

Neurosurgical Management of Aneurysmal Subarachnoid Hemorrhage

PVHMC STROKE SYMPOSIUM

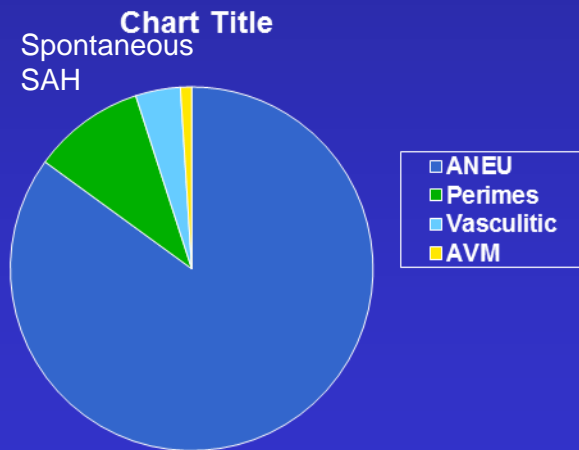
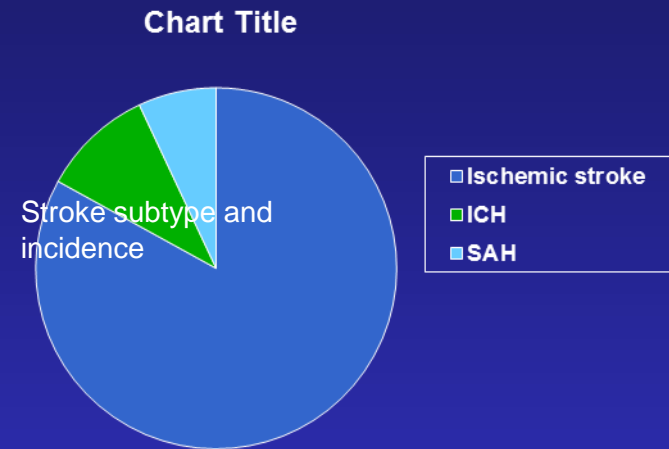
2018

10/27/18

Srinath Samudrala MD, FACS

Epidemiology of Subarachnoid Hemorrhage (SAH)

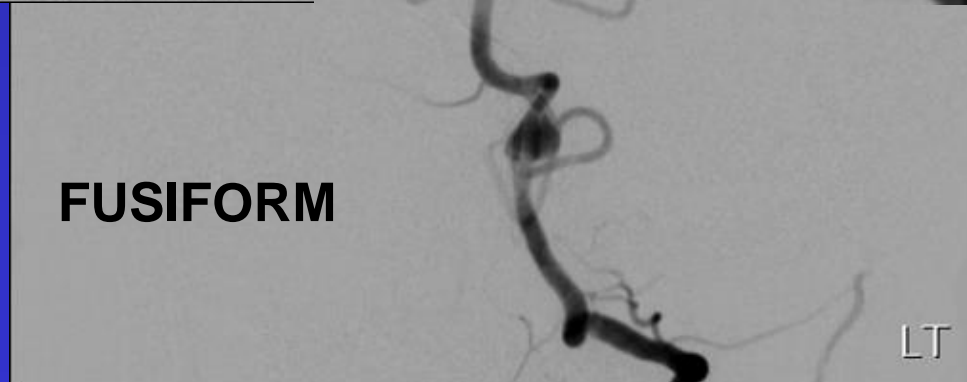
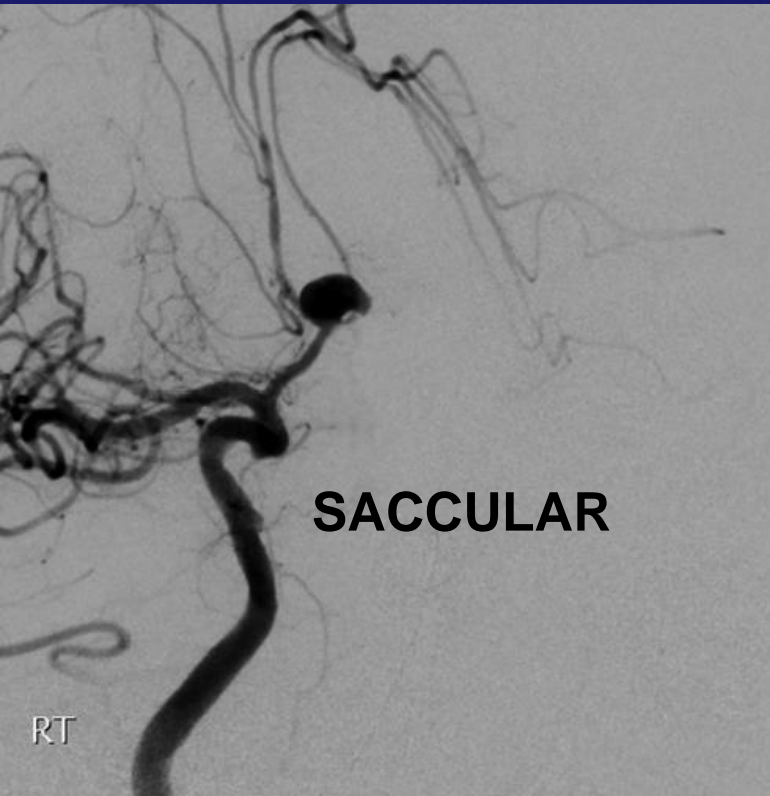
- Less than 10% of all stroke annually
- Acute mortality 25-50%; 30-50% morbidity
- Incidence of aneurysms ~5% general population
- Most SAH traumatic, but of non traumatic, majority due to aneurysm rupture (85%)



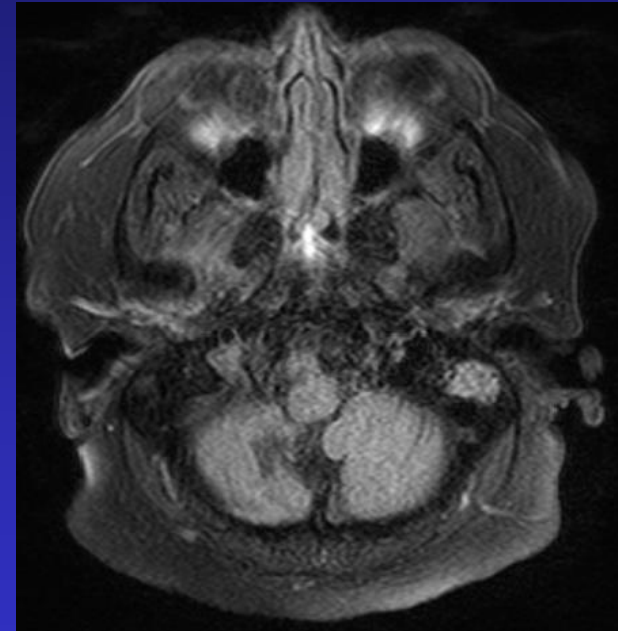
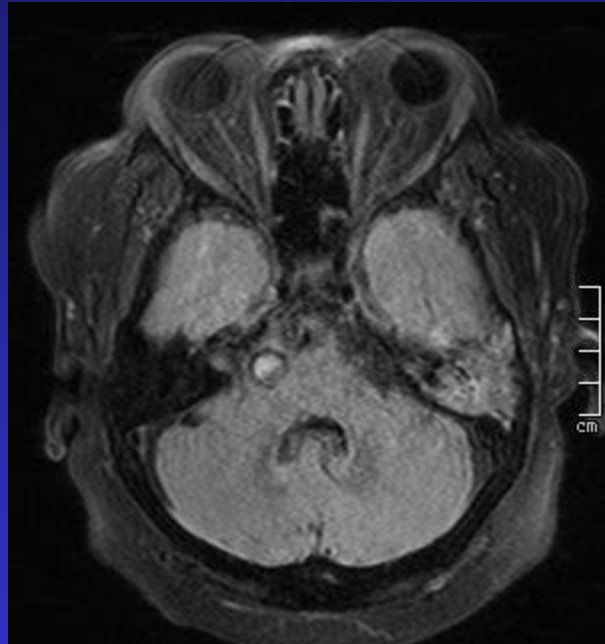
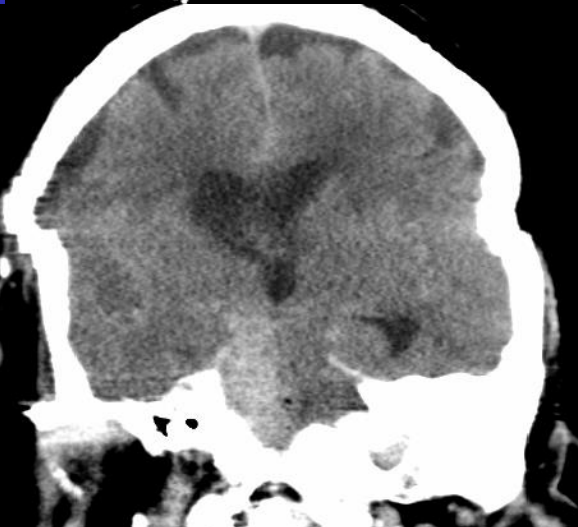
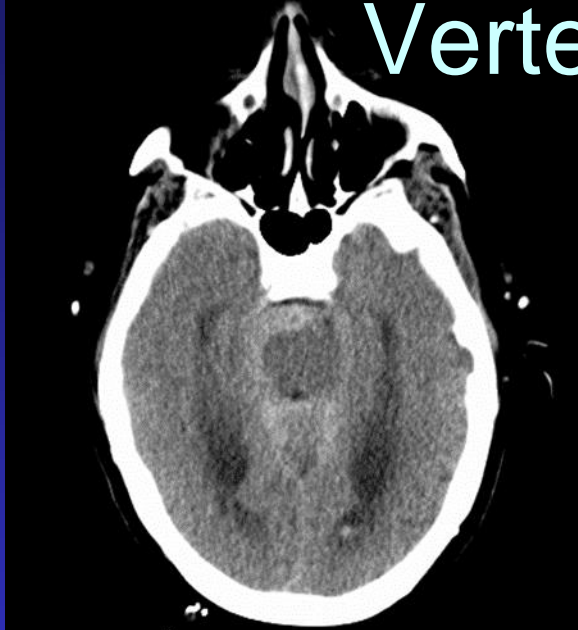
Risk Factors and Epidemiology of Aneurysmal SAH

