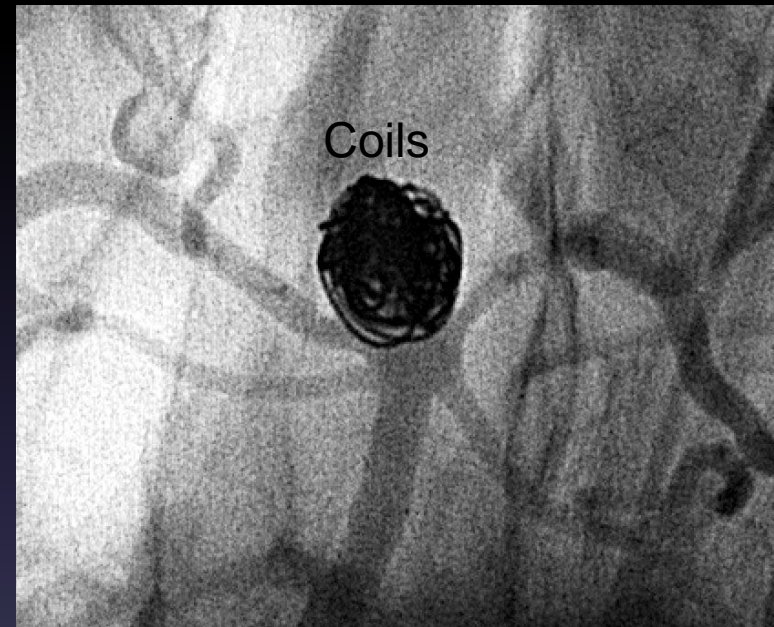
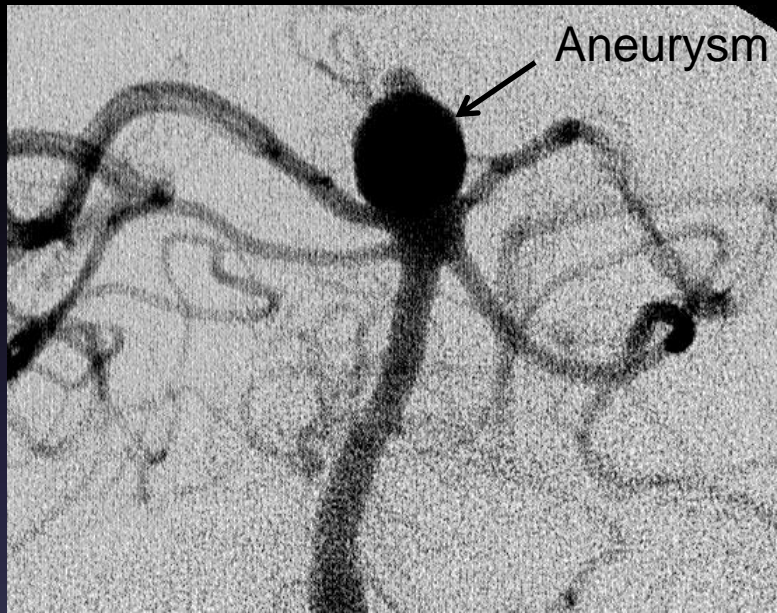


Coil Embolization

- Minimally invasive procedure performed by neurointerventionalist
- Been around since 1990s
- Shorter recovery times (unruptured aneurysms)
 - 1 night in hospital
 - Few days of light activity and back to 100% after 1 week
- Higher chance of aneurysm recurrence compared to clipping



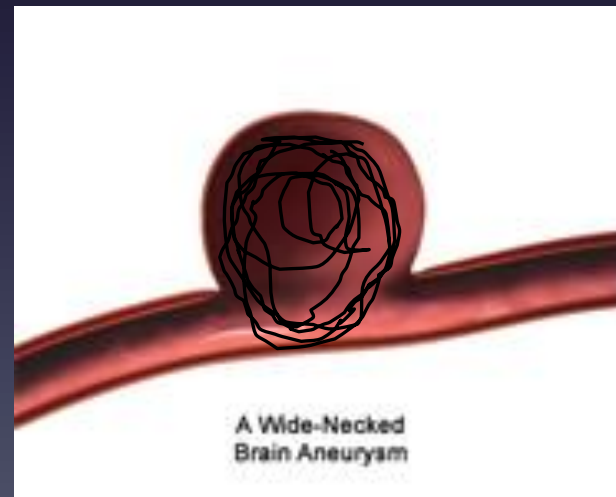
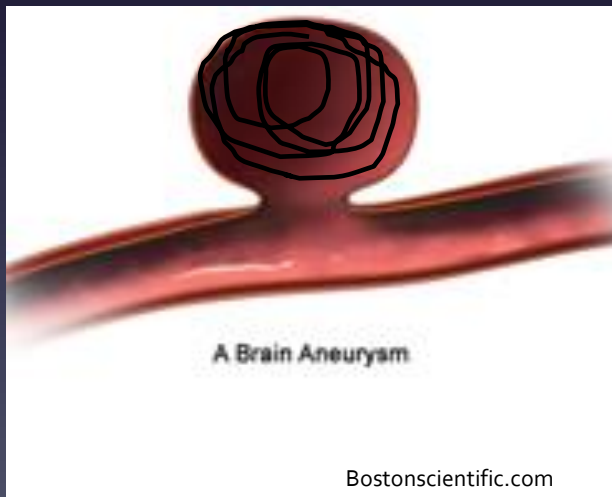
Coil Embolization Case



Aneurysm Morphology

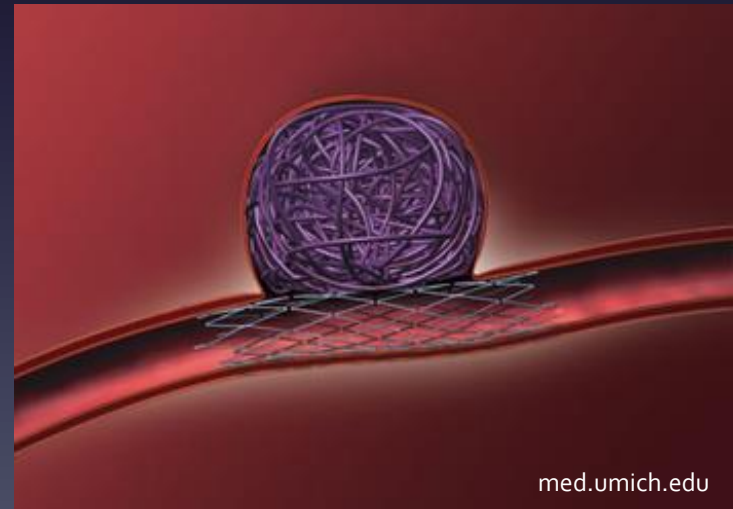
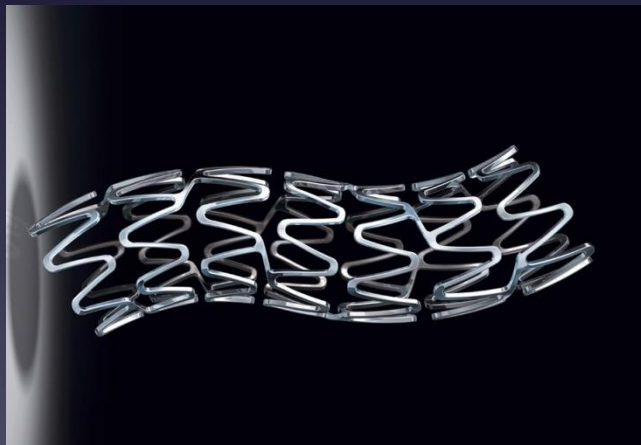
– Wide-necked Cerebral Aneurysms

