



NEURO  
INSTITUTE

Continuing Education for Rehabilitation Professionals



# NEUROSURGICAL PERSPECTIVES ON STROKE

John P Weaver MD

Neurosurgery

PENN STATE HEALTH  
ST JOSEPH MEDICAL CENTER

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# What is a Stroke or CVA?

## CVA - Cerebrovascular Accident

Interruption of blood flow to the brain

With little or no warning an event that results in sudden neurologic impairment or death

Brain cells die within minutes in the absence of oxygen and nutrients and generally do not regenerate

# | Ischemic Stroke (absence of blood flow)

Ischemic stroke is most common type of stroke (<85%)

- Thrombotic – blood clot forms within a damaged artery in the brain blocking blood flow
- Embolic – blood clot or a small piece of plaque from the heart or an artery feeding the brain travels and blocks a small brain blood vessel

- TIA - Transient Ischemic Attack

Temporary vessel blockage with resolving neurologic impairment

Symptoms generally <1 hour

Warning sign of future stroke

# Hemorrhagic Stroke (Bleeding in the Brain)

## Subarachnoid hemorrhage

- Bleeding on the brain surface
- Typically due to rupture of a cerebral aneurysm

## Intraparenchymal / Intracerebral hemorrhage

- Cortical
- Subcortical / basal ganglia
- Cerebellar
- Brainstem



# Stroke Statistics

(AHA Heart Disease and Stroke Statistics – 2010 Update)  
(CDC 2018 data)



- The 5th leading cause of death in the US
- Every 40 seconds someone in the US has a stroke and every 4 minutes someone dies - ~800,000 strokes / year
- 87% Ischemic, 10% intracerebral hemorrhagic, 3% subarachnoid hemorrhage
- A leading cause of long-term disability
- 2010 costs of direct and indirect costs of stroke ~\$73.7 Billion



# Stroke Risk Factors

## Controllable Risks

- Smoking
- Hypertension
- Physical inactivity and obesity
- Diabetes
- Hyperlipidemia
  - high total cholesterol
  - high LDL ('bad cholesterol')
  - low HDL ('good cholesterol')
  - high triglyceride
- Sympathomimetic: amphetamines, cocaine, phencyclidine, pseudoephedrine

## Uncontrollable Risks

- Age
- Genetics
  - Parent, grandparent or sibling
  - Black >2x that of Caucasian population
- Gender
  - Men > Women
  - Pregnancy
- Prior history of stroke or heart attack
- Liver dysfunction (impaired hemostasis)

## **Treatment goal is to remove the occlusion and restore cerebral blood flow – save the penumbra**

- Urgent ED processes
- Door to needle time

tPA – tissue plasminogen activator (Alteplase / Activase)

- Treatment guideline to administer within 3-4.5 hours of symptom onset
- Head CT must demonstrate no hemorrhage
- Given IV in the ED
- Unfortunately most patients do not present to the ED quickly enough
- Effectiveness ↓ and hemorrhage risks ↑ > 3 hours

## **Interventional surgical procedure to deliver medications ('clot- busters') or to retrieve clots**

- 2015 – positive clinical trial results in large vessel occlusions (LVO)
- Microcatheters are navigated under fluoroscopy x-ray guidance to the arteries in the brain
- Medications such as tPA can be delivered directly to the clot
- Devices can be deployed to retrieve and remove the clot
- Balloons or stents can be used to re-expand narrowed and diseased blood vessels

## Carotid Endarterectomy

- Advised for carotid blockage >70% with symptoms
- Blockage within the artery is removed
- Local or general anesthesia
- Home in 1-2 days
- 1-3% stroke peri-procedural stroke risk
- Recurrent blockage most common in smokers



## Carotid Angioplasty and Stenting

- Interventional procedure / surgery
- Stents and balloons navigated through the arteries from the groin under fluoroscopic guidance are used to expand the vessel
- The balloon opens the stent and vessel
- The stent acts as a scaffold maintaining an open vessel lumen
- Risks are emboli traveling to the brain
- Shorter vessel occlusion time for the brain blood flow
- No open surgery
- Used for patients with higher risks for open surgery (severe CAD, scar tissue from prior carotid or neck surgeries, prior neck radiation)

Spontaneous intracerebral hemorrhage

Aneurysmal subarachnoid hemorrhage

Arterial-venous malformations (AVMs)

Cavernous malformation or cerebral cavernomas

Venous fistulas

# Hemorrhagic Stroke - Intracerebral hemorrhage

## Key features

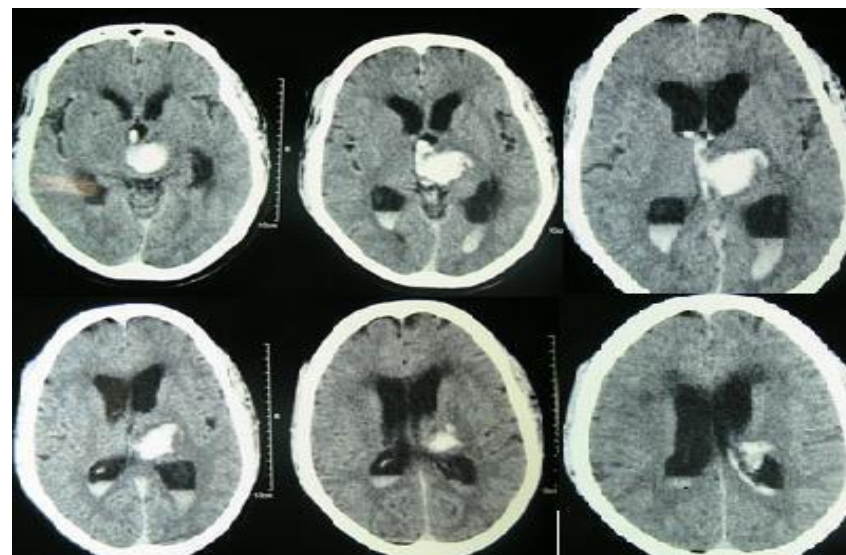
- 15-20% of all CVA
- Onset during activity
- Symptoms of severe HA, N/V, altered consciousness
- CT is diagnostic
- Catheter or CT angiogram performed for age <45 years
- Mortality ~45%



## Hemorrhagic Stroke - Intracerebral hemorrhage

### ICH Locations

- Basal ganglia – (putamen, globus pallidus, internal capsule) 30-35%
- Thalamus 15%
- White matter (lobar) 15-20%
- Pons 10-15%
- Cerebellum 10%
- Brain stem 1-6%

