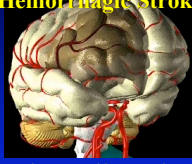


## Endovascular Treatment of Hemorrhagic Stroke

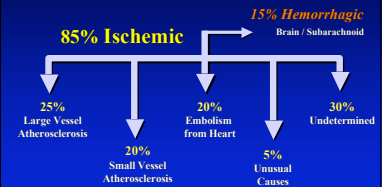


Robert L. Dodd, M.D., Ph.D.  
Assistant Professor of Neurosurgery Radiology  
Stanford University School of Medicine

## Neuro-Interventional Radiology



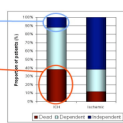
## Stroke Epidemiology



## Prognosis of ICH

### ICH is More Deadly and Disabling than Ischemic Stroke

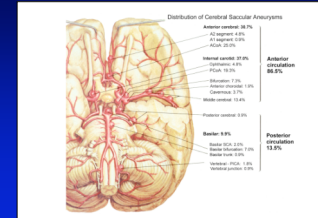
- Independence
  - Only 20% of ICH patients are independent at 6 months vs 40% of ischemic stroke patients
- Mortality
  - 6-month, 30-50%
  - 1-year, 50%



## Spontaneous Intracerebral Hemorrhage

- Primary (70-80% of cases)
  - Hypertension
  - Cerebral amyloid angiopathy
- Secondary
  - Aneurysms
  - AVMs
  - AV fistulas

## Intracranial Aneurysms



## Intracranial Aneurysm Statistics

- Nearly 30,000 new cases of aneurysmal SAH occur annually in the U.S.
- SAH accounts for 2-7% of all new strokes, 5% of deaths from stroke, and 27% of all stroke-related years of potential life lost before the age of 65
- The natural history of aneurysmal SAH without treatment is almost uniformly fatal

## Etiology of Intracranial Aneurysms

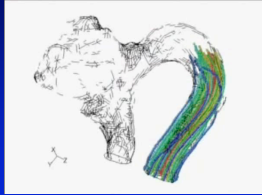
- Remains controversial:
  - Congenital predisposition
  - Atherosclerosis and hypertension
  - Embolic (atrial myxoma)
  - Infectious (mycotic)
  - Traumatic
  - Associated with other conditions

## Pathogenesis of Saccular Aneurysms

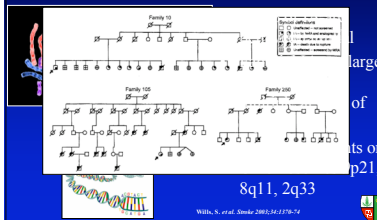


- Congenital defects in muscle and elastic tissue of arteries or acquired through degenerative changes in vessel walls
- Hemodynamic stress and heredity implicated in the development or rupture of aneurysms

## Effects of Hemodynamic Stress



## Genetics of Intracranial Aneurysms



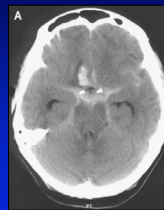
## Clinical Presentation

- Subarachnoid Hemorrhage
- Intraventricular Hemorrhage
- Intraparenchymal Hemorrhage
- Stroke
- Transient Ischemic Attacks (TIAs)
- Seizure
- Headache
- Cranial nerve deficits
- Mass effect

## Clinical Presentation of SAH

- Excruciating headache
- Nausea, vomiting, photophobia and neck pain
- Focal cranial neuropathies or neurological deficits
- Altered level of consciousness (obtundation and coma)
- Sentinel headaches (warning leaks) may precede major, clinically devastating SAH in as many as half of cases

## Computed Tomography of SAH



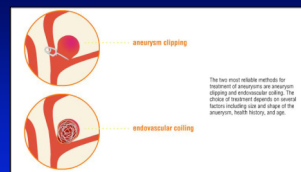
## 3D Angiography (DSA)