- Coils may protrude through aneurysm neck into parent artery
- Higher risk of thromboembolic complications if this occurs
- May require adjunctive techniques for coil embolization

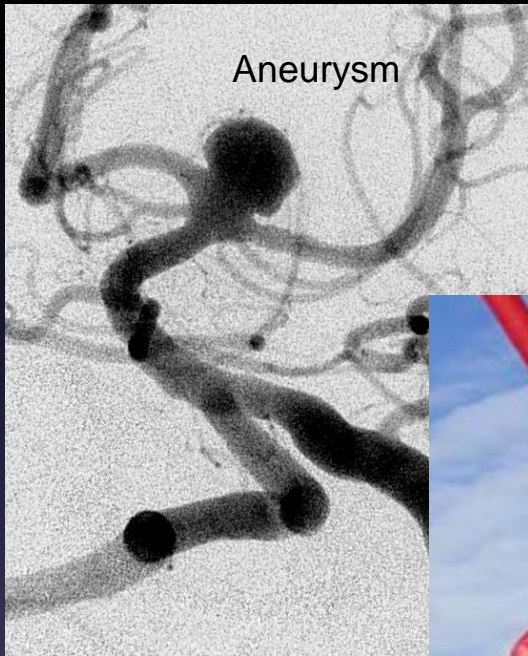


Adjunctive Techniques for Coil Embolization

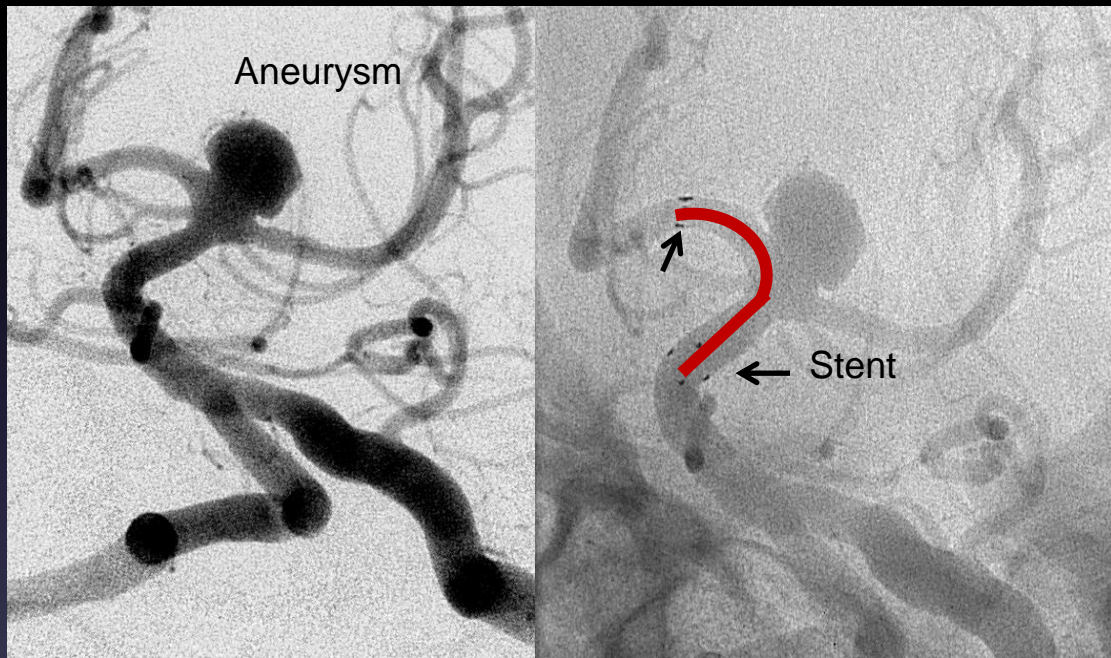
- Stent-assisted coil embolization
 - Scaffold prevents coil herniation into parent artery



