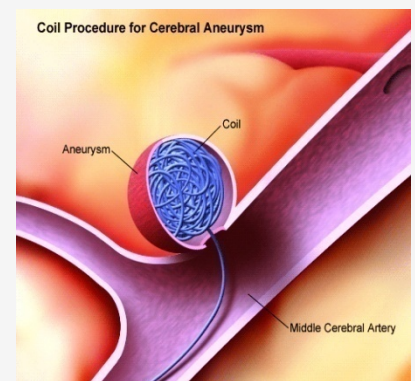
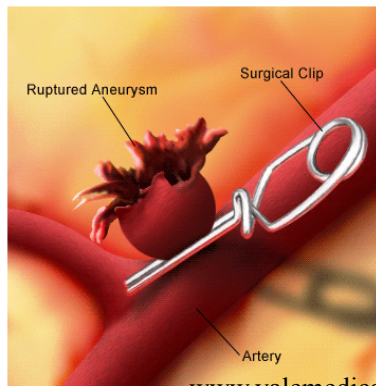
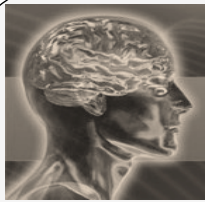


MANAGEMENT OF INTRACRANIAL ANEURYSMS

Clipping Treatment for Cerebral Aneurysm

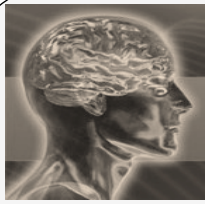




Introduction

- Incidence of aneurysm difficult to estimate
- Prevalence 0.2-7.9 %
- Half of the aneurysms ruptures
- The incidence of aneurysmal rupture is between 6 and 12 per 100,000.
- 2% present during childhood

*van Gijn J, Rinkel GJ. Subarachnoid hemorrhage: diagnosis, causes and management. *Brain* 2001;124(Pt 2):249–78.



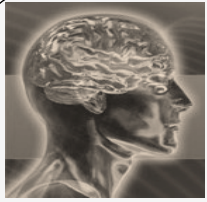
Introduction

- Overall mortality at 6 months: 40% - 50%
- 15% of patients expire before reaching the hospital
- 25% within 24 hours.
- Only one third of those who survive have functional independent lives.

Hop JW, Rinkel GJ, Algra A, et al. Case-fatality rates and functional outcome after subarachnoid hemorrhage: a systematic review. *Stroke* 1997;28: 660–4.

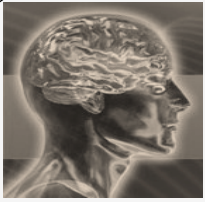
- Rebleed has a catastrophic morbidity : 48% to 78%.
- Treatment of a ruptured aneurysm: imperative.

Jane JA, Winn HR, Richardson AE. The natural history of intracranial aneurysms: rebleeding rates during the acute and long term period and implication for surgical management. *Clin Neurosurg* 1977; 24:176–84.



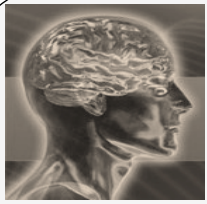
Etiology of intracranial aneurysm

- Congenital
- Atherosclerotic/ hypertensive
- Embolic
- Infectious
- Traumatic
- Associated with other conditions



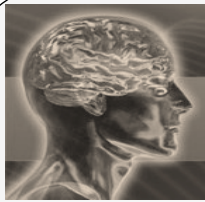
Presentation

- Major rupture
 - SAH
 - ICH
 - IVH
 - Subdural blood
- Mass effect- cranial nerve palsy:
 - 3rd nerve in PCOM
 - Chiasmal syndrome - ophthalmic, Acom, Basilar top
- Cranial neuropathy- giant aneurysm compressing brainstem
- Endocrine disturbance: sellar and suprasellar



Presentation

- Minor hemorrhage/sentinel hemorrhage
- Small infarcts
- Seizures
- Prodromal /warning/ sentinel headache: minor blood leakage or aneurysmal expansion- reported in 30-60% of SAH
 - Few hours to a few months before the rupture- median of 2 weeks
 - Due to sentinel leaks/ mass effect of aneurysm expansion/ emboli
- Incidentally discovered