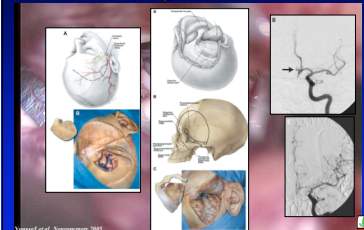
## 3D Angiography (DSA)



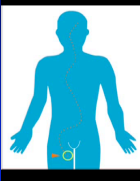
## Aneurysm Treatment Options



## Microsurgical Treatment

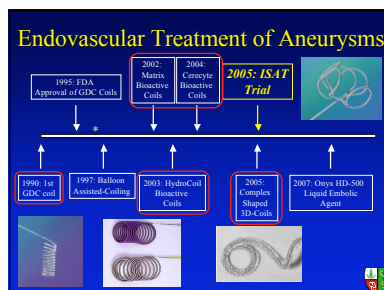


## Endovascular Treatment

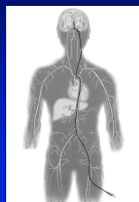


**endovascular coiling**

A thin tube called a catheter is inserted into a blood vessel inside the skull and is carefully guided to the site of the aneurysm in the brain.



## Endovascular Treatment

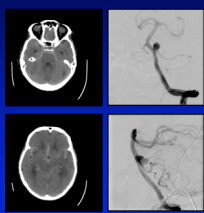


Primary Treatment

Balloon-Assisted

Stent-Assisted

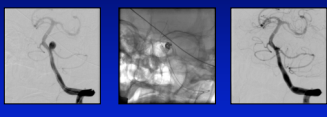
## 93 y.o. woman with acute headache



CT HEAD

ANGIO PRE


## Coil Embolization with Balloon Remodeling



ANGIO PRE

ANGIO POST

## Use of Intracranial Stents



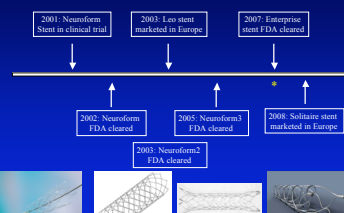
1976: 1st Coronary stent

1987: 1st report of a Coronary stent as used currently

1987: 1st Coronary Stent FDA cleared

1996: 1st report of a Coronary stent used intracranially

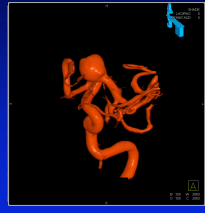
## Use of Intracranial Stents



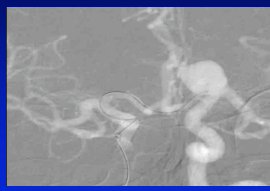
Timeline of Intracranial Stents:

- 2001: Neuroform Stent in clinical trial
- 2002: Neuroform FDA cleared
- 2003: Leo stent marketed in Europe
- 2004: Neuroform2 FDA cleared
- 2005: Neuroform3 FDA cleared
- 2006: Solitaire stent marketed in Europe
- 2007: Enterprise stent FDA cleared

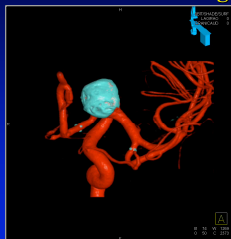
## Stent Assisted Coiling



## Stent Assisted Coiling



## Stent Assisted Coiling



## International Subarachnoid Aneurysm Trial (ISAT)

- 2143 primarily good grade patients with ruptured aneurysms were randomized between microsurgical clipping and endovascular coiling
- Most the centers were European, and most of the aneurysms were located in the anterior circulation