- Females greater than males
- Peak age 55-60
- May be higher amongst blacks
- **Smoking**, hypertension, heavy alcohol use
- (Note, these are not the same risk factors for aneurysms development which may include collagen-vascular disease and co-associated conditions such as polycystic kidney disease

Types of Cerebral aneurysms



Focal peripontine SAH and possible Vertebral artery dissection



Clinical features

- Sudden, severe headache “thunderclap” headache; Nuchal rigidity; Nausea/vomiting
- Subhyaloid vitreous hemorrhage
- Cranial nerve palsies, particularly IIIrd nerve palsy with PCOM aneurysms or other ocular cranial nerve palsies with giant cavernous carotid artery aneurysms
- Coma, convulsions at onset

Diagnosis

- Computed tomography: hyperdensity in SAS
 - Fisher rating scale:
 - 1: minimal or no blood
 - 2: diffuse thin
 - 3: thick layering in basal cisterns
 - 4: IVH or ICH out of proportion to basal cisternal blood
- Lumbar puncture: xanthochromia, constant red cell count b/w first and last tube
- FLAIR MRI increased signal on T2 FLAIR in SAS

Fisher grade on CT



Fisher 2
Diffuse thin



Fisher 3
Thick cisternal clot



Fisher 4
ICH, IVH > SAH

Clinical Grading Scales

- Hunt Hess grade
 - 1: mild headache*
 - 2: severe headache OR mild headache with cranial nerve palsy (e.g. dilated pupil)
 - 3: lethargy or focal neurological sign
 - 4: stupor
 - 5: coma
- World Federation of Neurological Surgeons (combination of GCS and presence or absence of focal symptoms)

*Occasional reference to H-H grade 0 (unruptured aneurysm), though technically this grading scale applies only to ruptured aneurysms

Natural history of ruptured aneurysms

- Very high incidence of early rebleeding, upto 50% within first 6 months with 30% of that risk being within first 2 weeks
- Second bleed is often fatal
- “sentinel bleed”: initial asymptomatic or mildly symptomatic bleed followed by subsequent bleed of increased clinical severity

Clinical Management of SAH

Pre-aneurysm repair:

Prevent rerupture

- Control BP
- Maintenance fluids
- Avoidance of anticoagulants
- Supportive therapy
- Treatment of hydro if present
- Nimodipine 60 mg q4
- **Secure aneurysm**

Post aneurysm repair:

Prevent/treat VSP

- 'permissive HTN'
- Fluid augmentation
- +/- pharm. VTE prophylaxis
- Supportive therapy
- Treatment of hydro/VSP if present/occurs
- Nimodipine x 21 days

Deciding on Repair procedure

- Decision based on aneurysm location, morphology, patient comorbidity factors
- Ex: basilar tip → endovascular treatment, vs MCA bifurcation → surgical clipping
- Wide necked → clipping
- Older patients, cardiopulmonary issues, etc → endovascular treatment

Clinical trials of aneurysm repair procedures

- International Surgical Aneurysm Trial (ISAT)
 - Good grade SAH patients
 - ‘clinical equipoise’
- Barrow Ruptured Aneurysm Trial (BRAT)
 - Single center study
 - not blinded
 - Significant crossover from endovasc to surg arm

ISAT

- 2143 patients, 22 UK centers
- 1 year Death/dependency ~24 vs 31% (EVE vs MSC)
- 10 years: 83% coiled pts alive vs 79% clipped; 82% coiled vs 78% clipped pts independent
- Combined OR 1.34, , 95% CI, 1.07-1.67
- Slightly higher rate rehemorrhage endo group

Barrow Ruptured Aneurysm Trial

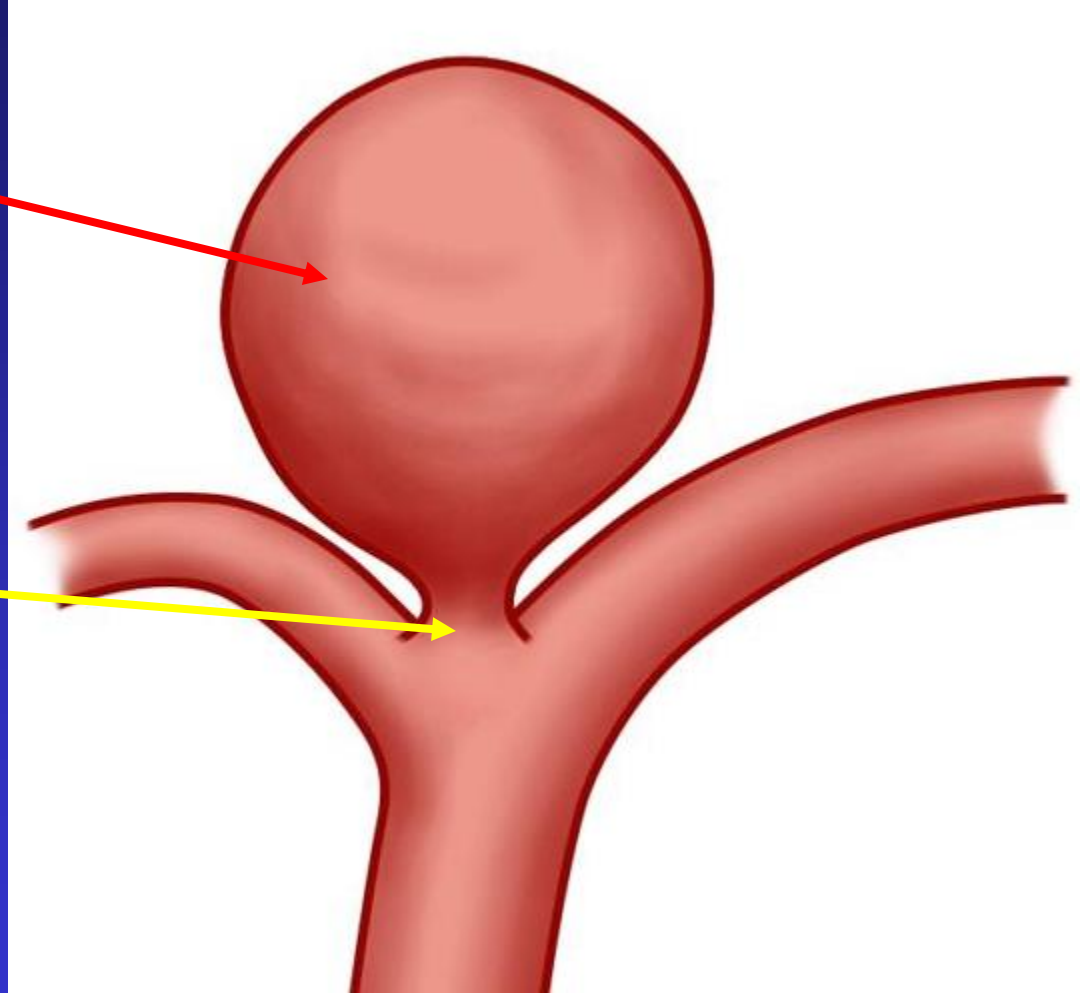
- 700 screened → 500 eligible → 403 eval
- 358 patients underwent treatment (remainder died pre-Tx or angio negative)
- 1 year data: Poor outcome in 33.7% clipped vs 23.2% coiled. OR 1.68, 95% CI 1.08-2.61, $p=0.02$
- 3 years: fav outcome, 5.8% absolute difference for coiled groups, $P=0.25$

