

SAH

Definition of SAH

- Blood accumulation in subarachnoid space

Etiology of SAH

- Mostly trauma
- In spontaneous SAH
 - **Rupture intracranial aneurysm 75-80%**
 - **Arteriovenous malformation 4-5%**
 - **No cause in 14-22%**
 - Vasculitis
 - Tumor
 - Cerebral artery dissection
 - Rupture of small superficial artery

Incidence of SAH

- Annual rate of aSAH in USA : 9.7 – 14.5 / 100,000
- Higher incidence in Japan and Finland
- Increase with age (avg. age of onset > 50)
- Higher in women

Risks factors for SAH

- Behavioral
 - Hypertension
 - Cigarette smoking
 - Alcohol abuse
 - Sympathomimetic drugs
- History of cerebral aneurysm
- Family history of aneurysms
 - (at least 1 first-degree family members and esp if ≥ 2 affected)
- Genetic syndromes

Symptoms of SAH

- Sudden onset of severe Headache
- Usually with vomiting, syncope, neck pain, and photophobia
- Loss of consciousness
- Focal cranial nerve deficits
 - Most common CN3 palsy due to aneurysmal compression
 - Causing diplopia and ptosis

Headache

- Most common symptoms, present in up to 97% of cases
- Usually severe (Most worst headache of my life)
- H/A may resolve (Sentinel hemorrhage or warning headache) 30-60%
- Warning headache may also occur without SAH
 - Aneurysmal enlargement or hemorrhage confined within the aneurysmal wall

Signs

- Meningismus
 - Nuchal rigidity, often ensues in 6 – 24 hrs
- Hypertension
- Focal neurological deficits
- Obtundation
- Coma
- Ocular hemorrhage

Presentation other than major rupture

- Thought of as warning signs
- Mass effect
- Minor hemorrhage
- Small infarcts or transient ischemia due to distal embolization
- Seizures
- Headache without hemorrhage

Cranial neuropathies from aneurysm compression

- Oculomotor palsy (ONP)
 - Occurs in 9% of p-com aneurysm
 - Less common in basilar apex aneurysm
 - Extraocular muscle palsy, ptosis, dilated unreactive pupil
- Visual loss
 - Compressive optic neuropathy in ophthalmic a. aneurysms
 - Chiasmal syndromes due to ophthalmic, a-comm, or basilar apex aneurysms
- Facial pain syndromes in ophthalmic or maxillary n. distributions
 - Occur with intracavernous or supraclinoid aneurysms

Locations of cerebral aneurysm

- 1. 85-95% in carotid system
 - ACoA 30%
 - P-comm 25%
 - MCA 20%
- 5 – 15% in posterior circulation
 - 10% in basilar artery
 - 5% in vertebral artery
- 20-30% of patient have multiple aneurysms

Coma following SAH

- Increased ICP
- Damage to brain tissue from ICH
- Hydrocephalus
- Diffuse ischemia
- Seizure
- Low blood flow (reduce CBF) due to reduce cardiac output

Work-up of suspected SAH

- Test to diagnose SAH
 - Non-contrast high-resolution CT
 - If CT is negative -> Lumbar puncture in suspicious cases
- Test to identify source of SAH
 - CTA, MRA or angiography

Grading SAH

- Hunt and Hess Grade
 - Grade 1 and 2 : operate as soon as aneurysm was diagnosed
 - Grade ≥ 3 : managed until the condition improved to grade 1 or 2
- WFNS grading
 - Use GCS and major focal deficits
 - Major focal deficits
 - Aphasia, hemiplegia, hemiparesis

Hunt and Hess Grade

Table 74.2 Hunt and Hess classification^a of SAH⁹⁶

Grade	Description
I	asymptomatic, or mild H/A and slight nuchal rigidity
II	Cr. N. palsy (e.g. III, VI), moderate to severe H/A, nuchal rigidity
III	mild focal deficit, lethargy, or confusion
IV	stupor, moderate to severe hemiparesis, early decerebrate rigidity
V	deep coma, decerebrate rigidity, moribund appearance

^a Add one grade for serious systemic disease (e.g. HTN, DM, severe atherosclerosis, COPD) or severe vasospasm on arteriography.