## ISAT Trial

	2 year clinical outcome		2 year mortality	
	Endovascular n=1065	Neurosurgery n=1063	Endovascular n=1063	Neurosurgery n=1063
<b>Modified Rankin Scale</b>				
0 No symptoms	203 (19.1%)	144 (13.6%)	266 (24.9%)	187 (17.7%)
1 Minor symptoms	330 (31.1%)	273 (25.7%)	301 (28.2%)	292 (27.7%)
2 Some independence	244 (23.0%)	254 (23.9%)	252 (23.7%)	290 (27.5%)
3 > 5% IAD	182 (17.3%)	673 (63.3%)	813 (76.5%)	739 (69.8%)
4 Signs of severe disability	102 (9.6%)	190 (17.9%)	107 (10.0%)	141 (13.3%)
5 Death	34 (3.2%)	45 (4.2%)	39 (3.6%)	42 (4.0%)
6 Dead	42 (4.0%)	21 (2.0%)	38 (3.6%)	38 (3.6%)
7 Dead	75 (7.0%)	84 (7.9%)	85 (8.0%)	105 (9.9%)
8 Death	278 (26.1%)	392 (36.9%)	290 (27.3%)	305 (28.8%)

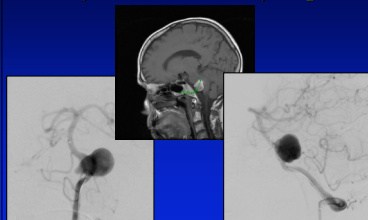
Table 2: Clinical outcome at 2 months and 1 year

Mohrman, A. J. et al. Lancet 2001; 358: 899-917

## Factors Influencing Treatment Options

- Patient's age
- Patient's medical condition
- Aneurysm location
- Aneurysm morphology
- Associated adjacent vessels
- Clinical presentation
- Existence of adjacent hematoma
- Existence of local mass effect

## 67 y.o. woman with syncope

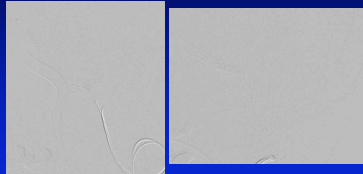




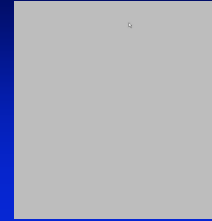
### Flow Diverter



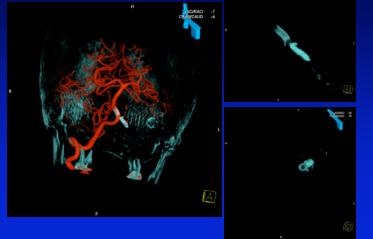
### Flow Diverter



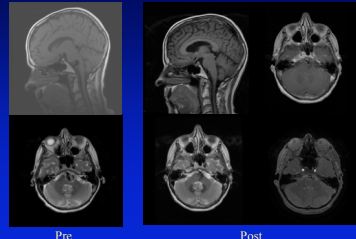
### Flow Diverter



### 3 Months Post Treatment

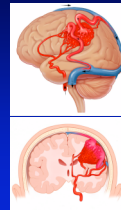


### 1 Year Post Treatment



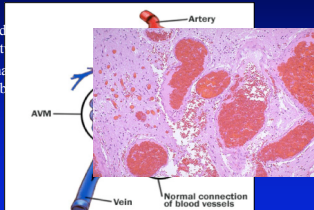
### Arteriovenous Malformations

- An abnormal collection of blood vessels wherein arterial blood flows directly into draining veins without the normal interposed capillary beds.
- Congenital, but may enlarge with age. Thus may involve an abnormality or dysregulation of vascular development or remodeling.