Aneurysm Repair

ENDOVASCULAR ANEURYSM TREATMENT

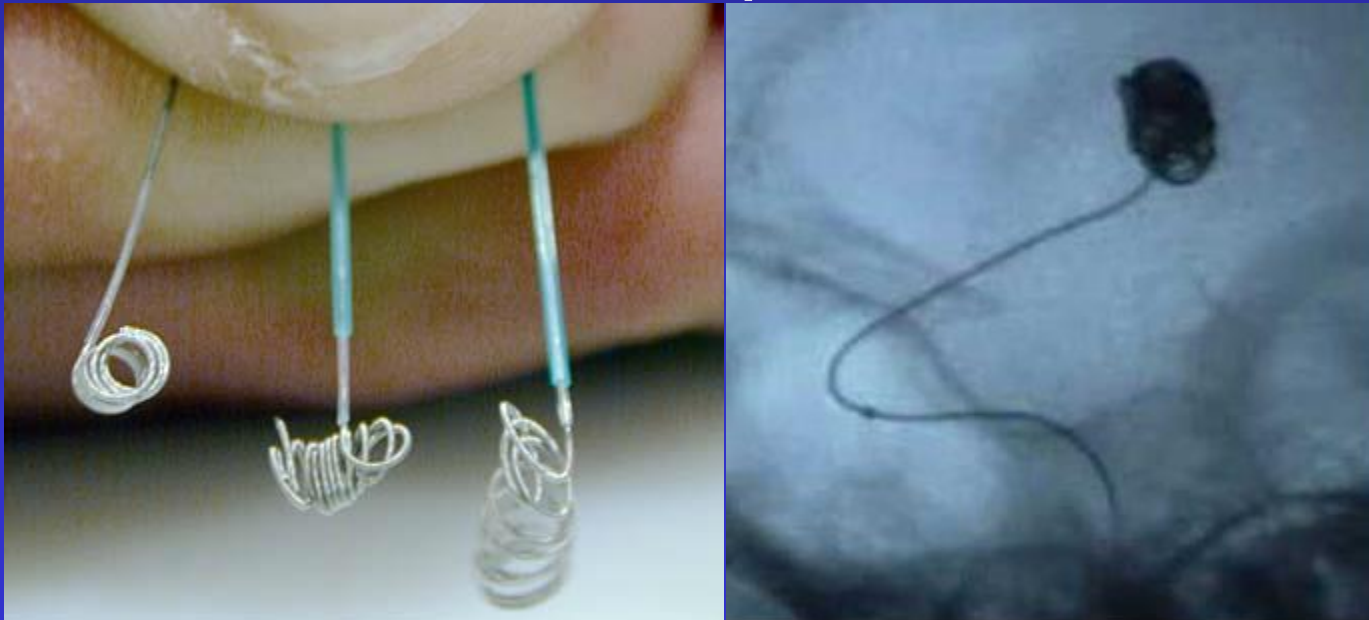
Endovascular Aneurysm Treatment

- Intrasaccular treatments
 - Coil embolization
 - Liquid embolic embolization
- Extrasaccular (neck treatments)
 - Flow diversion
 - Neck coverage



Development of Neurovascular Coils

- Guglielmi & Vinuela, UCLA, 1989-1990
- FDA approved 1995, Target Therapeutics
- Numerous manufacturers since then
- 'bioactive' vs bare platinum coils



Other general considerations

- Coils are MRI compatible
- Stents/Flow diverters are MRI compatible

OPEN NEUROSURGICAL ANEURYSM TREATMENT

Efficacy and risk factors of surgery

- More than 90% complete occlusion rate
- Mortality 0-3% in various series
- Morbidity 2-11% quoted in large studies
- Risk of surgery exceeds the 7.5 year risk of bleed in those aneurysm which are $<10\text{mm}$

Factors affecting surgical outcome

- Aneurysm related factors
 - Aneurysm size (>2.5).
 - Location (A comm, ICA bifurcation).
 - Orientation
- Patient related factors
 - Age
 - Ischemic cerebrovascular diseases
 - Diabetes mellitus

RUPTURED ANEURYSMS

- Sixty percent of patients either die or disabled.
- 20-30% rebleed in 30 days.
- 4% rebleed rate on day 1.
- more than 70% who rebleed, die.
- Aneurysm occlusion either surgical or endovascular is the only answer.

Options for definitive treatment

- Surgery.
 - Simple Clipping
 - Wrapping
 - Parent vessel occlusion
 - Revascularization procedures
- Endovascular methods.
 - Destructive procedures
 - Reconstructive procedures
- Endoscopy
- Conservative

Timing of surgery:

- Anterior circulation: early surgery has good results compared to late
- Posterior circulations:
 - Easy aneurysms: early surgery
 - Difficult aneurysms : after two weeks

(Haley EC jr et al the international cooperative study on the timing of aneurysm surgery; the north American experience. Stroke 23:205-214;1992)

Early surgery

- Virtually eliminates re-bleed
- Facilitates treatment of vasospasm
- Allows removal of vasospasmogenic material
- Though operative mortality higher, but overall outcome is better
- Factors favoring early surgery:
 - Good medical condition of patient
 - Good neurologic condition
 - Large clot, blood
 - Early rebleed, multiple episodes
 - Imminent rebleed signs

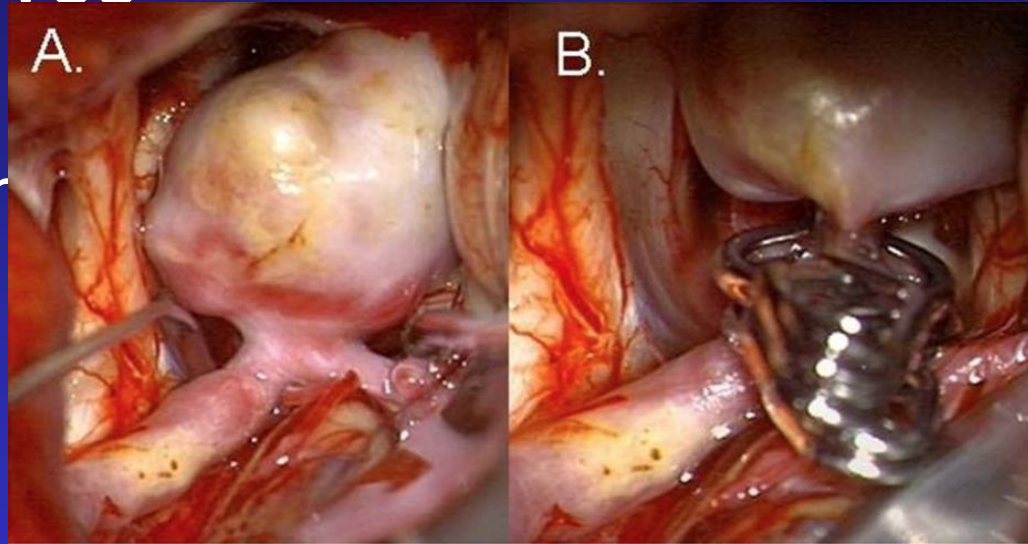
Disadvantages

- Inflammation and brain edema causes more difficult and traumatic retraction
- Acute clot makes dissection difficult
- Risk of intraoperative rupture is high
- Vessel injury may aggravate vasospasm
- Factors favoring late surgery:
 - Poor medical neurological condition
 - Difficult aneurysms
 - Significant edema on CT
 - Active vasospasm

Technical considerations of aneurysm surgery

Intraoperative objectives

- prevent rupture
- Further enlargement



Intraoperative surgical images of a large intracranial aneurysm (A) successfully treated by placing an aneurysm clip around the neck of the aneurysm (B).