^b Original paper did not consider patient's age, site of aneurysm, or time since bleed; patients were graded on admission and pre-op

WFNS Grade

Table 74.4 WFNS SAH grade⁹⁸

WFNS grade	GCS score ^a	Major focal deficit ^b
I	15	-
II	13-14	-
III	13-14	+
IV	7-12	+ or -
V	3-6	+ or -

GCS = Glasgow Coma Scale, see ► Table 18.1

^a Aphasia, hemiparesis or hemiplegia (+ = present, - = absent)

^b Contact aneurysm

Hydrocephalus

- The frequency of hydrocephalus 15-20%
 - with 30 – 60% showing no impairment of consciousness
- 3% of those without HCP on initial CT develop HCP within 1 week

Factors associates with acute HCP

- Increasing age
- Admission CT finding
 - IVH
 - Diffuse SAH, thick focal accumulation
- Hypertension
- Posterior circulation aneurysms

Treatment

- Half the patients with acute HCP improved spontaneously
- Patients in poor grade (H&H IV-V) with large ventricles should consider ventriculostomy, which caused improvement in 80% of pts
- Increased risks of aneurysmal rebleeding in pts undergoing ventriculostomy shortly after SAH
- Recommend keep ICP 15-25 mmHg to avoid rapid pressure reduction

Initial management concerns

- Rebleeding
 - Risk factor : female, high grade SAH, large aneurysm, SBP > 175 mmHg
- Hydrocephalus
- Delay cerebral ischemia (DCI)
- Hyponatremia with hypovolemia
- DVT and pulmonary embolism
- Seizures
- Augmenting cerebral O₂ delivery

Initial management

- **Level 1**

- Administer oral nimodipine to all patients with aSAH
- Maintain euvolemia and normal circulation blood volume

- **Level 2**

- Control hypertension
 - The ideal BP to reduce the risk of rebleeding has not been established
 - Reasonable target : SBP < 160 mmHg

Blood pressure and volume management

- Unsecure aneurysm
 - Gentle volume expansion with slight hemodilution and mild elevation of BP
 - Help prevent effect of vasospasm
- Initial blood pressure
 - Decrease SBP to < 160 mmHg
 - Nicardipine or clevidipine should be used

Post-SAH seizures

- Level II

- Prophylactic AEDs may be considered
- Long term use of AEDs may be considered with known risk factors for delay seizure disorder

- Level III

- The routine long-term use of AED is NOT recommended

Rebleeding

- Untreated ruptured aneurysm
 - Maximal frequency of rebleeding is in 1st day (4% - 13.6%)
 - More than 1/3 occurring within 3 hrs
 - ½ within 6hrs
 - The subsequent rebleeding risks after 1st day, 1.5% daily for 13 days
 - 15-20% rebleed within 14d
 - 50% rebleed within 6 months
 - Mortality rate : 2% / yr

Vasospasm

- Most commonly seen following some cases of aneurysmal SAH
- May also follow other intracranial hemorrhage
 - IVH from AVM
 - SAH of other etiology
 - Head trauma
 - Brain surgery
 - Lumbar puncture
 - Hypothalamic injury
 - infection

Definition

- Delay cerebral ischemia (DCI)
 - Delayed development of a neurological deficit
 - Decline of GCS of at least 2 points
 - Cerebral infarction unrelated to aneurysm treatment
- Early brain injury (EBI)
 - Direct mechanical damage from SAH
 - Transient increase in ICP
 - Reduction of CBF
 - Apoptosis and edema formation

Clinical vasospasm

- Sometimes referred to as delayed ischemic neurological deficit (DIND)
- Confusion or decreased level of consciousness sometime with focal neurological deficits

Table 75.1 Correlation of DIND with Hunt and Hess grade

Hunt and Hess grade	% DIND (clinical vasospasm)
1	22%
2	33%
3	52%
4	53%
5	74%

Diagnosis of vasospasm

- Ancillary tests for vasospasm
- TCD
- CTA
- MRA
- cEEG
- Alternation in cerebral blood flow

Transcranial doppler (TCD)

- Detectable changes may precede clinical symptoms by up to 24-48 hrs
- Lindegaard ratio : MCA / ICA

Table 75.5 Interpretation of transcranial Doppler for vasospasm

Mean MCA velocity (cm/sec)	MCA:ICA (Lindegaard) ratio	Interpretation
<20	<3	normal
20-200 ^a	3-6	mild vasospasm ^a
>200	>6	severe vasospasm

Velocities in this range are specific for vasospasm but are only ≈ 60% sensitive

Treatment for vasospasm

- Prevention of vasospasm
- No effective prophylactic intervention for CVS
 - Early aneurysm treatment does not prevent CVS, but facilitates treatment for CVS by eliminating risks of rebleeding

Vasospasm treatment options - I

- Direct pharmacological arterial dilatation
 - Smooth muscle relaxants
 - Calcium channel blockers
 - Endothelin receptor antagonists
 - Ryanodine receptor blocker
 - Magnesium
 - Sympatholytics
 - Intra-arterial papaverine
 - α 1CAM-1 inhibition
- Direct mechanical arterial dilatation

Vasospasm treatment options - II

- Indirect arterial dilatation
- Removal of potential vasospasmogenic agents
- Protection of the CNS from ischemic injury
- Improvement of the rheologic properties of intravascular blood
- Statins
- Extracranial-intracranial bypass