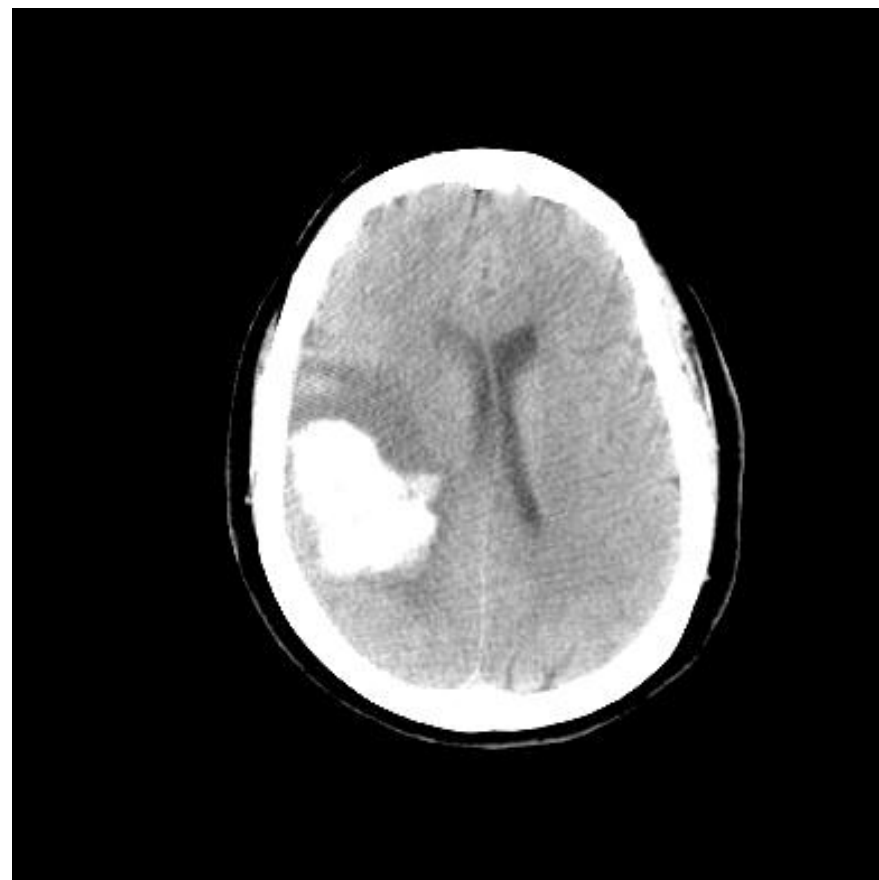


# Hemorrhagic Stroke - Intracerebral Hemorrhage Treatment

**Most hemorrhage stroke is non-operative**

## Medical treatments

- ABC'S
- Intubate for stupor or coma
- Baseline stroke severity score documented
- Rapid neuro imaging
- Reverse coagulopathy
- Manage BP to 140mm Hg
- Determine treatment site – transfer to tertiary center?



# Comprehensive Stroke Center - Multidisciplinary Services



- Emergency Medical Responders
- Emergency Medicine Physicians
- Stroke Neurology Physicians
- Cerebrovascular Neurosurgeon
- Neuro Interventionalist
- Neuroanesthesia
- Neurophysiology
- Neuroradiology
- Neurocritical Care Physicians
- Stereotactic Radiosurgery facilities
- Social Services and Case Management
- Pharmacy and Nutrition
- Data Abstractors and HIM coders
- Administration and Quality Departments

# Hemorrhagic Stroke - Intracerebral Hemorrhage Treatment

## Surgical Management

- Best indicated for cerebellar hemorrhage
- Direct brainstem compression
- Blocks CSF outflow causing hydrocephalus
- Limited surgical indications for supratentorial ICH
- The previously common resection of ICH has been shown not to be effective in improving long term outcome
- Offered to the deteriorating patient as life saving measure
- STICH (1033 pts), STICH II (601 pts) randomized trials with extended Glasgow Outcome Scale at 6 months

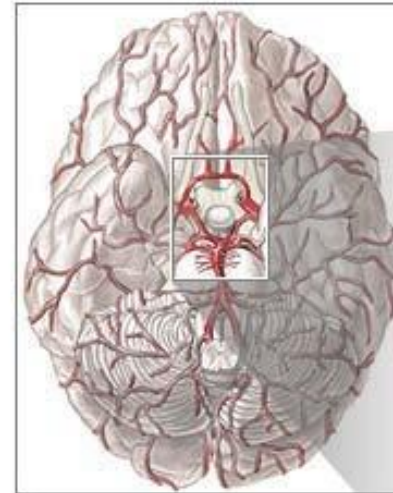
## Epidemiology

- Incidence 10:100,000 persons/year (~30,000/yr in US)
- 3-5% of all strokes
- Significant cause of morbidity and mortality in previously healthy group (more potential years of life lost than other causes of stroke)
- 1.6x higher risk in women
- Higher incidence in Japan, Finland, African-American and Hispanic populations
- Major risk factor: smoking and potentially alcohol and tobacco abuse
- Associated disorders: PKD, Ehlers-Danlos IV, Neurofibromatosis type I, Marfan's syndrome

# Hemorrhagic Stroke – Cerebral Aneurysms

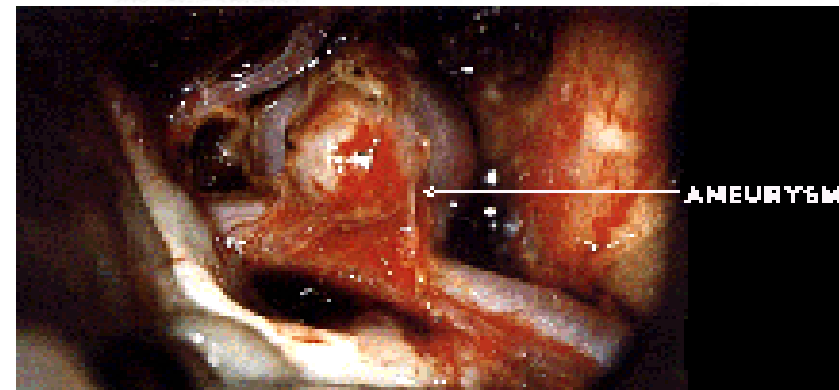
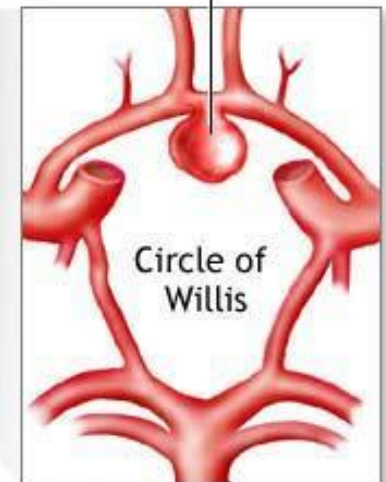
## Warning Signs and Symptoms