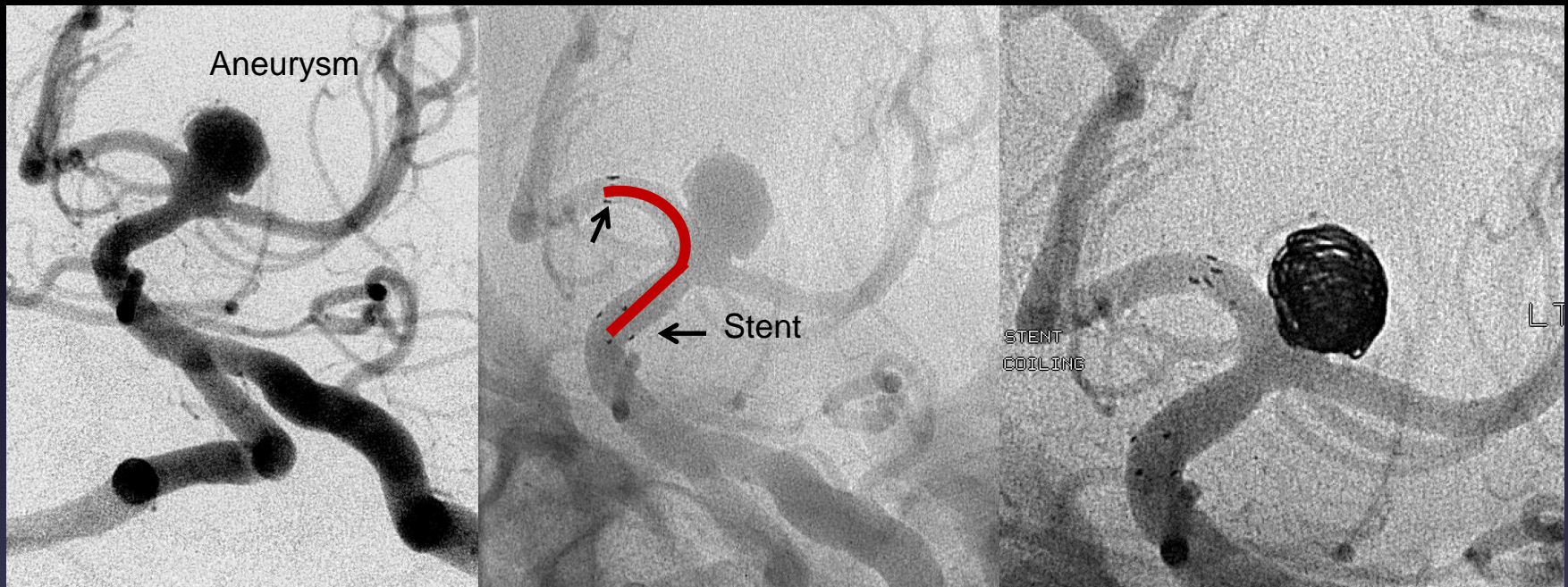
Coil Embolization with Stent



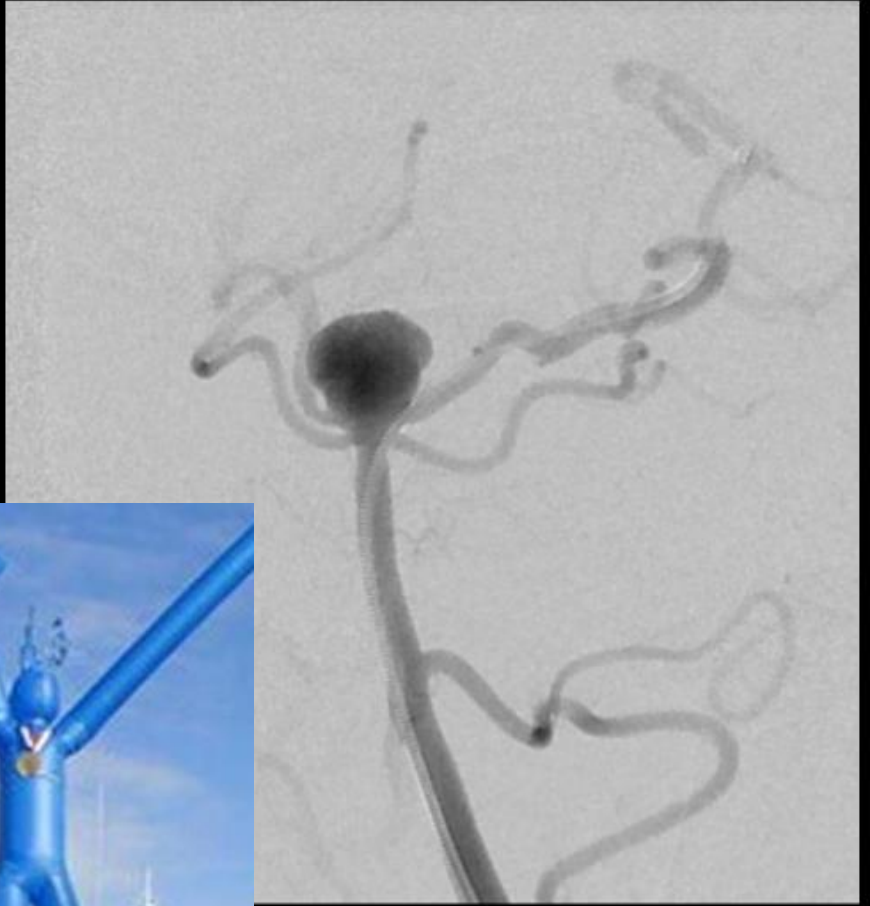
Coil Embolization with Stent



Coil Embolization with Stent



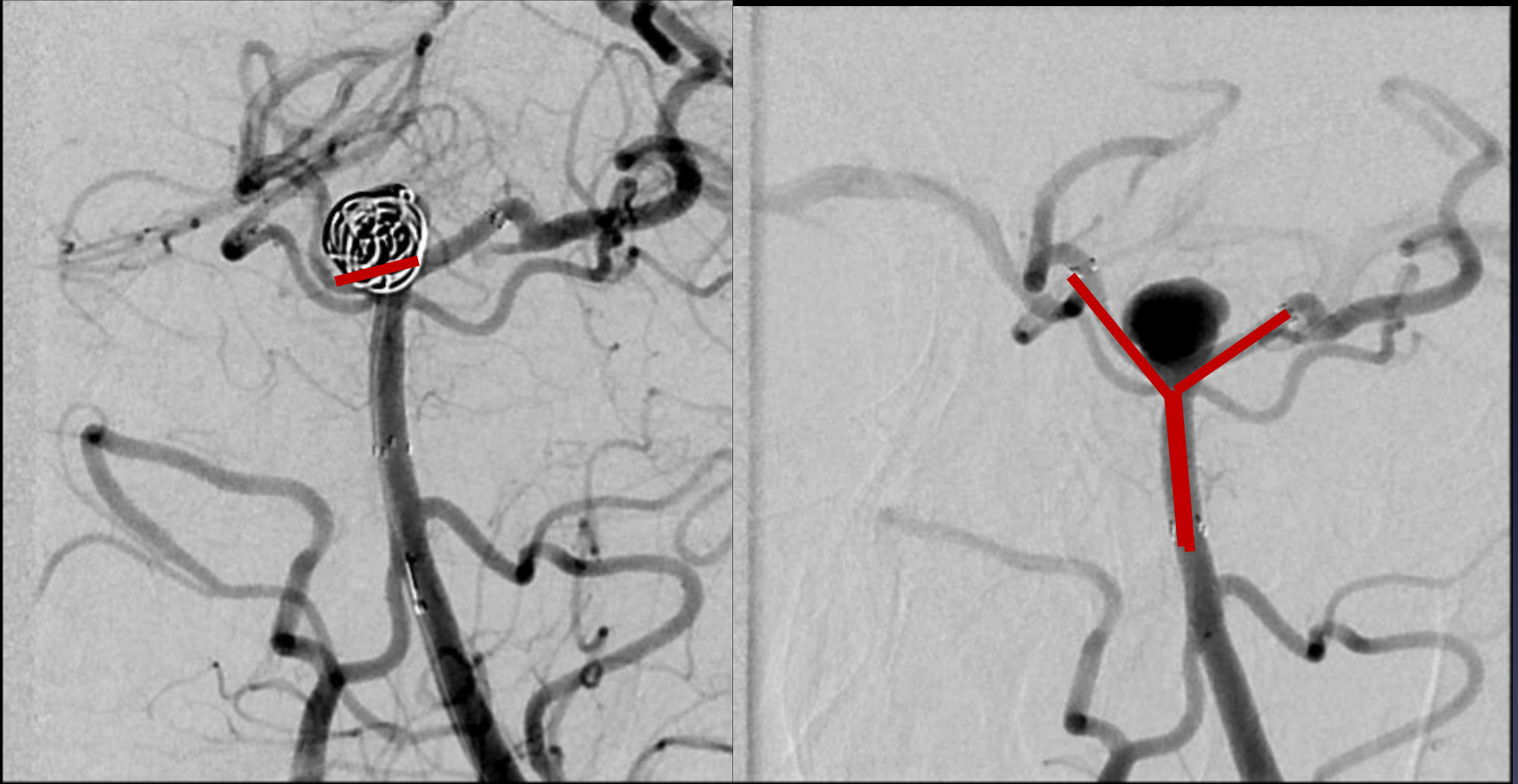
Coil Embolization with “Y” Stents



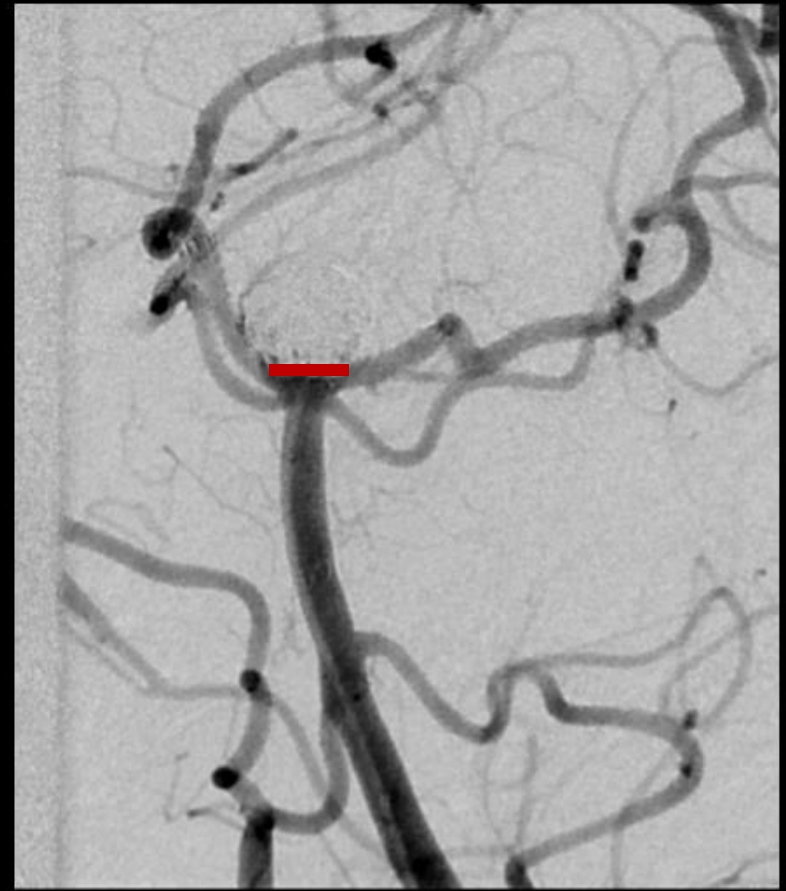
Coil Embolization with "Y" Stents



Coil Embolization with “Y” Stents