Treatment options for aneurysms

- Optimal treatment for aneurysm depends on
 - age and condition of the patient
 - the anatomy of aneurysm and associated vasculature.
 - The ability of the surgeon
 - Availability of the endovascular treatment options
 - Weighed against the natural history of the condition
 - Treatment of the aneurysm facilitates treatment of vasospasm

Treatment decisions

Coiling vs. Clipping

Table 76.1 Summary of rebleeding, complete occlusion, and retreatment rates as a function of treatment modality (clip vs. coil) for the 4 randomized controlled trials

	Rebleed ^a : Clip	Rebleed ^a : Coil	Complete occlusion: Clip	Complete occlusion: Coil	Retreat- ment: Clip	Retreat- ment: Coil
Finnish	0%	0%	73.7% ^b	50% ^b	7%	23.1%
ISAT	1.0%	2.6%	82%	66%	4.2%	15.1%
ISAT ₅ ^c	0.3%*	0.9%*	n/a	n/a	—	—
ISAT ₁₀ ^c	0.4%	1.6%	n/a	n/a	—	—
Chinese	3.3%	3.2%	83.7%*	64.9%*	—	—
BRAT ^d	0.8% ^e	0%	85%	58%	4.5%*	10.6%*
BRAT ₃ ^d	0%	0%	87%	52%	5%*	13%*

* statistically significant difference ($p < 0.05$)

^aRebleeding from target aneurysm after first procedure

^bResult achieved after treatment during first hospitalization

^cISAT₅ & ISAT₁₀ refer to the 5- and 10-year follow-up studies. Rebleeding results for these studies refer to recurrent SAH after the 1st year of follow-up

^dBRAT₃ refers to the 3-year follow-up study. BRAT & BRAT₃ are "as-treated" results

^eBoth rebleeding events occurred during the initial hospitalization

ISAT

- The largest trial
- Result :
- Absolute reduction of risk of having poor outcome by 7% with coiling compared to clipping
- Rebleeding in the first year was higher for coiling than clipping
 - Not statistically significant

BRAT

- At 3 years, there was no significant difference in poor outcome between coiling and clipping
- Aneurysm obliteration rate, rate of aneurysm recurrence and rate of retreatment were significantly better in group treated with clipping

Vasospasm in different treatment

- One meta-analysis suggested a trend toward less symptomatic vasospasm after coiling compared to clipping
- In the Chinese RCT, symptomatic vasospasm and consequent cerebral infarction was more common in clipping group
- Li et al found vasospasm more common after clipping

Shunt-dependent hydrocephalus

- One study showed a lower incident of shunt-dependent hydrocephalus in the surgical group
 - Many others have failed to show this relationship
- A suggestion that fenestration of the lamina terminalis at the time of surgery may decrease shunt-dependent chronic hydrocephalus

Factors to consider between clipping and coiling

- Health care environment
- Skill set and experience of the operator
- Anatomy and location of aneurysm
 - Favorable dome/neck ratio vs wide neck aneurysms
 - MCA aneurysms may be difficult to coil
 - Basilar apex : favor coiling
 - Associated IPH/SDH : favor surgery for clot evacuation
 - Symptoms due to mass effect : clipping better
- Patient age
- Clinical status / comorbidities

Aneurysm treatment decisions

Practice guideline: Aneurysm treatment decisions

Level C⁹²: Treatment decisions should be multidisciplinary (made by experienced cerebrovascular and endovascular specialists) based on characteristics of the patient and aneurysm.

Level C⁹²: Microsurgical clipping may receive increased consideration in patients presenting with large (>50 ml) intraparenchymal hematomas and middle cerebral artery aneurysms (► Fig. 74.1).

Level C⁹²: Endovascular coiling may receive increased consideration in the elderly (>70 yo), in those presenting with poor-grade WFNS classification (IV/V) aSAH, and in those with aneurysms of the basilar apex

Level B⁹²: For patients with ruptured aneurysms judged to be technically amenable to both endovascular coiling and neurosurgical clipping, endovascular coiling should be considered

Timing of aneurysm surgery

- Early surgery : $\leq 48 - 96$ hrs
- Late surgery : usually $\geq 10 - 14$ days
- Ultra-early : < 24 hrs after SAH

Factors favoring early surgery

- Good medical condition
- Good neurological condition (H&H grade ≤ 3)
- Large amounts of SAH
- Large clots with mass effect associated with SAH
- Early rebleeding
- Indications of imminent rebleeding

Factors favoring late surgery

- Poor medical condition or neurological condition
 - H&H grade ≥ 4
- Aneurysms difficult to clip
- Significant brain edema seen on CT
- Presence of active vasospasm