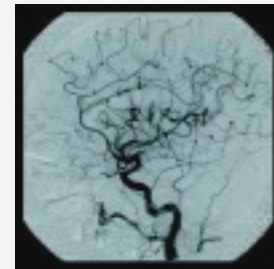


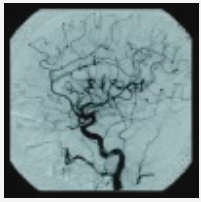
Decision making ?

- Mode of presentation
 - Ruptured aneurysm
 - Un-ruptured aneurysm
- Patients related factors
 - General condition
 - Medical co-morbidities
- Aneurysm related factors
 - Location
 - Anatomy
 - Size
- Availability of expertise
 - Surgical
 - Endovascular

Goals of aneurysm treatment

- Complete, permanent and safe occlusion of aneurysm.
- Less morbidity and mortality.
- Good quality of life.



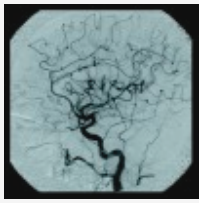


Un-ruptured aneurysms

Importance of treatment

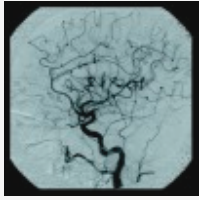
1. Risk of SAH is 0.05-6 % each year.
2. Around 50 % of these ruptures are fatal
3. Increase in size >1 cm increases the risk 11 fold

(ISUIA trial. N Engl J Med 1998;339:1725-33)



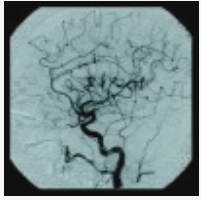
Risks factors for SAH in un-ruptured aneurysms

- Increased aneurysm size on serial imaging
- Aneurysm size > 10 mm
- Aneurysm between 6-9 mm in middle and young age group
- Posterior circulation aneurysms: especially basilar apex
- Previous SAH from another aneurysm
- Symptomatic aneurysms
- Females
- Cigarette smoking
- Binge alcohol drinking



Factors affecting surgical outcome

- Aneurysm related factors
 - Aneurysm size (>2.5 cm).
 - Location (A-com, ICA bifurcation).
 - Orientation
- Patient related factors
 - Age
 - Ischemic cerebro-vascular diseases
 - Diabetes mellitus

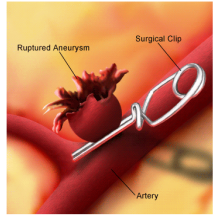


Options for definitive treatment

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

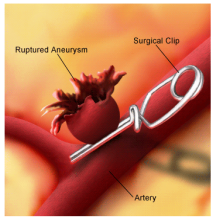
Exclusive Indications for surgery

- SAH with ICH
- Hydrocephalus
- Signs of raised ICP
- Endovascular treatment is contraindicated



Clipping : Indications

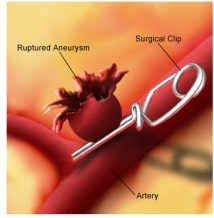
- The choice of open surgical intervention is influenced by several factors:
 - complexity of the aneurysm,
 - size (too small or too large),
 - geometry,
 - unfavorable dome-to-neck ratio,
 - access (inability to navigate delivery system to aneurysm site),
 - anatomy (parent artery, branch artery, or perforator incorporation into neck).