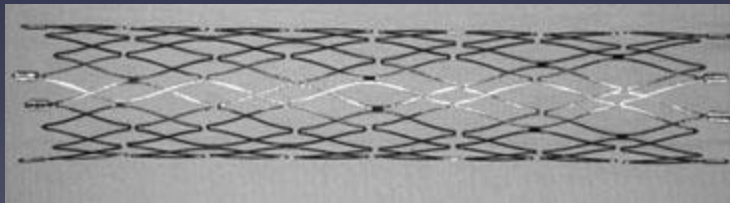


Coil Embolization with “Y” Stents

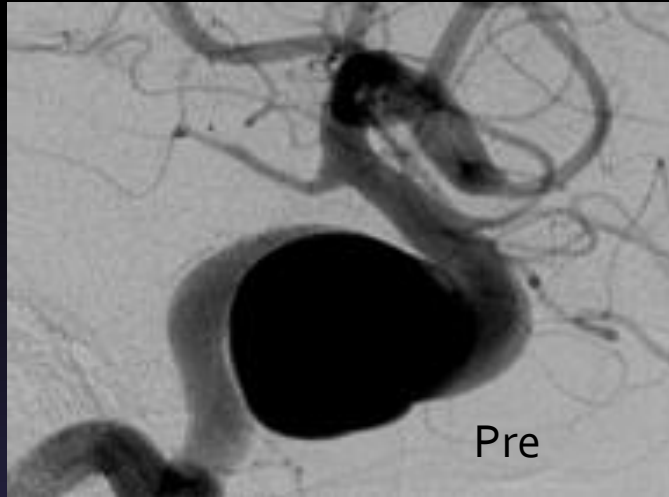


Flow Diverting Stents

- Concept: Instead of filling the aneurysm with coils, divert flow away from the aneurysm
- Tightly braided mesh stent-type device that allows flow into normal arterial branches but causes stagnation in aneurysm sac so it occludes