- Sudden and severe headache (thunderclap / worst in my life)
- Nausea and vomiting
- Stiff neck
- Photophobia
- Seizure
- Drooping eyelid
- Dilated pupil
- Loss of consciousness
- Confusion
- Weakness and/or numbness



Bottom view of brain  
and major arteries  
of the brain

Berry aneurysm on the  
anterior communicating  
artery of the brain



# Hemorrhagic Stroke – Cerebral Aneurysms

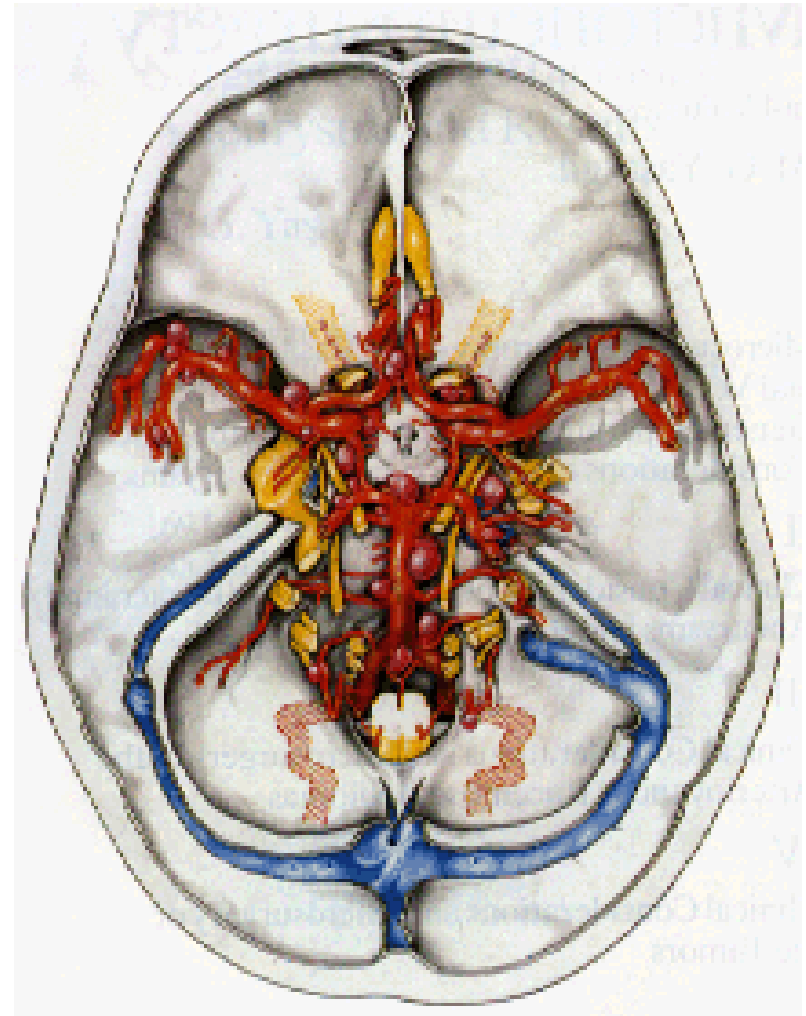
## Locations

85% Anterior / 15% Posterior Circulation

Occurs at branch point or vessel bifurcation

Most common posterior communicating (PCoA),  
Anterior communicating (ACA) and middle  
cerebral arteries (MCA)

15-20% are multiple (and often mirror  
aneurysms)



# Hemorrhagic Stroke – Cerebral Aneurysms

## Diagnostic studies

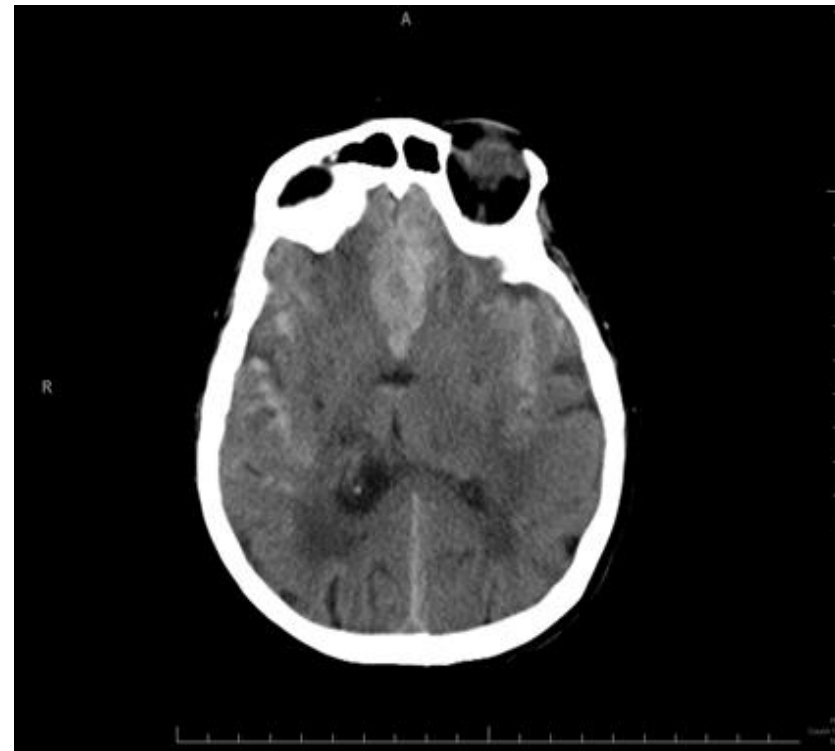
CT scan (non-contrast) - fast, available, highly diagnostic of acute hemorrhage

CTA - good resolution of vascular anatomy  
- appropriate for rapid assessment (e.g. surgical emergency)

Cerebral angiogram - gold standard anatomic study

MRI - sensitive for blood products if non-contrast CT is negative; especially with delayed presentation (sensitive up to 6 weeks)