Timing of surgery

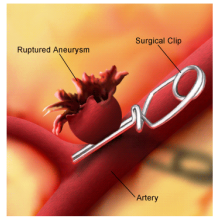
- Anterior circulation: early surgery has good results
- Posterior circulations:
 - Easy aneurysms: early surgery
 - Difficult aneurysms : after two weeks

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



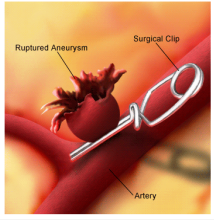
Early surgery: Advantages

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



Disadvantages of Early Surgery

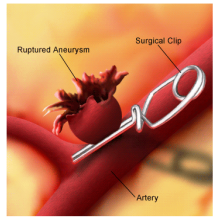
- Inflammation and brain edema causes more difficult and traumatic retraction
- Acute clot makes dissection difficult
- Risk of intraoperative rupture is high
- Vessel injury may aggravate vasospasm
- Factors favoring late surgery:
 - Poor medical and/or neurological condition
 - Difficult aneurysms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



Surgery : Technical considerations

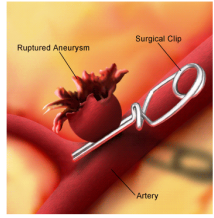
Intraoperative objectives

- Prevent rupture
- Further enlargement
- Preserve normal vessels
- Minimize injury to the brain



Surgery : Technical considerations

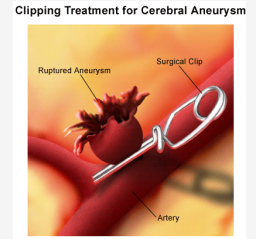
- Clip too low- may occlude parent vessel
- Distal placement- aneurysmal rest
- Aneurysmal rest expand in future and may rebleed
- Surgical exposure:
 - Avoid retraction
 - Brain relaxation- hyperventilation, CSF drainage, lumbar spinal drainage, cisternal drainage
 - Drugs



Surgery : Technical considerations

- Intra operative aneurysm rupture- 18- 40%
- Morbidity and mortality approach 30- 35%
- When aneurysm can rupture
 - Initial exposure-
 - Reduce BP
 - Temporary clip if possible
 - Lobectomy if necessary for exposure
 - Dissection of aneurysm-
 - Blunt or sharp tears- tamponade, temporary clip
 - If extends to parent vessel micro sutures may be taken
 - Clip application- reapply clip or a second clip

Surgical technique



- The cornerstone of open surgical management
 - microsurgical dissection of the subarachnoid planes
 - proximal and distal vascular control
 - direct visualization of clip application
 - puncture verification of total aneurysm obliteration.

Yasargil MG, Fox JL. The microsurgical approach to intracranial aneurysms. Surg Neurol 1975;3:7–14.

Advances in surgery

- Surgical innovations, such as cranial base approaches.

Origitano TC, Anderson DE, Tarassoli Y, et al. Skull base approaches to complex cerebral aneurysms. *Surg Neurol* 1993;40:339–46.

- Intraoperative angiography: confirming parent or branch artery patency and aneurysm obliteration.

- Alexander TD, Macdonald RL, Weir B, et al. Intraoperative angiography in cerebral aneurysm surgery: a prospective study of 100 craniotomies. *Neurosurgery* 1996;39:10–7 [discussion: 17–8].
- Origitano TC, Schwartz K, Anderson D, et al. Optimal clip application and intraoperative angiography for intracranial aneurysms. *Surg Neurol* 1999;51: 117–24 [discussion: 124–8].

Wrapping

Indications

- Aneurysm cannot be clipped
- Intraoperative rupture
- Materials used
 - Muscle
 - Muslin
 - Plastic resin or polymer
 - Artificial glue and muscle
 - Fascia
 - Teflon

Parent vessel ligation

- Indications:
 - Large surgically difficult aneurysms
 - Recurred after coiling
 - Other unclipable aneurysms
- Prerequisite:
 - Good collateral circulation on balloon occlusion test or cross compression test
- Methods of parent vessel ligation
 - Direct neck vessel ligation
 - Gradual occlusion: Silverstone clamp

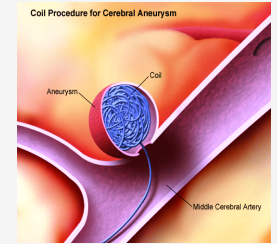
Revascularization procedures

- Indications:
 - All those patients planned for ligation of parent vessel ligation but poor collateral circulation.
- Results:
 - Good outcome
 - 80% of anterior circulation
 - 44% of posterior circulation
 - Graft patency rate of 86% at 18 months
- Complications
 - Acute graft occlusion
 - Aneurysm rupture: d/t hemodynamic changes
 - Ischemic deficits