- Preserve normal vessels
- Minimize injury to the brain

Technical considerations of aneurysm surgery

- Clip too low- may occlude parent vessel
- Distal placement- aneurysmal rest
- Aneurysmal rest expand in future and may rebleed
- Surgical exposure:
 - avoid retraction
 - Brain relaxation- hyperventilation, CSF drainage, lumbar spinal drainage, cisternal drainage
 - drugs

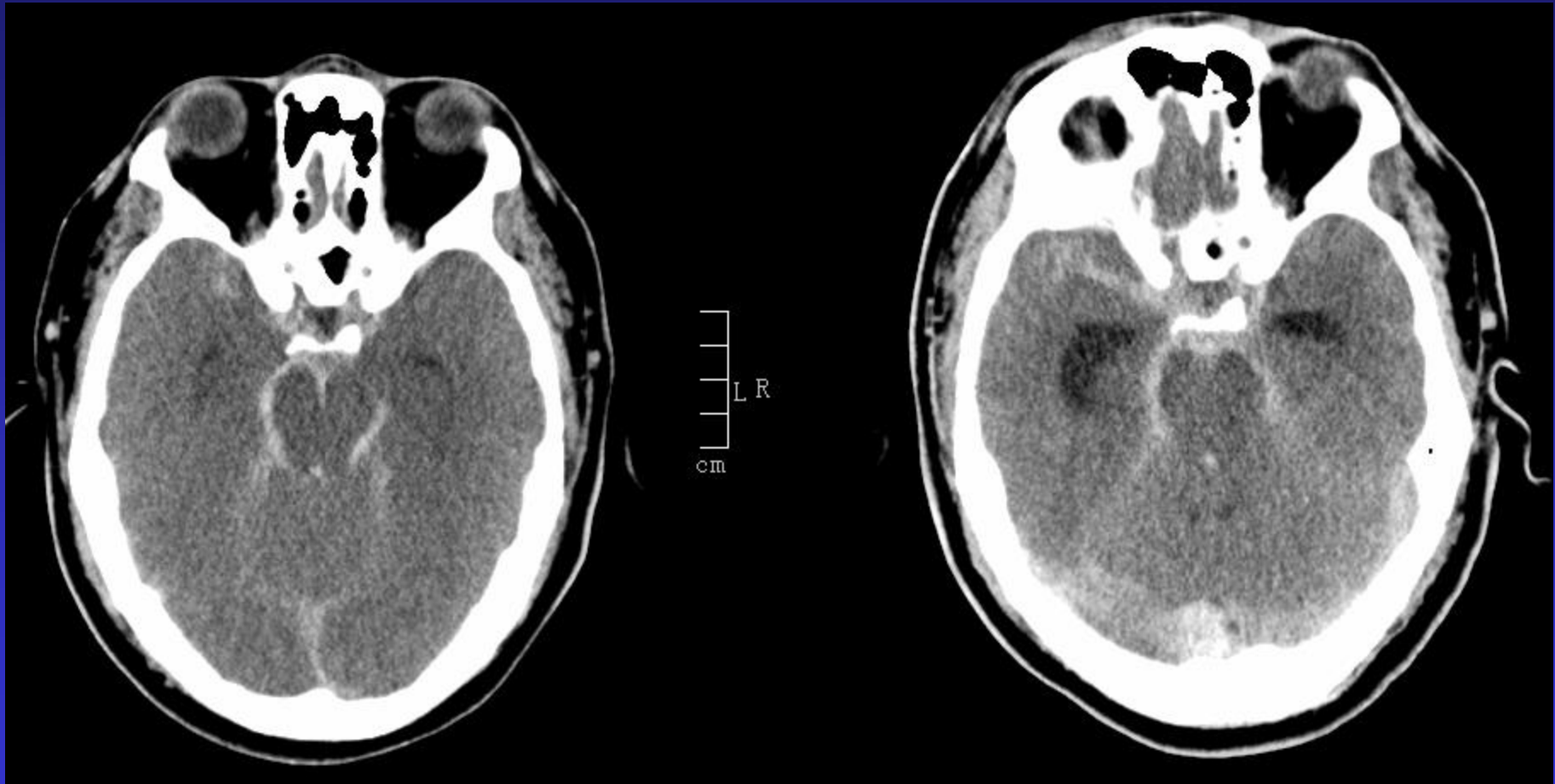
POST ANEURYSM REPAIR CONSIDERATIONS

NEUROLOGICAL SEQUELAE OF SAH AND CLINICAL MANAGEMENT

Brain Injury and Neuro sequelae post SAH

- Ultra-early injury (initial hours)
 - ICP crisis, cerebral circulatory arrest
 - Microthrombosis
 - Cortical spreading ischemia
- Early injury (first few days)
 - Vasospasm
 - hydrocephalus
- Late/subacute (first 6-12 months)
 - Depression
 - Fatigue
 - Cognitive problems
- Delayed complications (remote from incident event)
 - Normal pressure hydrocephalus

34 M with sudden LOC, L vertebral artery aneurysm



6:30 AM

2:17 PM

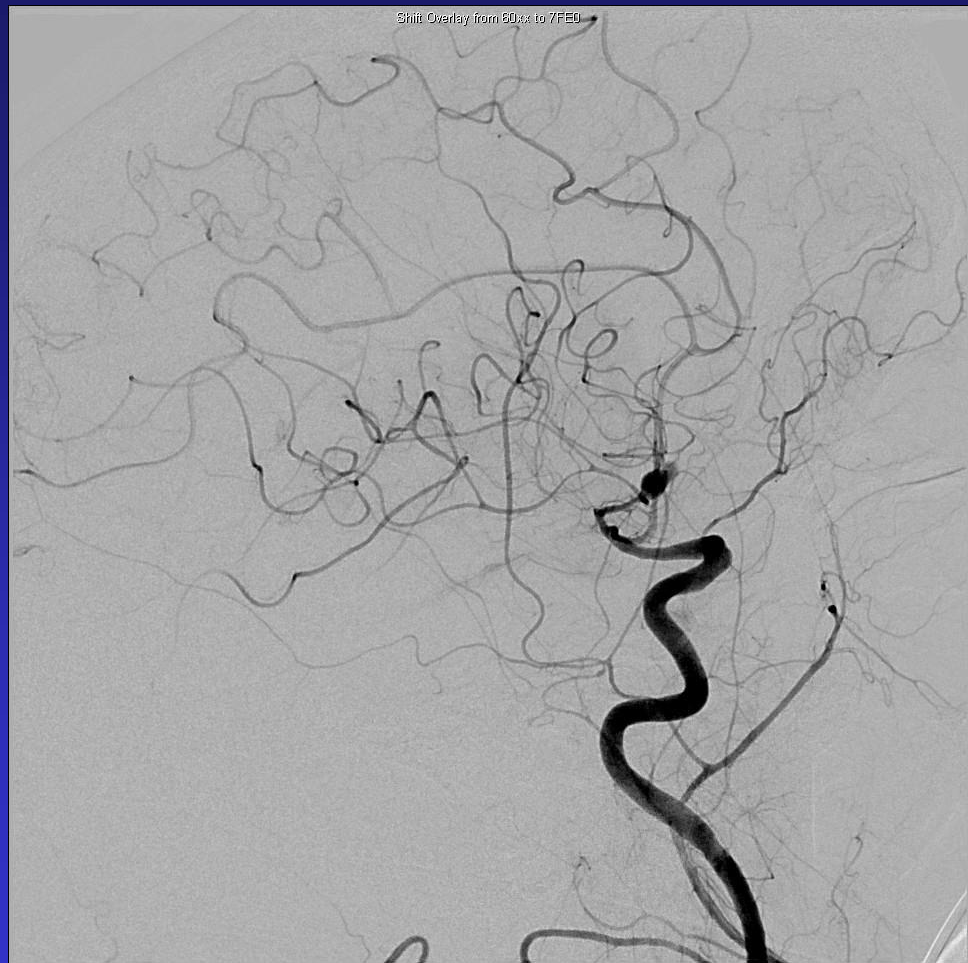
Vasospasm and HHT

- Constriction of blood vessels due to inflammatory effect of blood breakdown products
- Peak incidence days 3-10 post SAH
- Diagnosed by TCD with MFV in major intracranial vessels > 120 cm/sec
- Treated by 'triple H therapy' (hypertension, hypervolemia, hemodilution) or first two arms, intra-arterial vasodilator administration, intracranial angioplasty

Shift Overlay from 80.4% to 7FE0



Shift Overlay from 80.4% to 7FE0



HHT

- Many patients 'auto-hypertense'
- Induced hypertension with vasoactive medications, inotropes
- In extreme cases IABP
- Hypervolemic therapy to maintain CVP > 8 mm Hg with albumin, NS, 3% HTS
- Early move to definitive therapy for refractory cases (no improvement w/in 1 hour of HHT, or despite max HHT)

Magnesium therapy

- Experience with eclampsia patients
- Neuroprotectant (glutamate antagonist)
- 5 g bolus
- MgSO₄ 2 gm/250 cc NS at 23 cc/hr

Endovascular Tx of VSP

- IA vasodilators: papaverine (very short duration of action), verapamil, nicardipine, NTG
- Intracranial angioplasty more durable, with low or no incidence of recurrence of VSP at angioplastied segment

Im:302 (F1/1)