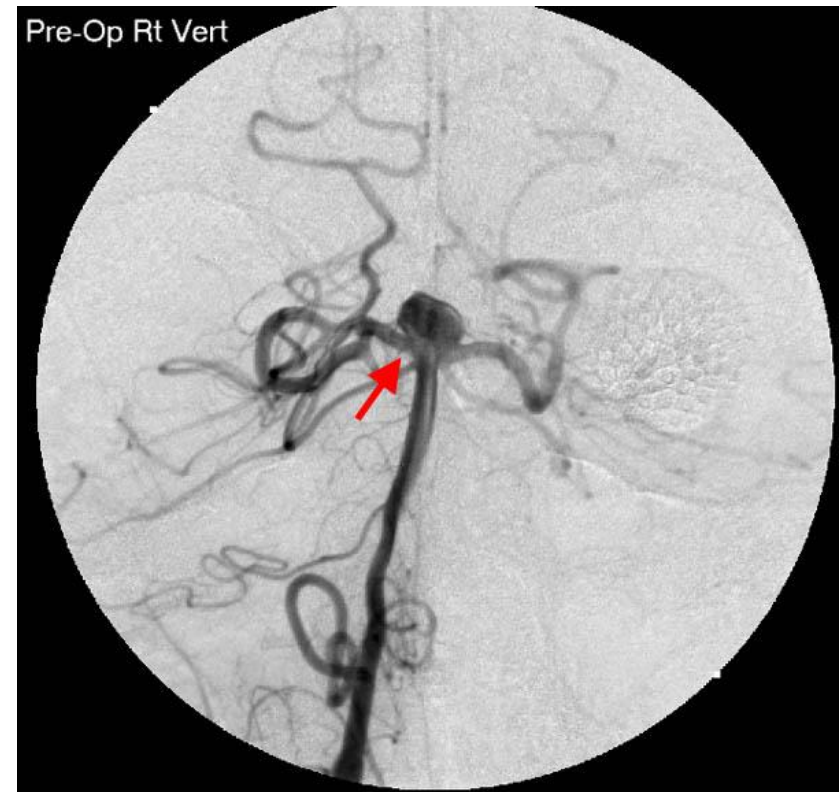
MRA - preferred diagnostic screening test





## Cerebral Angiogram

- 4 vessels injected
- Selective extra and intracranial carotid
- Common causes of hemorrhage include aneurysms, AVMs arterial dissections
- Spinal imaging to determine presence of AVM or dural fistula

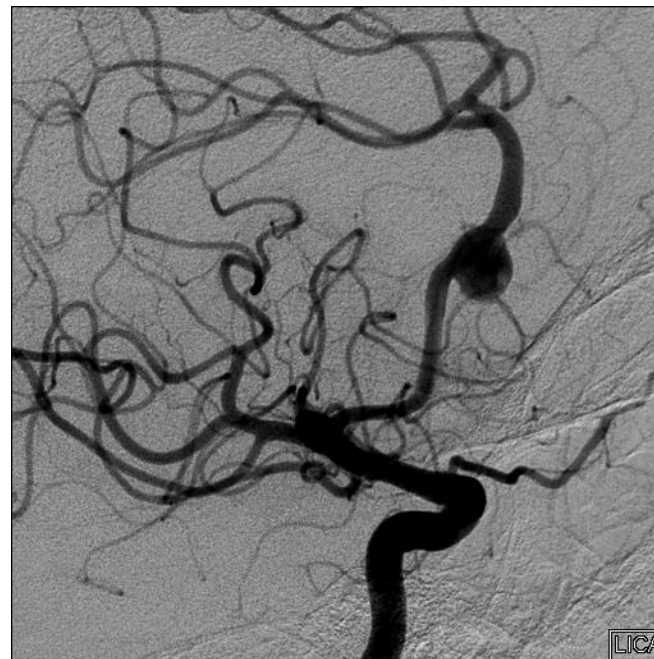


## Outcomes

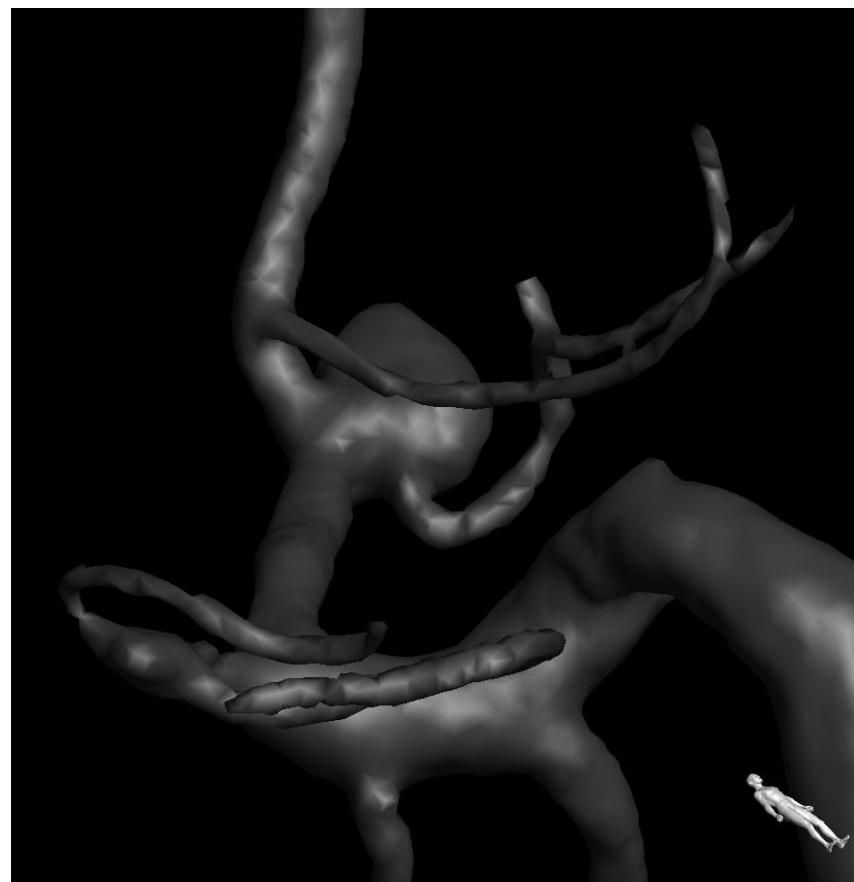
20-30% sudden death

For those who survive initial rupture and present to hospital

- 10-15% complete recovery
- 30-40% survive with disability
- 30-40% survive dependent
- 20% die