Endovascular methods

- Exclusive Indications:
 - Poor grade SAH
 - Medical illness
 - Surgically difficult aneurysms eg:
 - proximal ICA
 - basilar top
 - giant aneurysm
 - Patients preference

Endovascular methods



- Destructive procedures
 - Balloon occlusion of parent vessel
- Reconstructive procedures
 - GDC coils
 - Balloon remodeling technique
 - Stent coil technique

Balloon occlusion

- Generally used for proximal ICA and vertebro-basilar aneurysms
- Advantages
 - Mass effect resolves
 - Cranial neuropathies are known to improve
- Disadvantages:
 - Recanalize, regrowth or rupture
 - Ischemic symptoms
 - Formation of de-novo aneurysms

GDC coils

- Platinum spiral coils with circular memory
- Fit snugly in the aneurysm and induce thrombosis
- Disadvantages:
 - Incomplete obliteration
 - Recanalization
 - Prolapse of coil and distal migration
 - Parent artery thrombosis

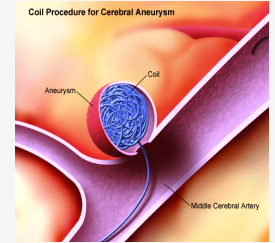
Balloon remolding technique

- Introduced to overcome the problem of wide neck aneurysms
- Balloon is inflated in parent vessel against the neck and then coils are put in sac

Stent-coil technique

- Used in complex wide neck aneurysms
- Increases the density of coil packing

Limiting factors of coiling



- Dome to neck ratio < 2
- Neck width > 4 mm
- Inadequate endovascular access
- Unstable intraluminal thrombus
- Arterial branch incorporated in neck
- Middle cerebral artery aneurysms

Endoscopy

- Endoscope (fiberscope) to assist the microsurgical clipping of cerebral aneurysm- first reported by Fischer and Mustafa in 1994
- Rigid endoscope: structures around the aneurysm can be detected with high quality imaging
- Supportive role in planning surgical manoeuvres and verifying whether clipping has been performed correctly
- Aneurysms of anterior circulation- esp. those of ICA and Acom artery.
- Many have the posterior communicating artery, choroidal artery or one of the distal cerebral arteries hidden behind the aneurysm dome

Special circumstances

- POOR GRADE SAH
 - Rapid resuscitation
 - Intracranial pressure monitoring
 - Early aneurysm occlusion
 - Prophylaxis against delayed ischemia

- Factors affecting outcome after definitive treatment
 1. Diffuse SAH on NCCT head
 2. Intraventricular bleed
 3. Higher Fisher's Grade on NCCT head
 4. Location of aneurysm (posterior circulation)
 5. Rebleed before intervention
 6. Post intervention infarct/hydrocephalus/meningitis
 7. Acute renal failure
 8. Septicemia
- A significant number of patients with poor grade SAH can have favorable outcome after aggressive definitive treatment.
- Patients who improve with resuscitation, merit intervention.
- Large craniotomy flaps / decompressive craniectomies are helpful in such patients.
- Ashish Suri,, Karanjit Singh Narang, B.S.Sharma. Department of Neurosurgery. AIIMS

Advanced age ??

- Surgically treated patients do better than conservatively managed.
- Treatment of unruptured aneurysm is beneficial if life expectancy is more than 13 years.
- Treatment should not be denied only on the basis of age.

PREGNANCY ??

- Investigated and treated as same.
- Pregnancy can be continued
- Temporary clips than hypotension during surgery
- Mannitol and hyperventilation to be curtailed
- LSCS is preferred in unruptured cases
- Craniotomy and LSCS performed together
- Anticonvulsants and CCB to be avoided.