Study Date:9/23/2008
Study Time:10:07:0...
MRN:00001328397
DOB:12/2/1947
Sex:F

76 KV
ICA RT
IODINE

C2048
W4096



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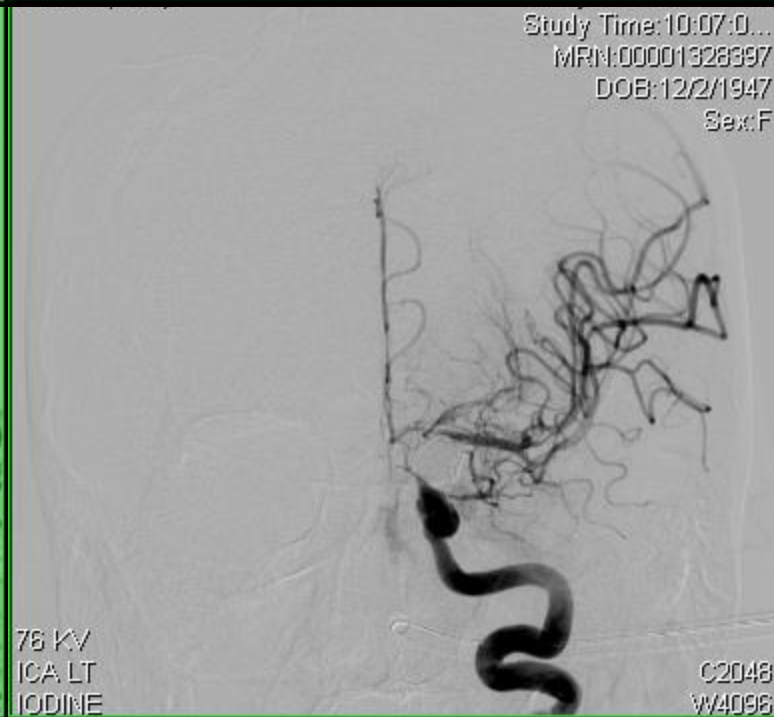
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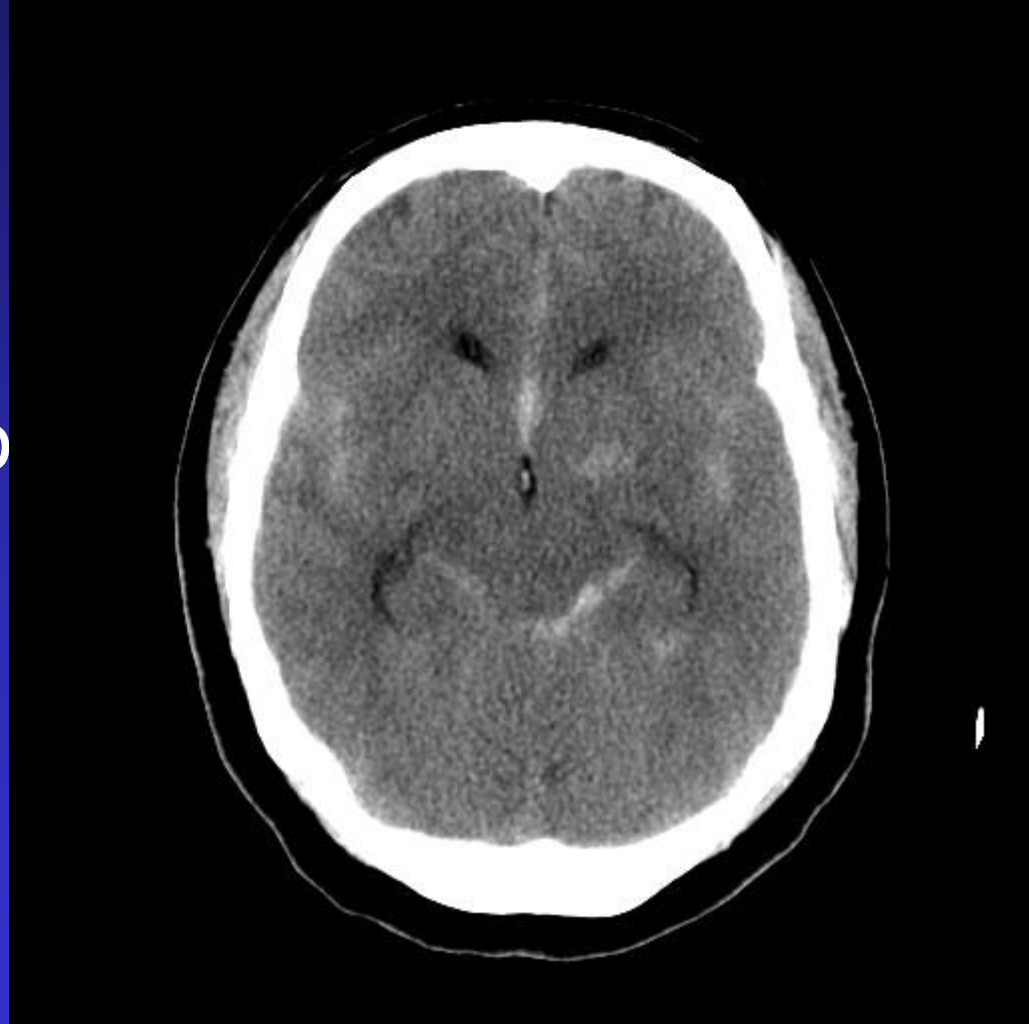
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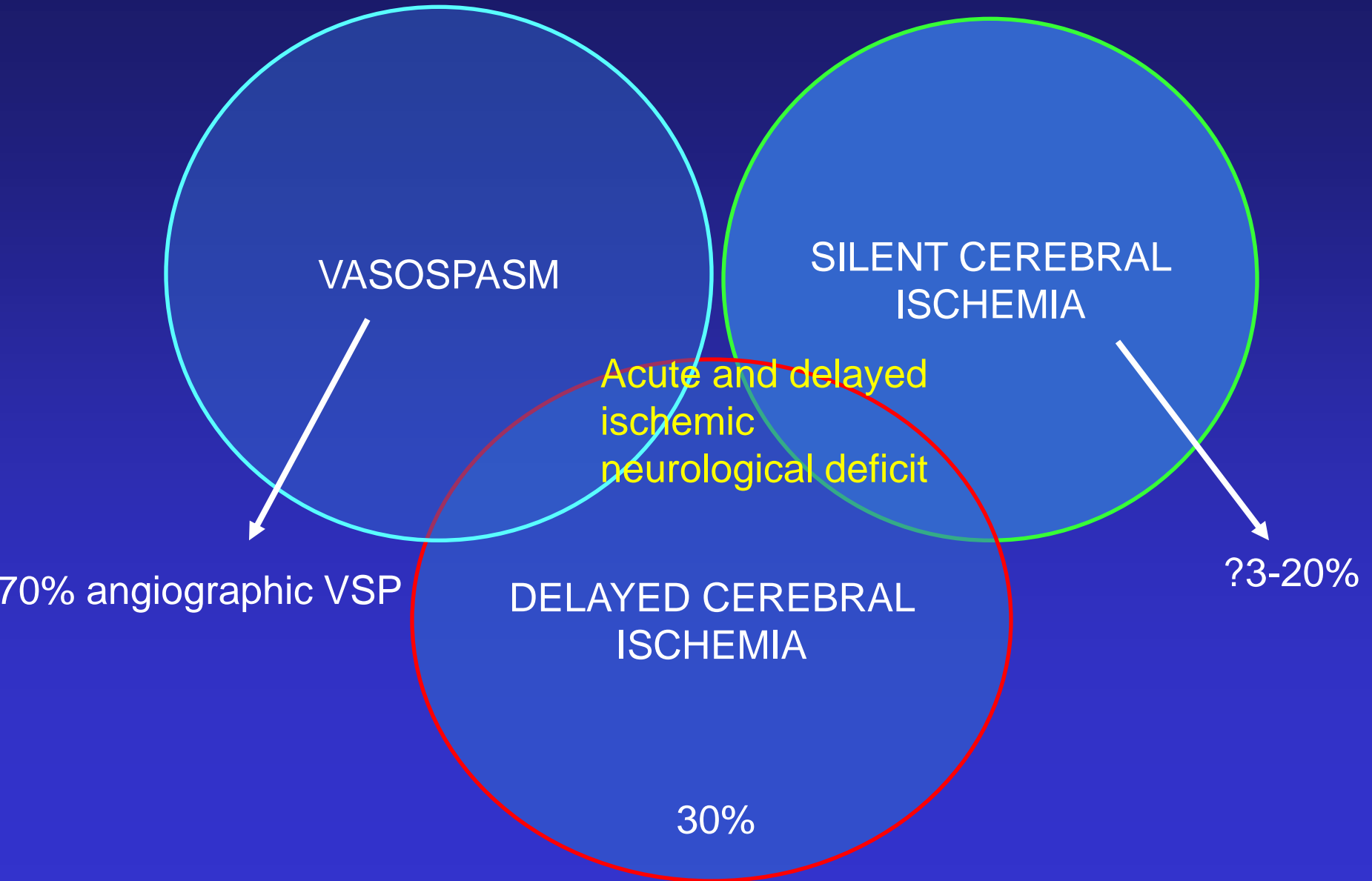
C2048
W4096

Global cerebral edema

- More common in poor grade patients
- Extension of white matter hypodensity to cortical surface on HCT
- *May be exacerbated by HHT therapy*