### Pathogenesis of AVMs

- Thinned
- loss of t
- Enceph
- loss of b

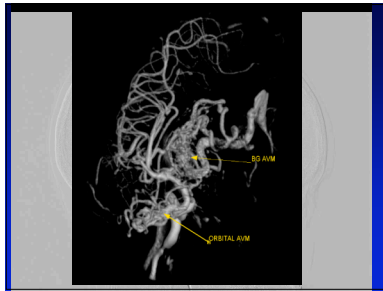


### Epidemiology

- The prevalence in the general population is about 1-2 per 100,000 people
- Can present from the newborn period throughout adulthood
- The majority of AVMs are diagnosed in patients 20-40 years of age
- The majority of AVMs patients present with hemorrhage

### Rational for Treatment

- Each bleed results in 30% chance of permanent morbidity or mortality
- Risk of subsequent hemorrhages increases to 6-18% in the first year after initial bleed

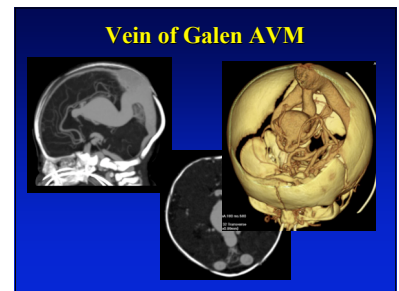
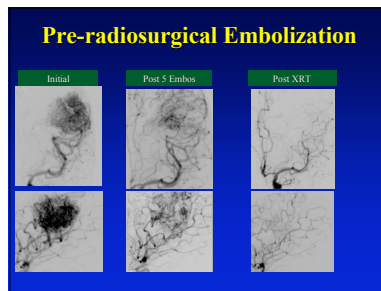
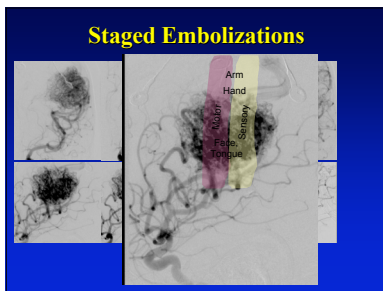
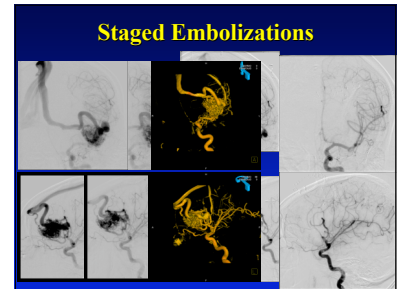
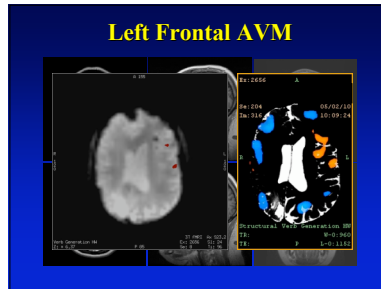
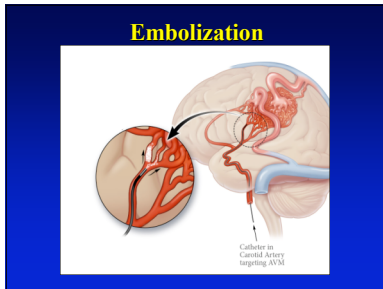


### AVM Treatment Strategies

- Goal: Complete obliteration of AVM nidus
- Microsurgery
- Stereotactic radiosurgery
- Endovascular embolization

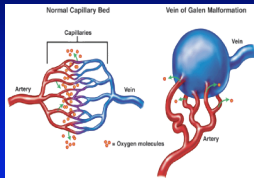
### Advances in Embolization

- Biplane Fluoroscopy and 3-D Angio
- Electrophysiologic Monitoring with provocative testing
- Flow-directed micro catheters
- Liquid Embolics

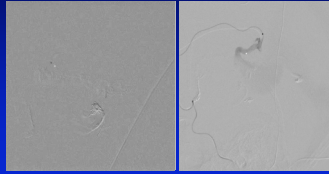


## Vein of Galen AVM

- Commonly diagnosed in newborns
- High blood flow in the lesion
- High output congestive heart failure



## Vein of Galen AVM



## Conclusions

*Advances in imaging and endovascular techniques (coils, balloons, stents, and liquid embolic materials) have substantially improved outcomes for many causes of hemorrhagic stroke.*