# Hemorrhagic Stroke – Cerebral Aneurysms

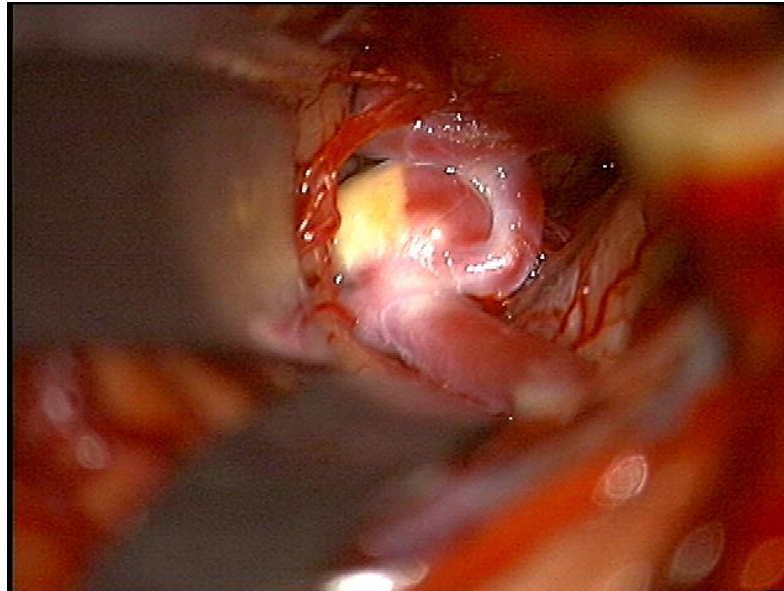


# Hemorrhagic Stroke – Cerebral Aneurysms

## **Treatment by surgical clipping**

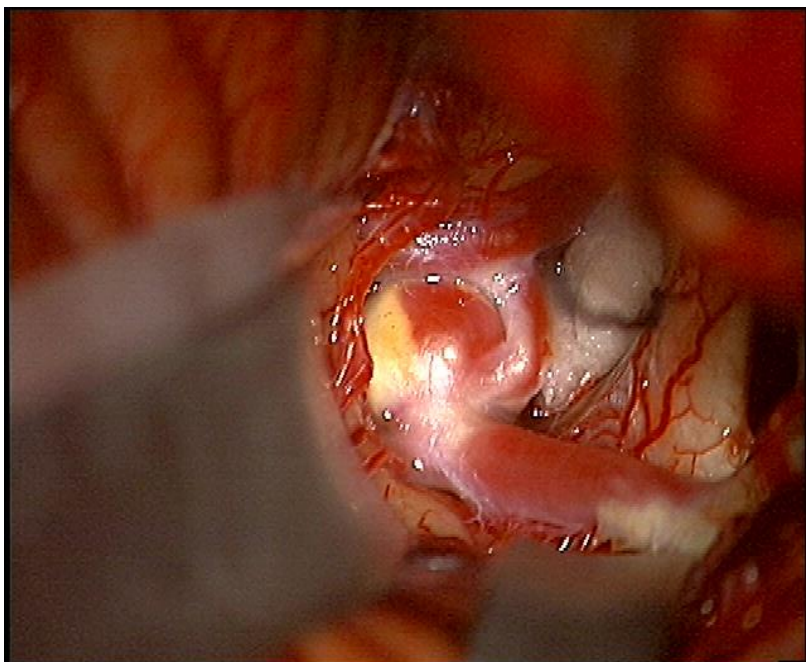
Craniotomy and microsurgery to place a titanium clip with a spring mechanism on the base of the aneurysm isolating it from the blood supply.

Angiography is then necessary to confirm the absence of the aneurysm and the preservation of all normal brain blood vessels

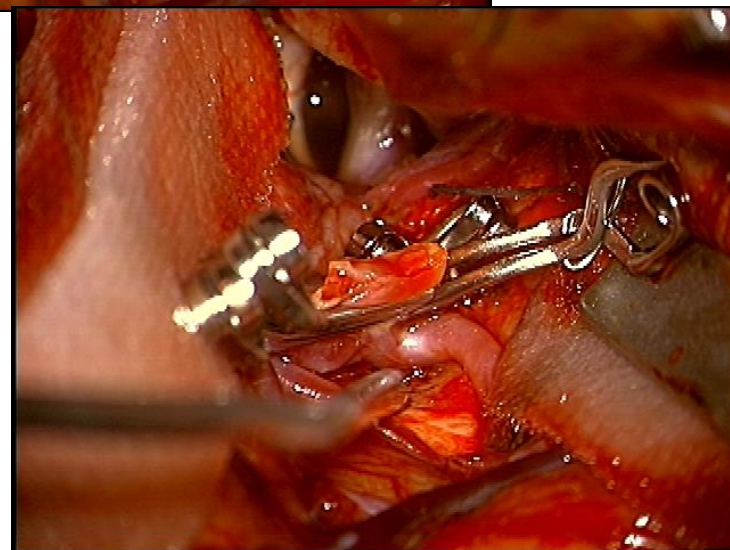
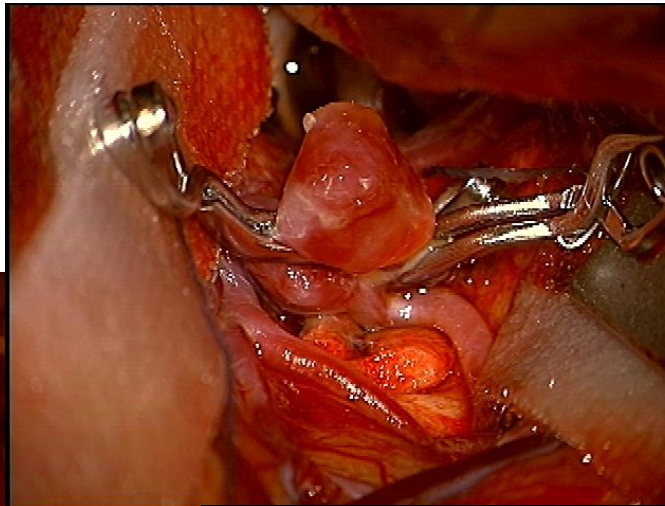
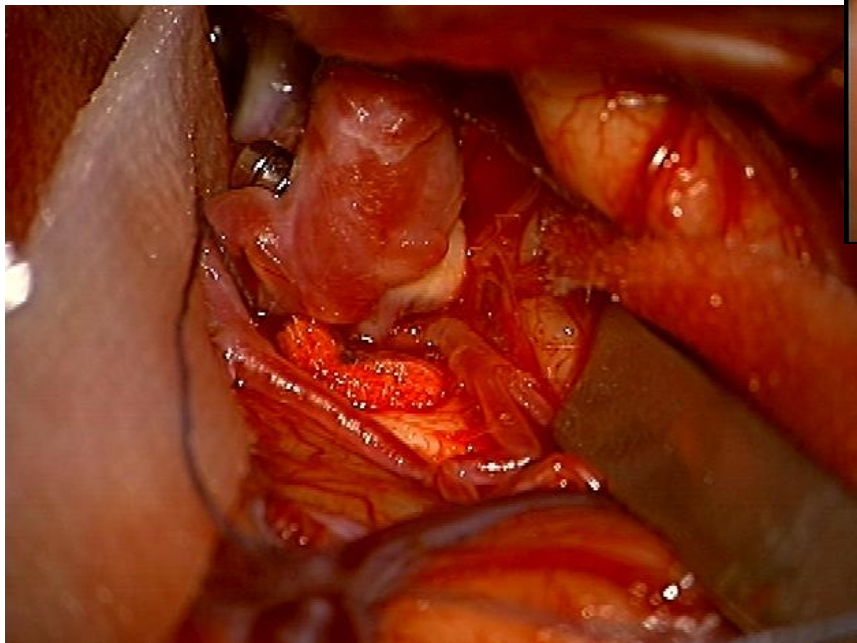