Ischemia in Subarachnoid Hemorrhage



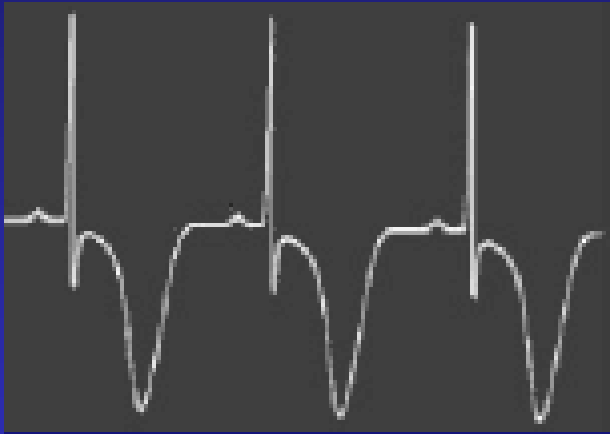
Prevention/Treatment of Cerebral Ischemia in SAH

- Detection/treatment of vasospasm
- Nimodipine
- Negative/equivocal trials: clozasantan, cilostazol, dantrolene, albumin, statins, magnesium, intra-theecal nimodipine

POST ANEURYSM REPAIR CONSIDERATIONS

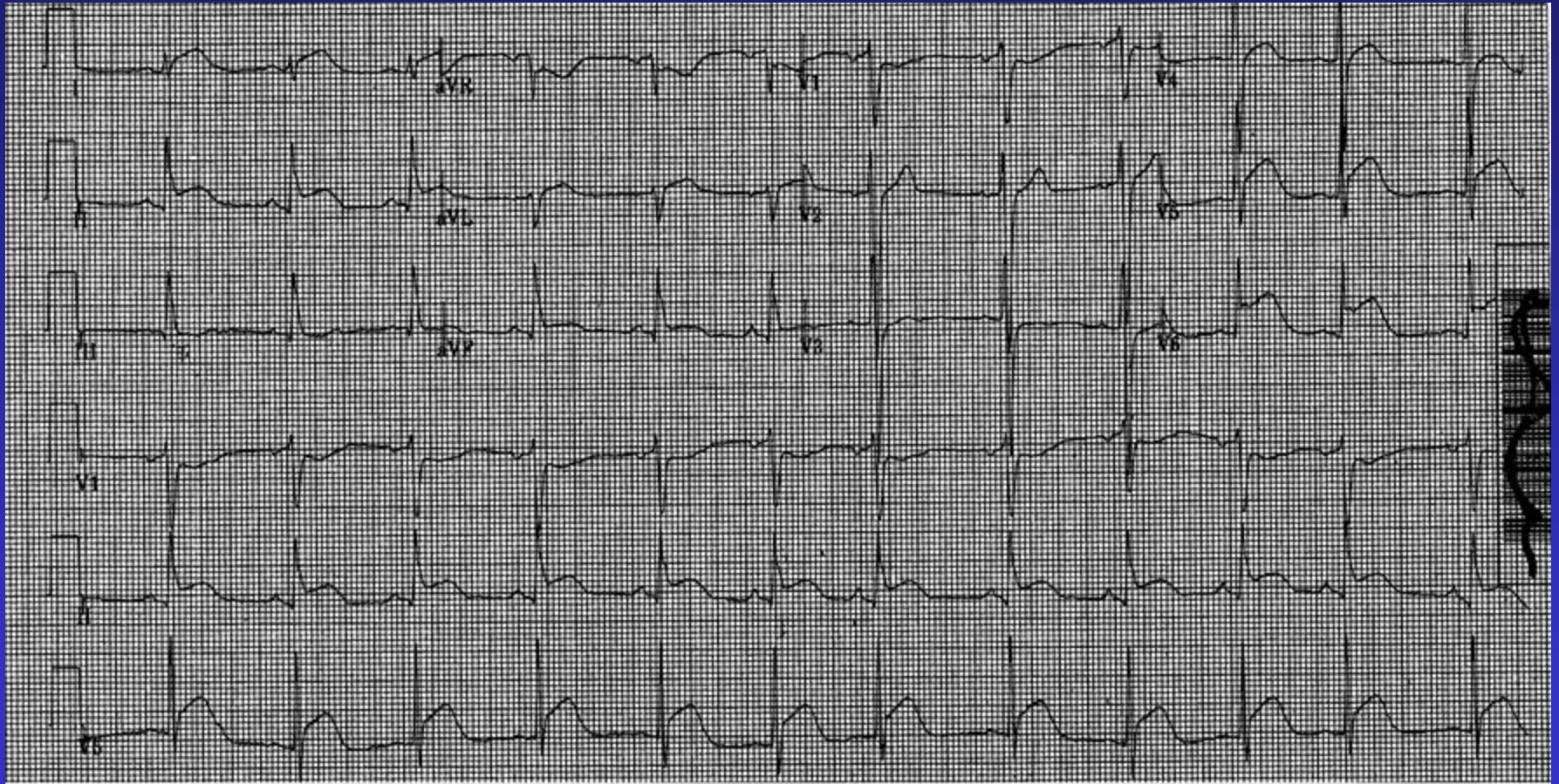
MEDICAL COMPLICATIONS OF SAH

EKG changes in SAH



- T wave inversions
- Diffuse ST elevations or depressions
- (changes that do not respect coronary artery territory)
- Prolonged QT interval
- *Torsade de pointes*

32 M sudden seizure, SAH



Neurogenic stunned myocardium

- Sympathetic surge leads to catecholamine release and global depressed cardiac function
- More common among middle aged women
- Echocardiography may show hypokinesis which does not follow pattern of coronary artery distribution
- May have elevation of cardiac enzymes
- Can be reversible

Differentiating Etiology of Myocardial Dysfunction

Neurogenic

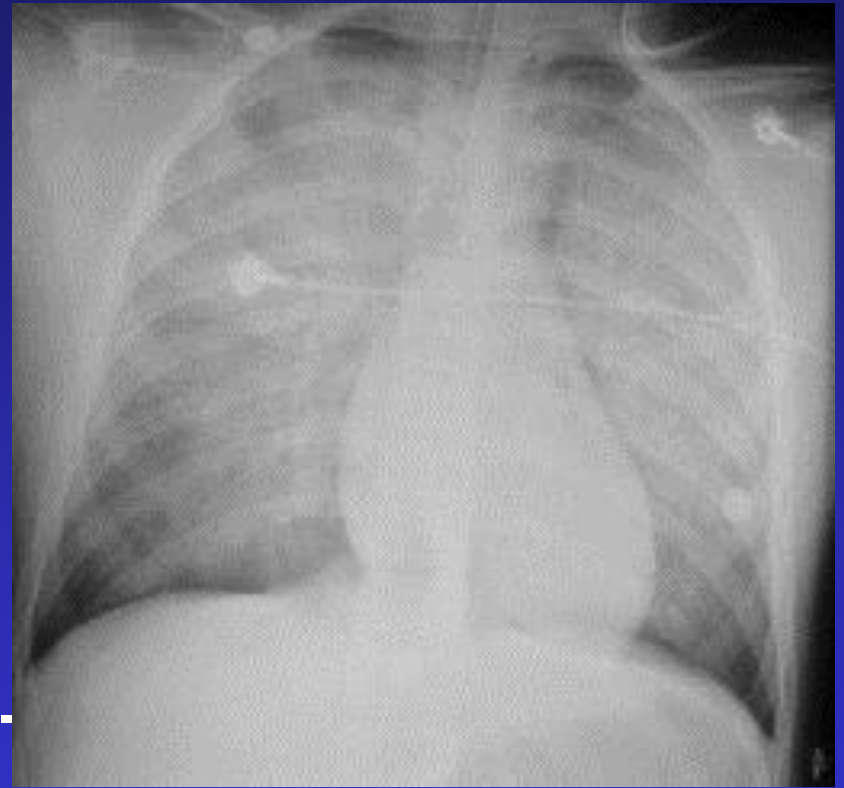
- Age < 50
- F > M
- Diffuse/global dysfunction

Cardiogenic

- Older
- M > F
- Regional wall motion abnormalities

Neurogenic pulmonary edema

- Can develop within minutes of CNS injury
- Causes: changes in pulmonary capillary hydrostatic pressure and permeability due to catecholamine surge
- Lower PCWP than with non-neurological causes of pulmonary edema



<http://www.mypacs.net/repos/mpv3>

repo/viz/full/4664/233221.jpg;
accessed 6/4/08

Fever in SAH

- May be more common in poorer grade SAH patients and those with IVH
- Mees et al, *Stroke*, 2008: 42% patients experienced fever, 34% infections
- Fernandez et al, *Neurology*, 2007: for every 1 C over 37, 9x inc risk of death, 3x inc risk disability
- Circuit controlled temperature regulatory mechanisms
- Acetaminophen, NSAIDs, cyproheptadine