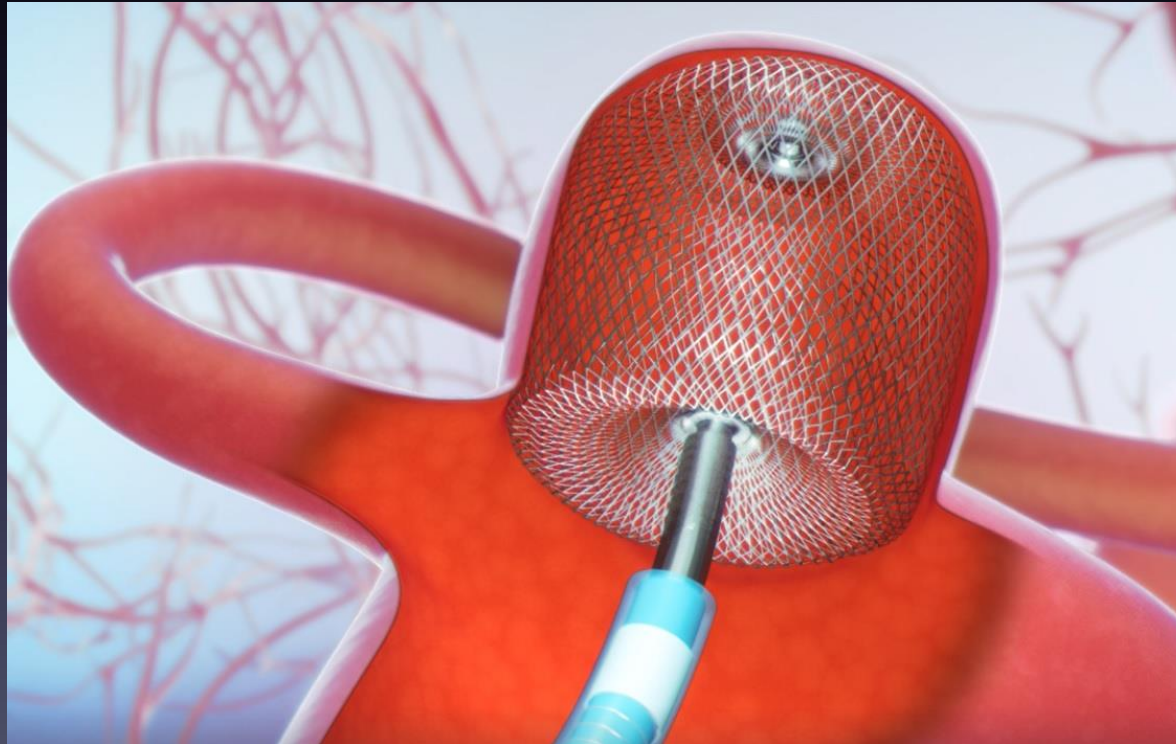


Flow Diverting Stent

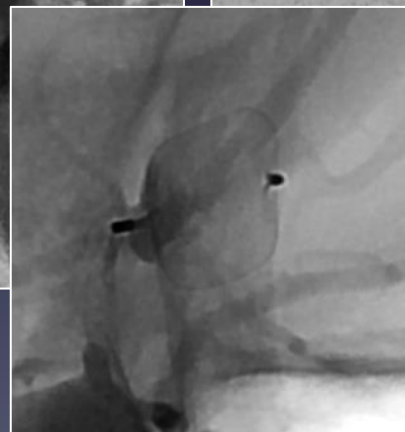
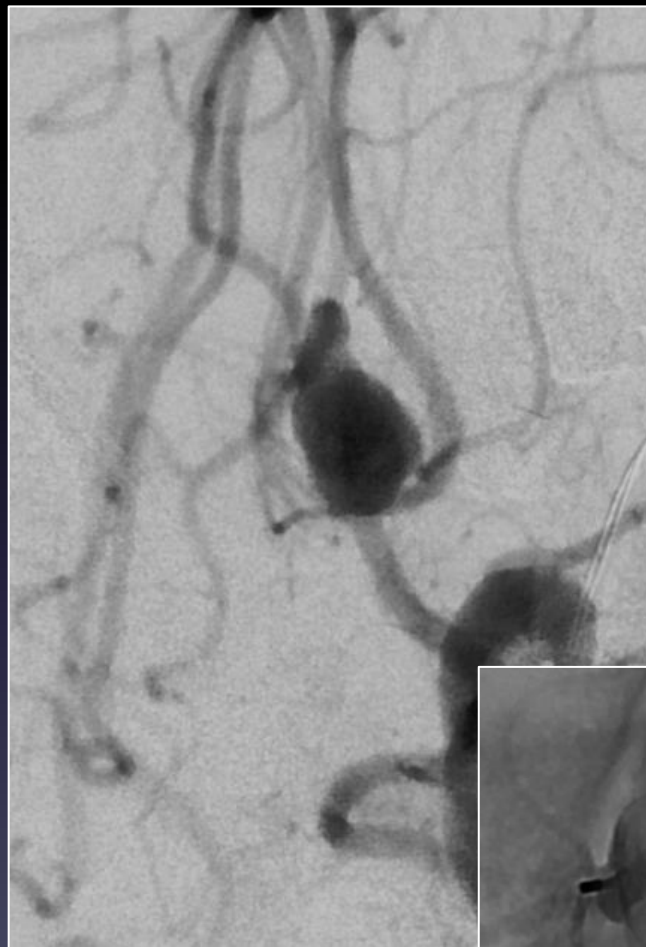
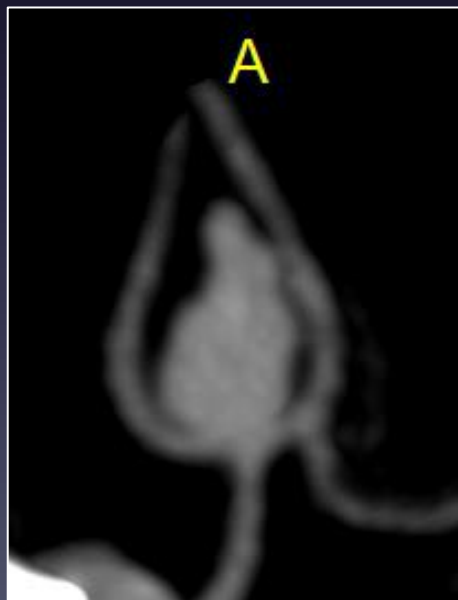
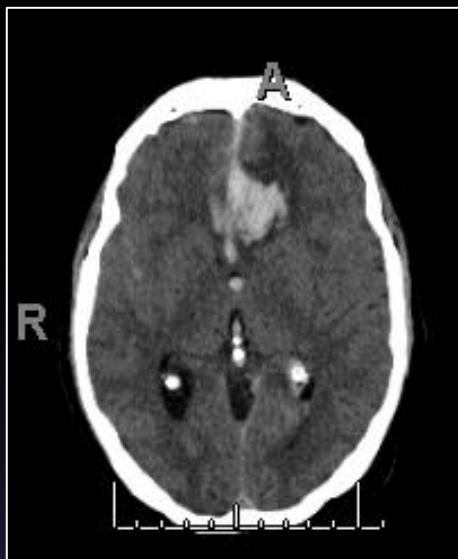


Intrasaccular Devices

- WEB (Woven EndoBridge) Device
 - Sphere of woven wires, like a basket
 - Fills the aneurysm and reduces flow into it