# Right craniotomy and clipping of an anterior communicating artery aneurysm



# Right craniotomy and clipping of a large middle cerebral artery (MCA) aneurysm



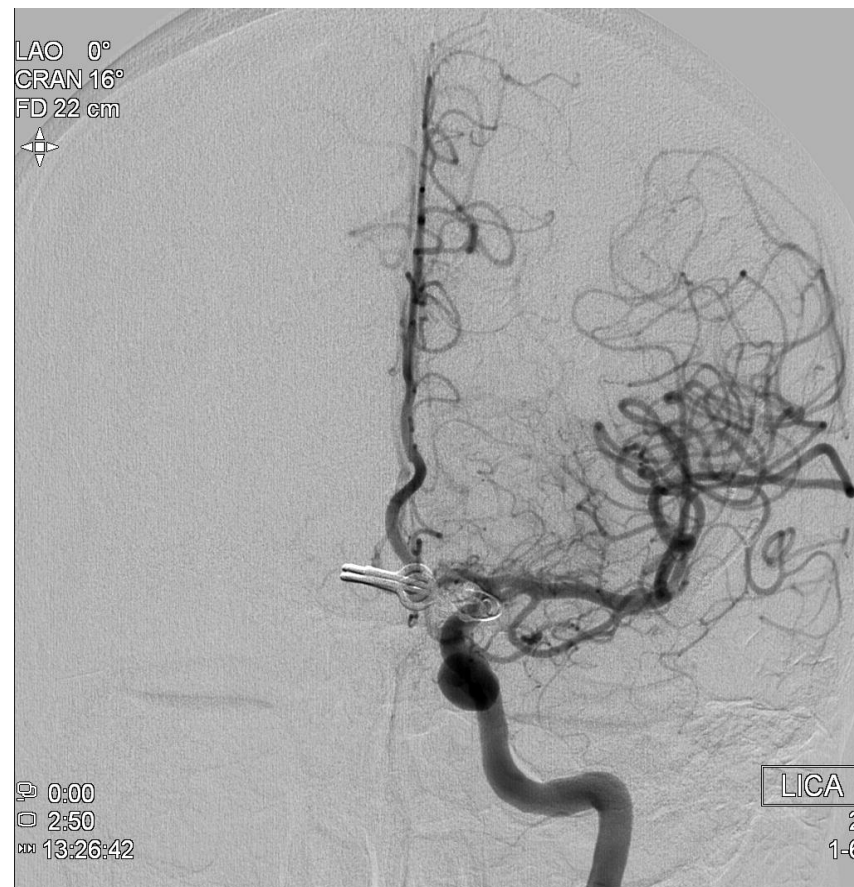


# Hemorrhagic Stroke – Cerebral Aneurysms

## Pre-op Angiogram



## Post-op Angiogram



# Hemorrhagic Stroke – Cerebral Aneurysms

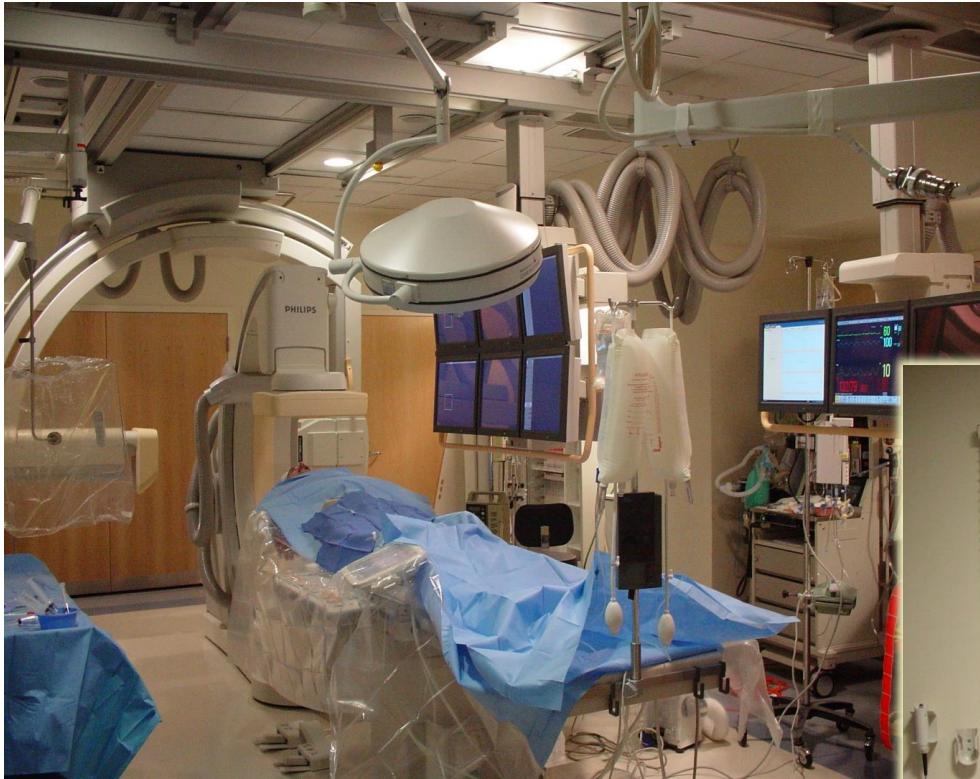
## Treatment by Endovascular Surgery

- Neurointerventional technologies have advanced rapidly and these procedures have replaced many open surgical approaches
- The procedures are catheter based, so no craniotomy is needed and anesthesia time may be shorter than for craniotomy and microsurgical clipping
- With fluoroscopic guidance a catheter is directed to the brain, then a micro catheter is placed into the aneurysm and through it is deployed a flexible platinum coil that fills the aneurysm
- Balloons or stents may be used to shape and secure the coils within the aneurysm
- Intracranial stenting for flow diversion and other novel technologies are being developed for those aneurysms not ideally suited for coiling