Cerebral Salt Wasting

- Sodium derangements (hyponatremia) common initially thought to be due to SIADH, now understood to be far more commonly due to cerebral natriuresis
- Hypervolemic therapy rather than fluid restriction
- Hypertonic saline in refractory cases
- PO salt tabs (not very effective)
- Avoidance of hypotonic fluids

Standard ICU orders for SAH patients (pre-Tx)

- Hourly neurological checks
- A-line, maintenance of BP $\leq 140/90$ mm Hg
- Ventilatory support for lethargic patients
- EVD drainage for lethargic patients, pts with hydrocephalus, EVD at 15 cm H₂O to tragus
- Dilantin/leviteracetam or other AED through first few days

Pre-Tx orders ctd

- Nimodipine 60 mg q4 (can give 30 mg q4 for lower BP)
- IVF (NS, no hypotonic fluids)
- Stool softener
- PPI
- Non medical DVT prophylaxis

ICU orders (post Tx)

- Liberalization of BP parameters
- Consider starting SQ heparin for DVT prophylaxis
- consider lower EVD reservoir level
- Consider D/Cing AEDs at day 7-14 for grades 1 and 2 without intraparenchymal clot
- Steroids not routine, but may alleviate chemical meningitis pain

Differential of Worsening Neurological Status in SAH

- Rebleeding
- Worsening hydrocephalus
- vasospasm
- Developing edema or other mass effect
- Seizures (up to 30% poor grade patients with SAH may have subclinical status epilepticus)
- Worsening of medical comorbidities/dysfunction

Management of Neurological Decline in SAH

- Treatment of medical comorbidities
- Clinical assessment, pupillary exam, look for clinical signs of herniation, if present treat as for ICP crisis
- Early CT scan
- If rebleeding or concern for VSP, angiography and treatment
- additional monitoring (EEG)

Management of ICP crisis

- Osmotic therapy (mannitol, hypertonic saline)
- Hyperventilation to PCO_2 35 mm Hg
- Sedation (propofol, extreme cases, barbiturates)
- CSF diversion or other surgical therapy

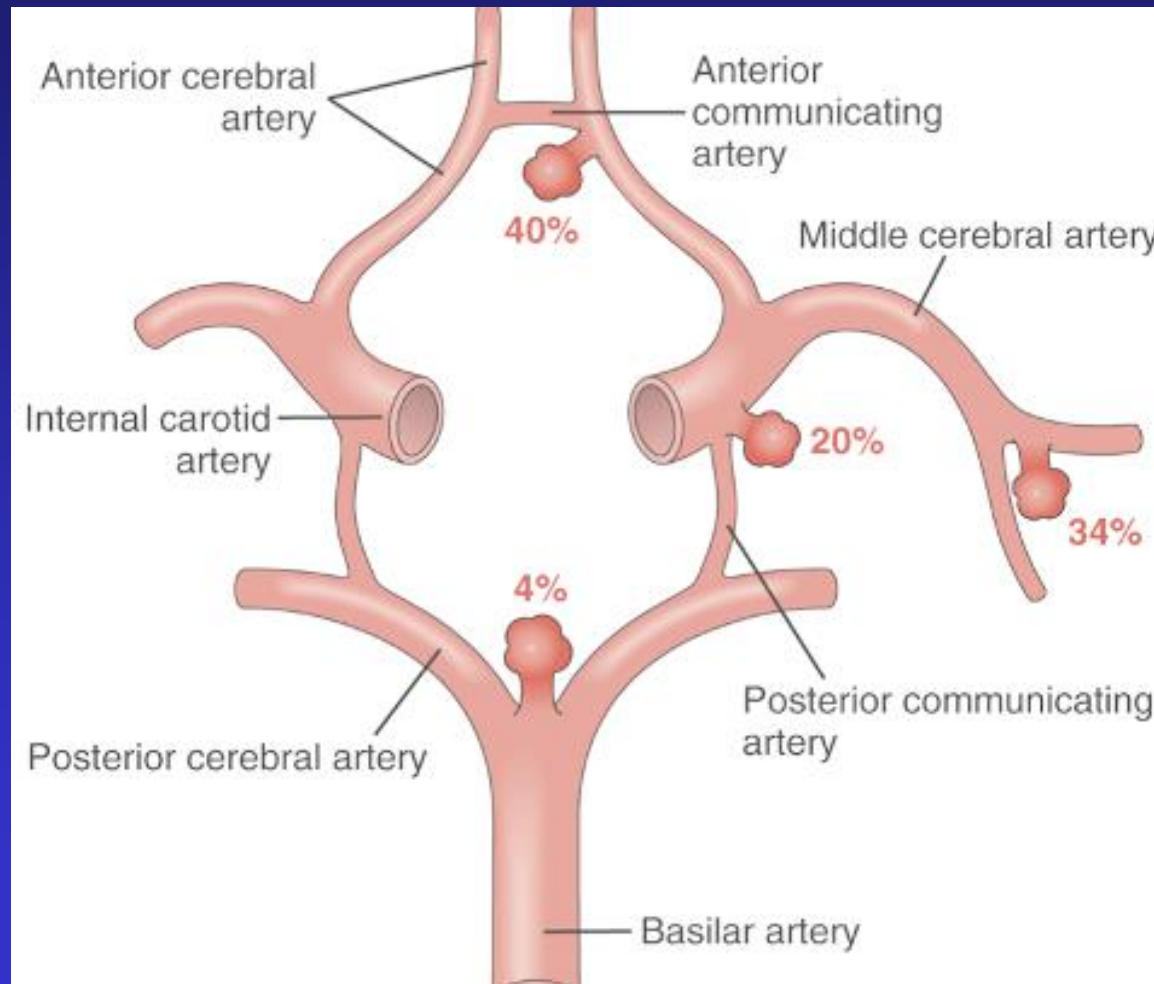
Predictors of Poor Outcome

- McDonald et al, Toronto, Canada:
 - Worse Hunt and Hess/WFNS scores
 - Leukocytosis at presentation
 - Hemodynamic instability
- Mayer et al, Columbia, NY, NY
 - Hypoxemia, Aa gradient > 125 mm Hg
 - $\text{HCO}_3^- < 20$ mmol/L
 - Glucose > 180 mg/dL
 - MAP < 70, > 130 mm Hg

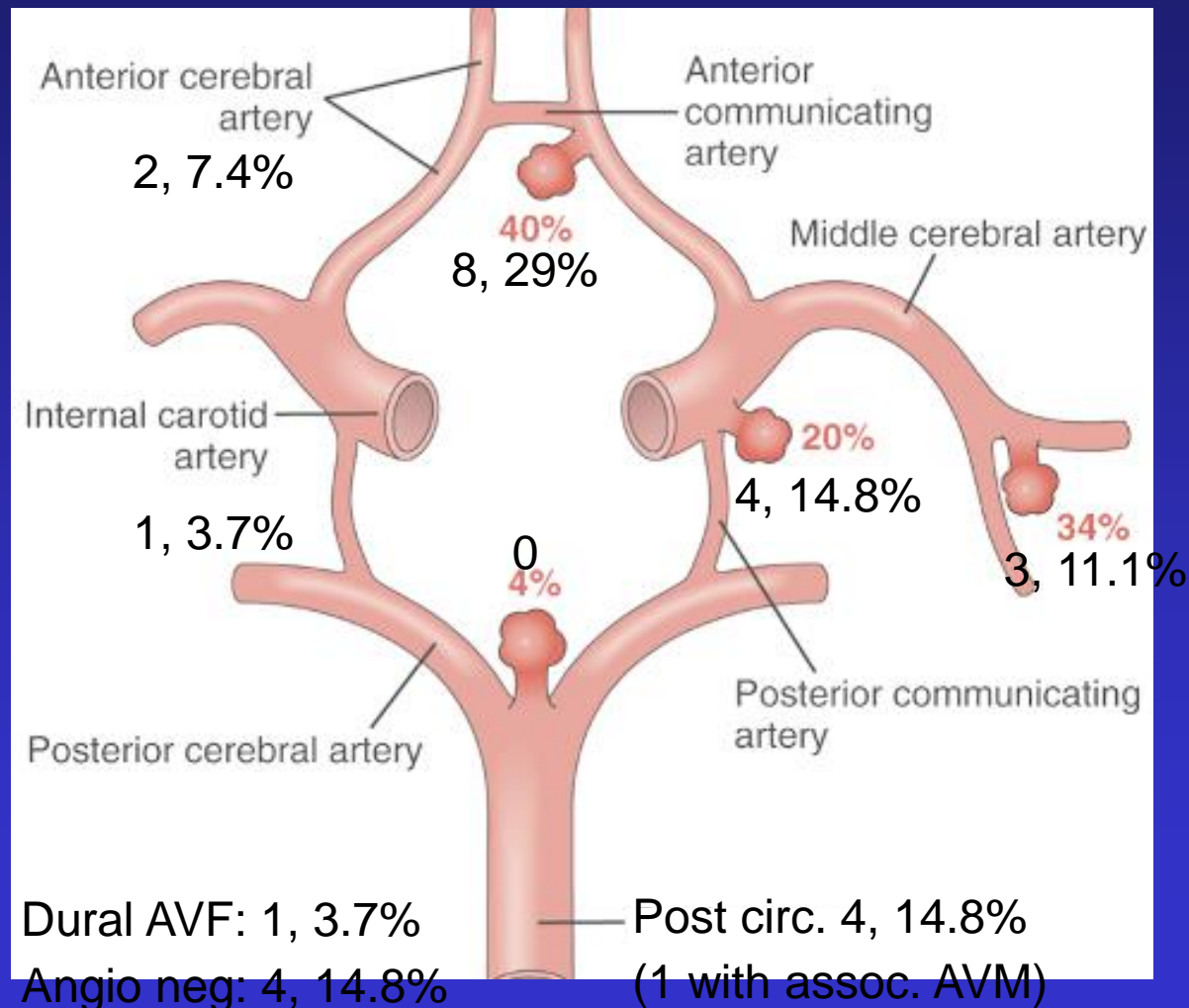
Which Unruptured Aneurysms Should be Treated?