WEB Device

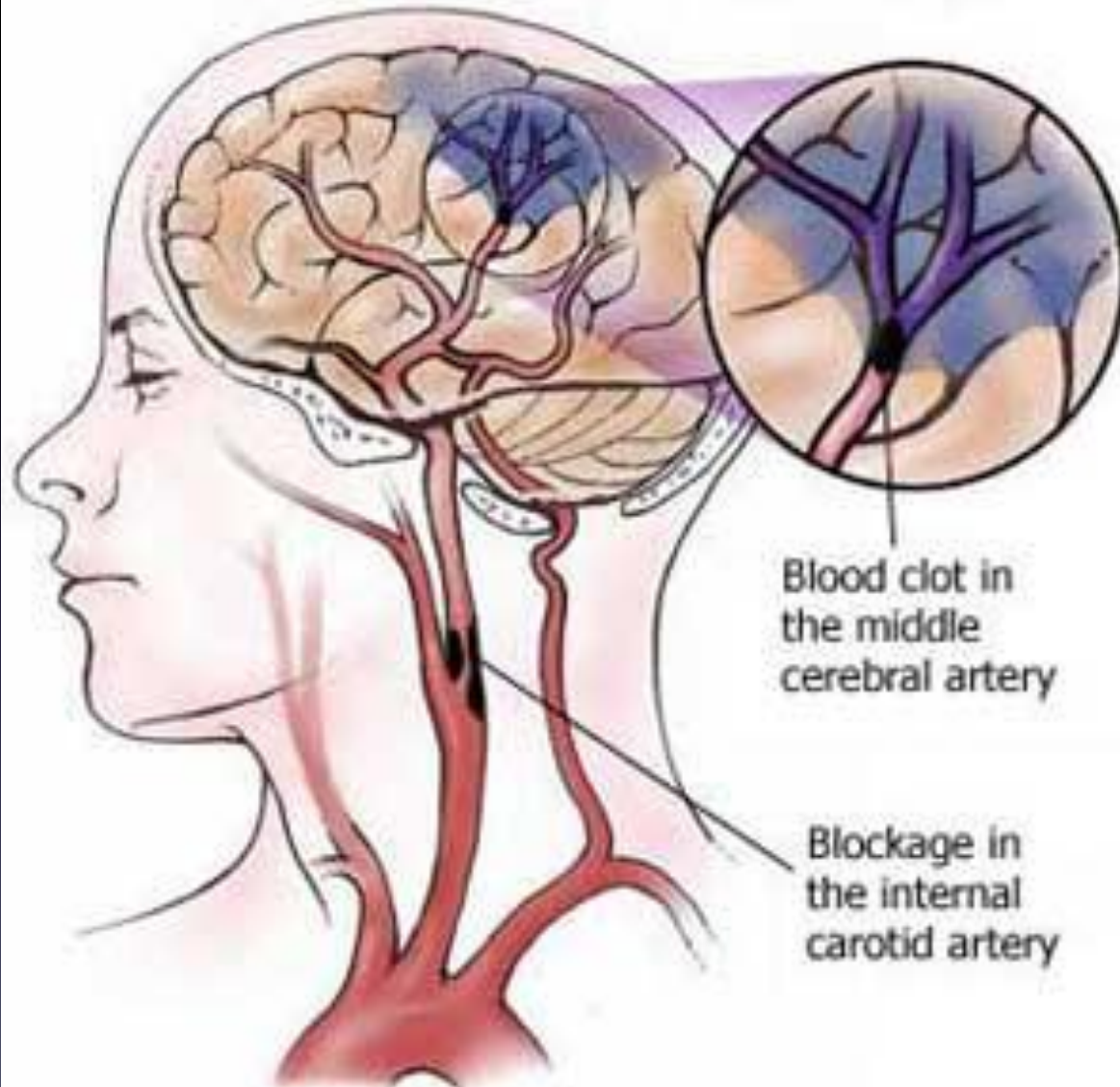


Mechanical Thrombectomy for Acute Ischemic Stroke



Ischemic Stroke

Occurs when oxygen-rich blood flow to the brain is restricted by a blood clot or other blockage



Time is Brain!!

- In a typical large vessel acute ischemic stroke:
 - 1.9 million neurons are lost every minute the vessel remains occluded
 - Compared to normal brain aging, the ischemic brain ages 3.6 years every hour without treatment



Saver JL, Stroke. 2006;37:263-266.

Time is Brain!!

- For every 30 minute delay in reperfusion, the probability of a good outcome is reduced by 10%

Khatri P et al., Neurology 2009;73: 1066–1072

Saver JL, Stroke. 2006;37:263-266.

Stroke Severity - NIHSS



- National Institutes of Health Stroke Scale

- Score calculated from 11 components
- Used to quantify severity of strokes
- Range: 0 – 42

- 0 = no symptoms
- 1-4 = mild stroke
- 5-15 = moderate stroke
- 16-20 = moderate to severe stroke
- > 20 = severe stroke



You know how.
Down to earth.
I got home from work.
Near the table in the dining room.
They heard him speak on the radio last night.

MAMA
TIP – TOP
FIFTY – FIFTY
THANKS
HUCKLEBERRY
BASEBALL PLAYER

Signs and Symptoms of Stroke...

For anyone

SPOT A STROKE

LEARN THE WARNING SIGNS AND ACT FAST



B

E

F

A

S

T



BALANCE

LOSS OF BALANCE,
HEADACHE
OR DIZZINESS

EYES

BLURRED VISION

FACE

ONE SIDE OF THE
FACE IS DROOPING

ARMS

ARM OR LEG
WEAKNESS

SPEECH

SPEECH DIFFICULTY

TIME

TIME TO CALL
FOR AMBULANCE
IMMEDIATELY



CALL 911 IMMEDIATELY

Treatment Options for Patients Experiencing an Ischemic Stroke

IV thrombolytics

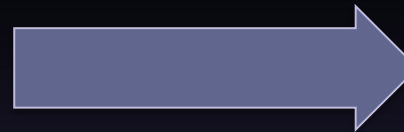
- Drug is designed to break apart the clot
- Typically within 4.5 hrs from last known well
- Not very effective for larger clots

Mechanical thrombectomy

- Endovascular removal of the clot

Medical Management

Monitor vitals and provide secondary stroke prevention.

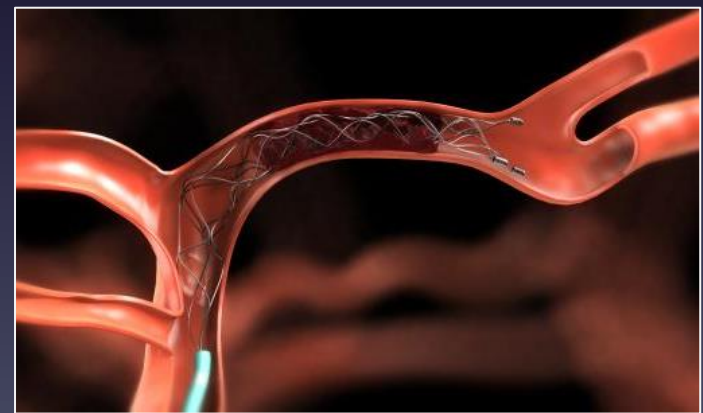
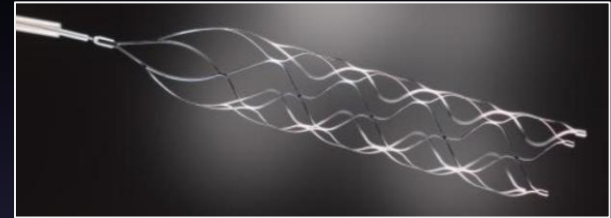