# Hemorrhagic Stroke – Cerebral Aneurysms

## – Biplane 3D Neuroendovascular Suite



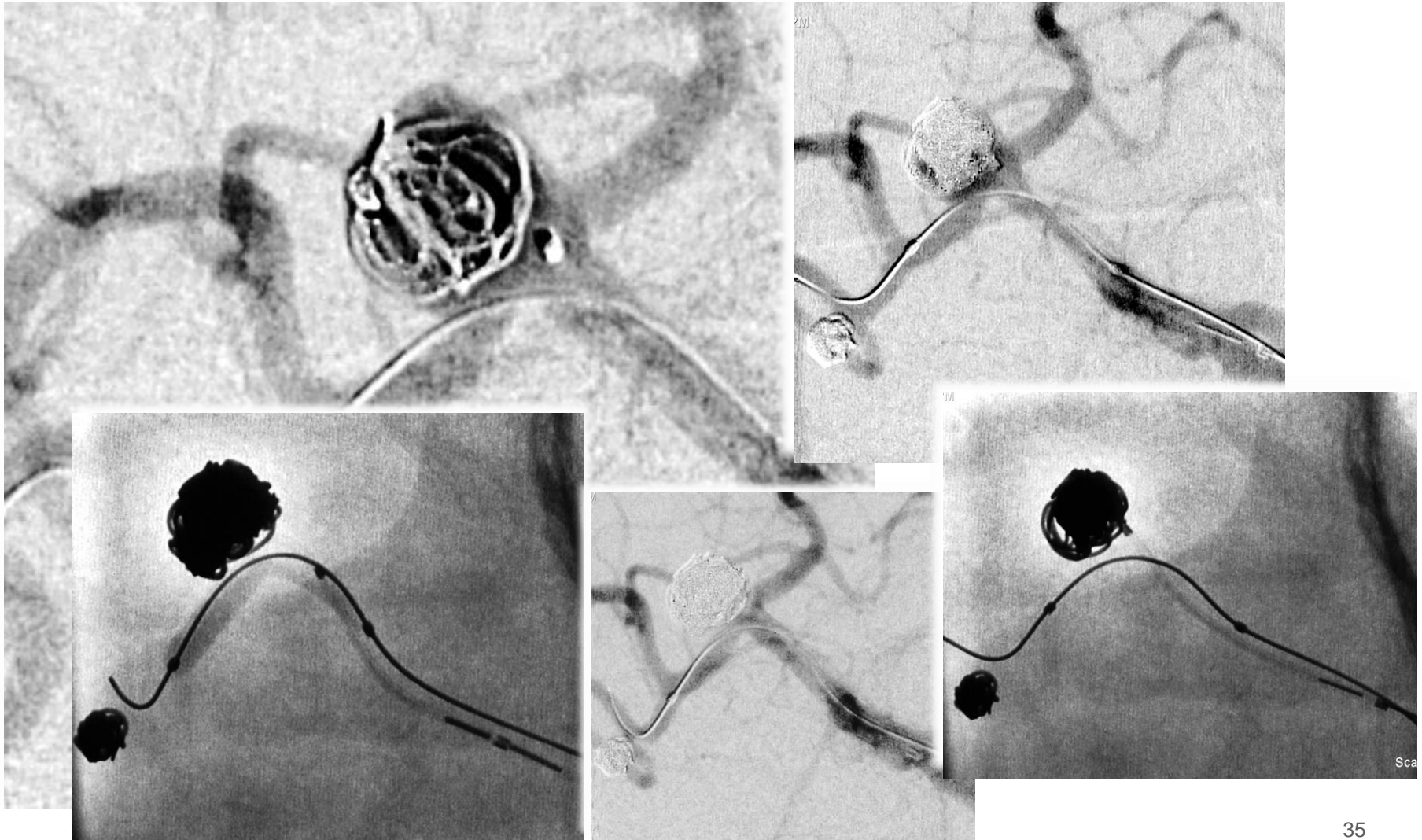
# Hemorrhagic Stroke – Cerebral Aneurysm Interventional Treatment with Coils





# Hemorrhagic Stroke – Cerebral Aneurysms

## – Balloon assisted coil embolization



# | Hemorrhagic Stroke – AVMs

## Arterial-venous malformations

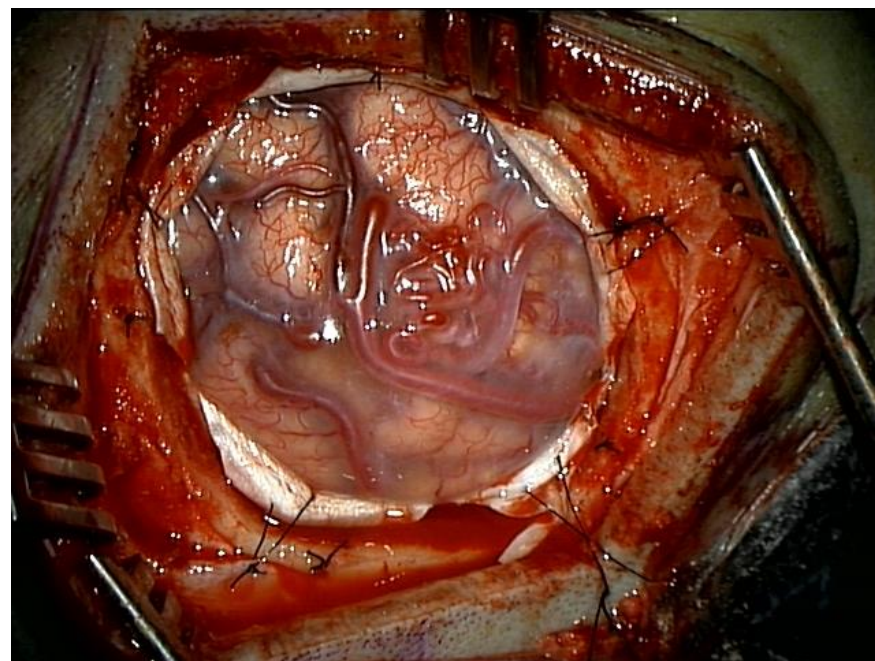
- Abnormal connection between cerebral artery and vein creates vascular tangles with blood shunted from artery to veins without capillaries and intervening brain tissue
- Expands with time with increasing shunting and more abnormal vessels
- Creates ischemia or causes hemorrhage
- 50% present with hemorrhage
- Others present with ischemic brain symptoms: seizures, headache, weakness, language difficulties confusion, coordination difficulties and other deficits dependent on brain location