- All newly discovered aneurysms should be referred for further evaluation
- ISUIA: Low annual risk of hemorrhage for anterior circulation aneurysms < 7 mm, and posterior/PCOM < 5 mm
- In patients with prior SAH and multiple aneurysms, higher risk of hemorrhage for small aneurysms compared with other pts
- 2+ Family history \rightarrow 25% lifetime risk SAH

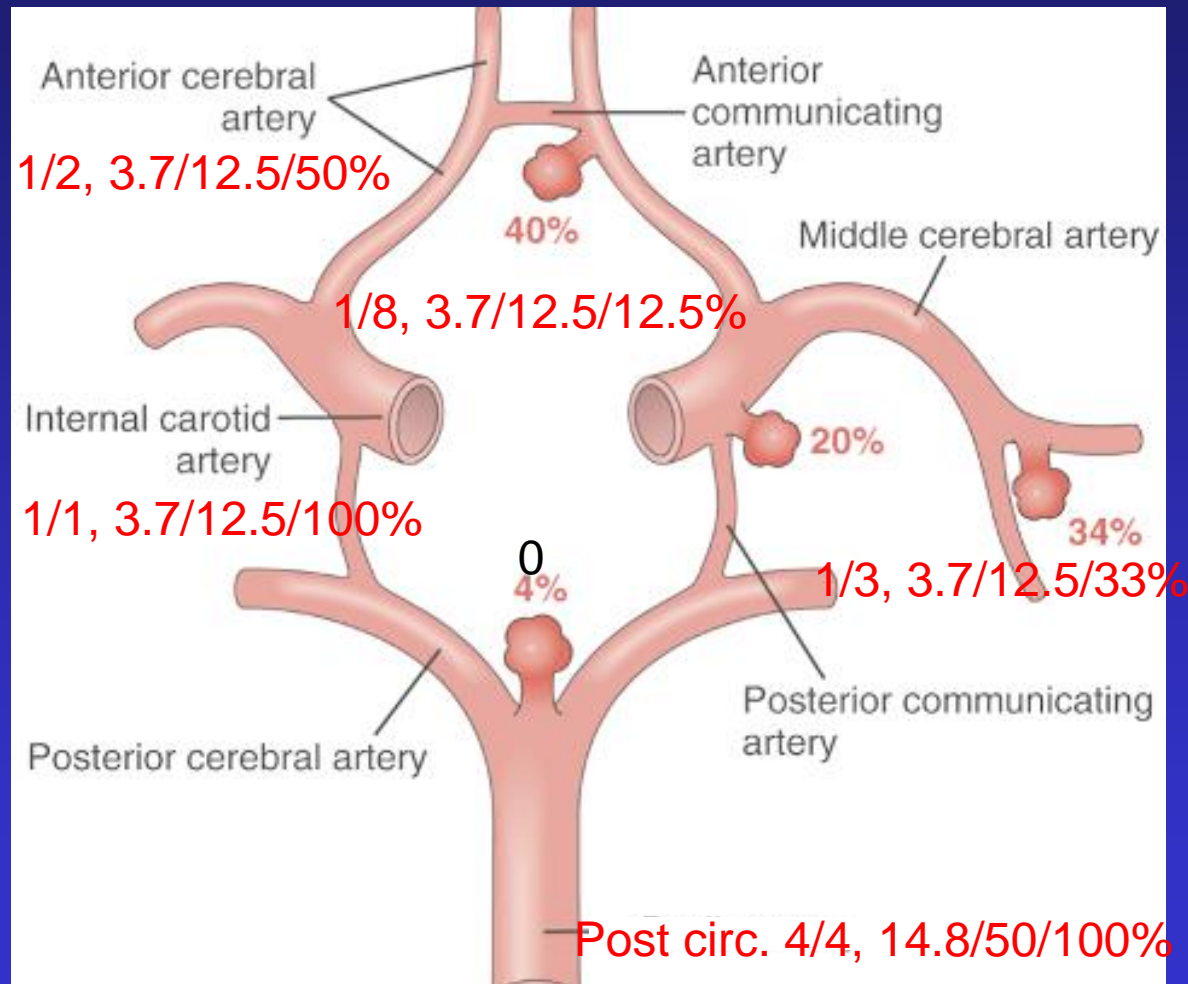
Common Intracranial Aneurysm Locations



PVHMC pt Intracranial Aneurysm Locations



Mortality by Intracranial Aneurysm Locations

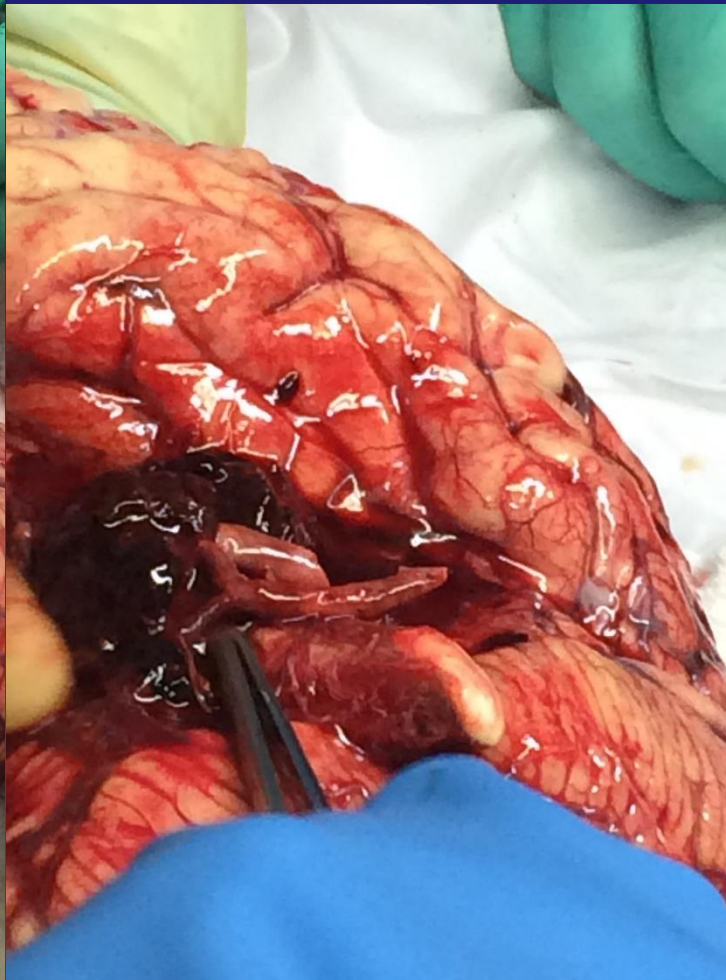


% of total # of SAH patients/% of expired patients/% w/in this ANEU group

PVHMC SAH Data

	Age	Female	HH 1-2	HH 3-5	misdx	Delay hosp. arr.	>1 aneu
Total (27)	58	16, 59%	8, 29.6%	19, 70.4%	3, 11.1%	9, 33.3%	3, 11%
Mort. 8, 29.6%	46	5, 62.5%	1, 12.5%	7, 87.5%	1, 12.5%	4, 50%	1, 12.5

65 F H/A, prior R cerebellar infarction, ?? R VAD,
expired SAH day 7, sepsis, cardiopulmonary
arrest



- Severe atherosclerosis with dense calcification of R VA
- Inflammatory thrombus of the R VA associated with focal vasculitis

Conclusion

- SAH highly morbid subset of stroke, mortality rates 40%
- Early aneurysm repair
- Treatment of concomitant hydrocephalus
- Close ICU observation during vasospasm period and treatment if it occurs essential
- Treatment of other medical comorbidities