Mechanical Thrombectomy

Aspiration



Stent Retriever



Aspiration Case

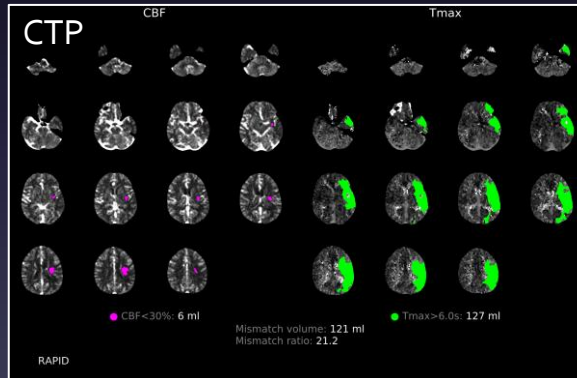
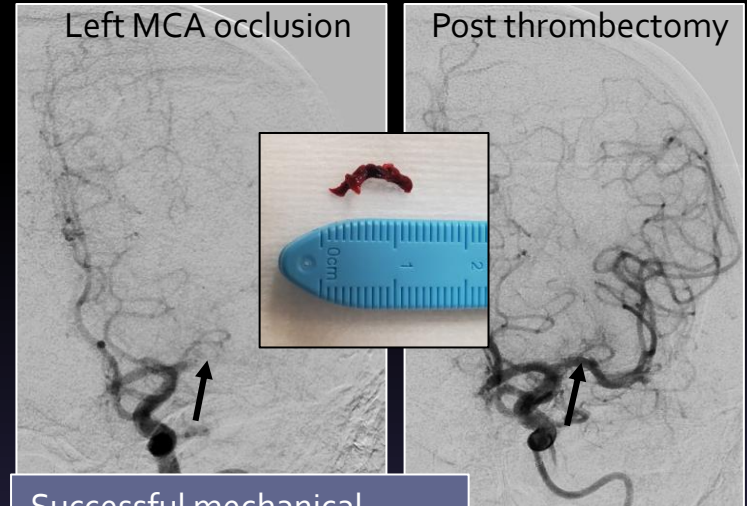
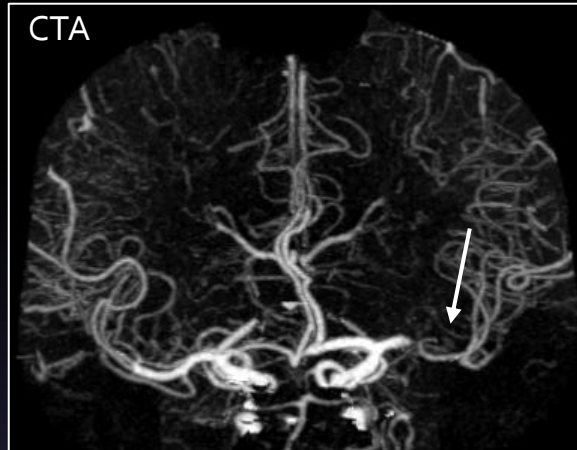
Patient 1

65 yo man

Last seen normal
7.5 hrs ago

NIHSS 23

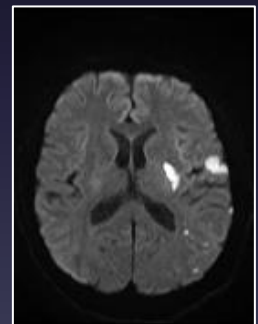
- Global aphasia
- Right sided weakness
- Left gaze deviation