## | Hemorrhagic Stroke – AVMs

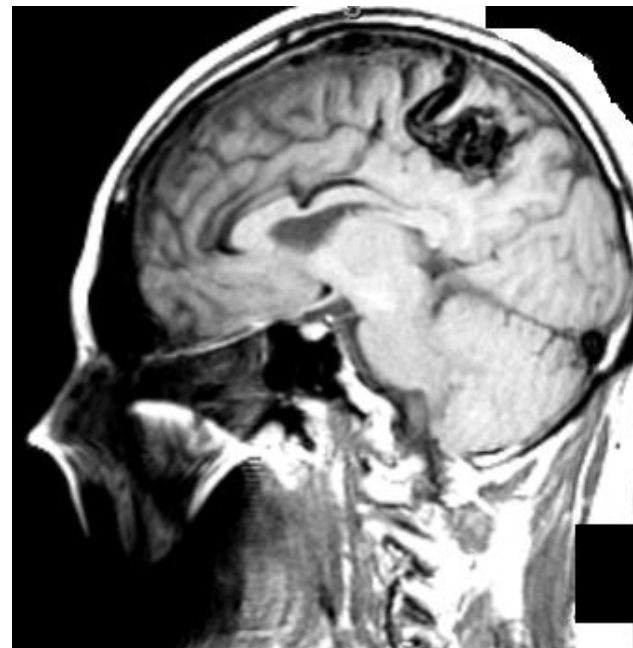
Annual rupture rate is low: 1-4%/year

### Increased risks of rupture

- initial presentation with hemorrhage
- deep venous drainage
- associated with aneurysms
- deep location



# Hemorrhagic Stroke – Arteriovenous Malformations



Diagnosis by CT, MRI and Angiogram

Most AVM's are treated by microvascular excision

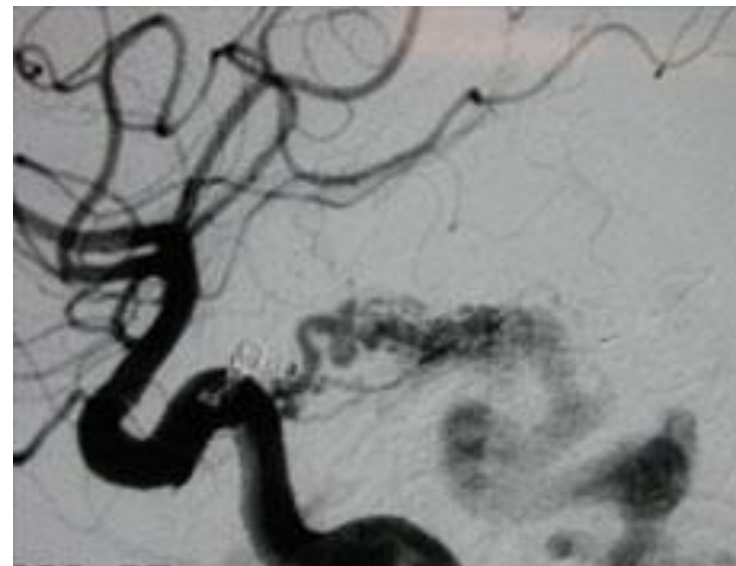
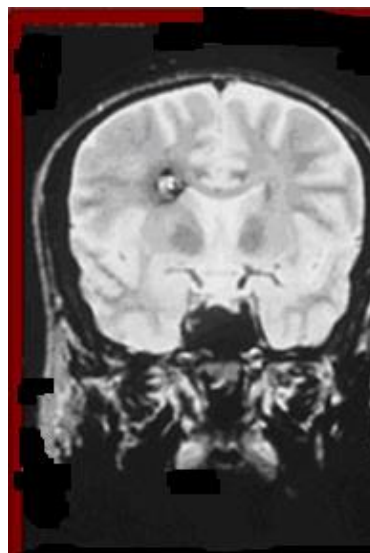
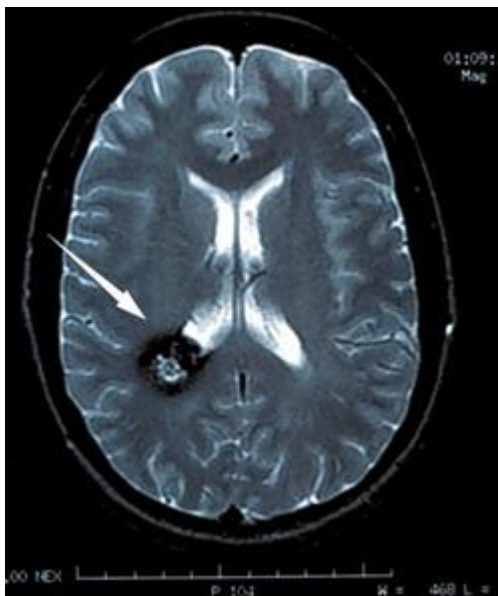
Many are partly embolized by interventional techniques

Stereotactic radiosurgery is used to treat small and/or residual AVM's



## Hemorrhagic Stroke

- Other Vascular Malformations



### **Cavernous malformations**

Causes seizures or focal deficits depending on location and hemorrhage

### **Dural AV fistulas**

Abnormal connection between artery and venous drainage of the dura

Usually treated by embolization

Beyond the acute hospitalization, rehabilitation and recovery are the most important aspects of stroke treatment.

Most strokes are associated with some recovery

Multidisciplinary treatment includes PT, OT, ST, Nutrition, Physiatry, Psychiatry

Recovery is measured in years!



## | Conclusion



The incidence of stroke is rising as the population ages

Ongoing advances in medical treatments and interventions are enabling greater survival with improved function

Technical advances allow alternative procedures that are less invasive for all forms of stroke

Public awareness and access to advanced stroke treatments has increased as more physicians are trained and technologies made available at more hospitals

| Questions?