Successful mechanical thrombectomy

Radial artery puncture to revascularization 14 minutes

NIHSS 0 at discharge



Stent Retriever Case



CTA: Right MCA M1 Trunk Occlusion

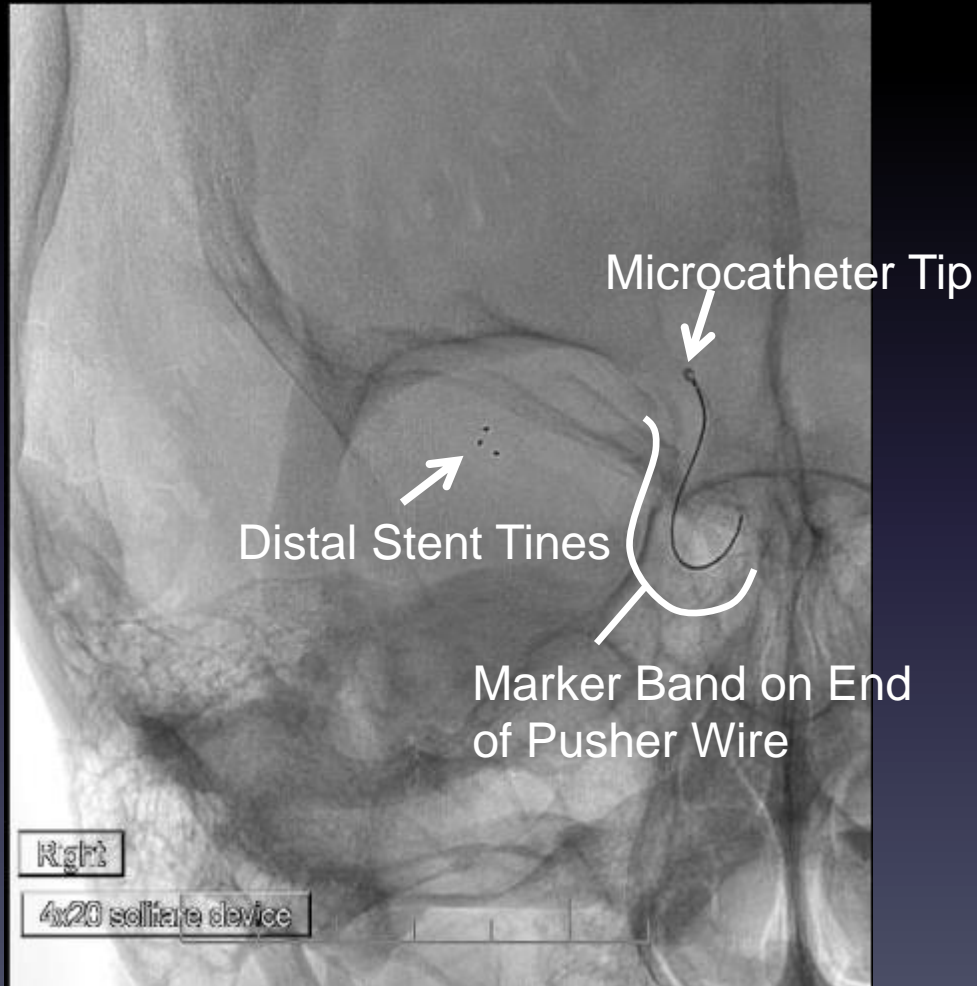
NIHSS Score 15

Stent Retriever Case

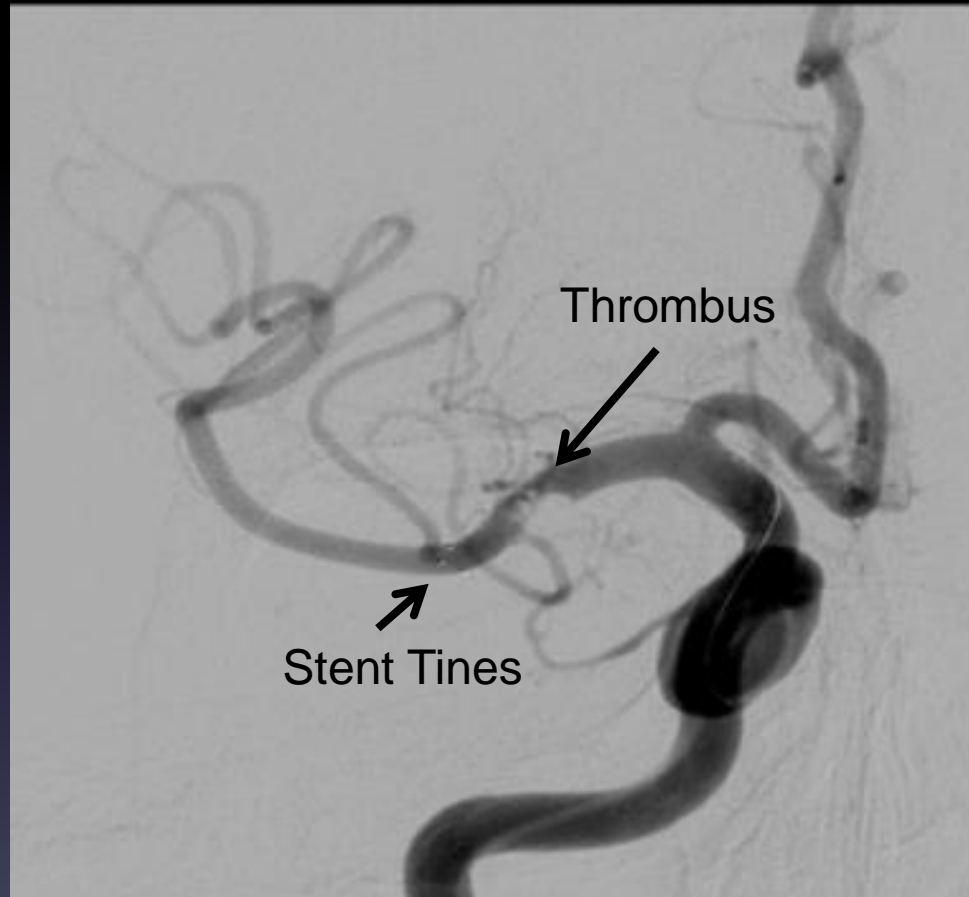


Pre-treatment Frontal View

Stent Retriever Case



Stent Retriever Case



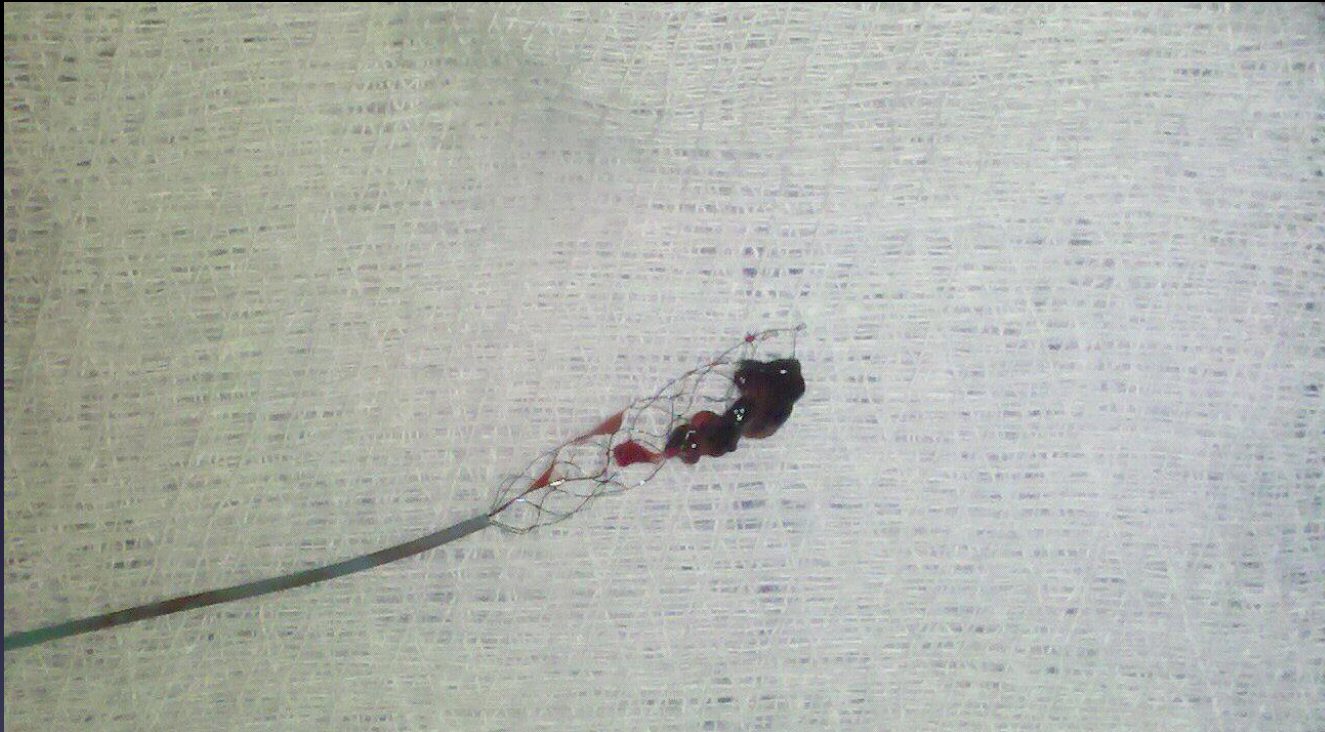
Immediate Post-Deployment Angiogram

Stent Retriever Case



Device Removed

Stent Retriever Case



Stent Retriever Case

- Pre-NIHSS 15
- Post-NIHSS 2 at 24 hours



Head CT 2 Days Later:
No Infarction

Summary

- Neurointerventional Surgery encompasses endovascular procedures of the brain and spine, as well as a spectrum of additional minimally invasive, image-guided procedures of the spine and head/neck
- We perform a breadth of procedures of different types, but much of the work we do revolves around treating vascular diseases of the brain, such as strokes and brain aneurysms
- Schooling and training to become a Neurointerventional Surgeon is a lengthy process, but the results are extremely rewarding

Thank you!
Questions?