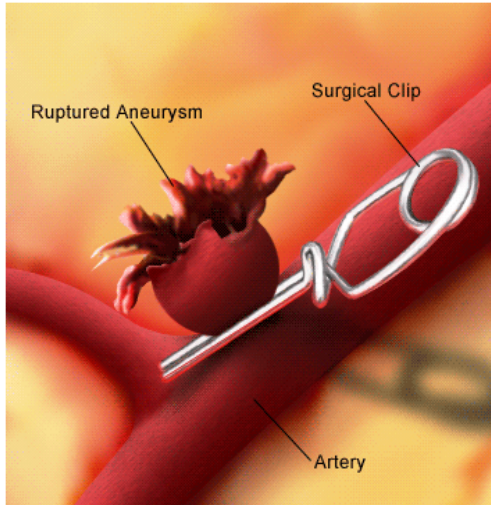
Infective aneurysms ??

- Streptococcus is most common cause
- Course of IV antibiotics for 4-6 wks.
- Surgical excision of aneurysm followed by bypass, anastomosis, or ligation of vessel.

Giant aneurysm

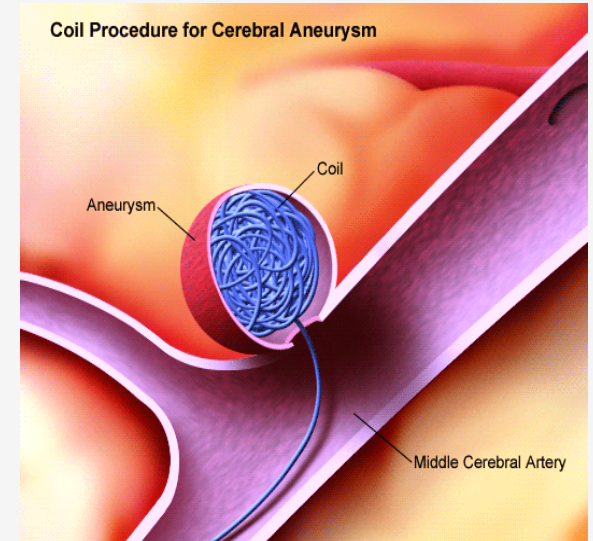
- Aneurysm >25 mm
- Mortality : 5-25%
- Good or excellent outcome in 70-80%
- Treatment options
 - Clipping (multiple clipping, fenestrated clips)
 - Parent vessel ligation
 - Revascularization with or without trapping
 - Endovascular occlusion

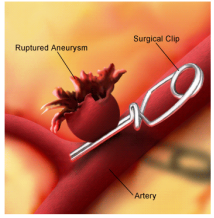
Clipping Treatment for Cerebral Aneurysm



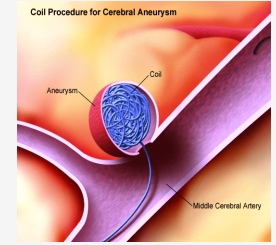
CLIPPING V/S COILING

Coil Procedure for Cerebral Aneurysm





Clip vs coil: Safety



- Clipping

the mortality rate 1% -3.8%

the morbidity rate 4% - 12%.

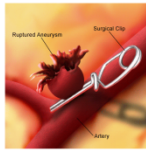
King JT Jr, Berlin JA, et al. Morbidity and mortality from elective surgery for asymptomatic, unruptured, intracranial aneurysms: a meta-analysis. J Neurosurg 1994;81(6):837–42.

- Coiling

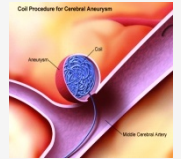
the mortality rate 0.5% - 2%

the morbidity rate is 4% to 5%.

Johnston SC, Dudley RA, et al. Surgical and endovascular treatment of unruptured cerebral aneurysms at university hospitals. Neurology 1999;52(9): 1799–805.



Efficacy: Clip vs coil

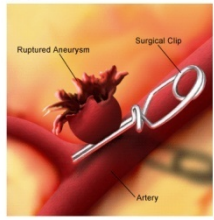


- Clipping seems to be superior to coiling in achieving goals over the short and long term.
- Most series report a 92% to 96% exclusion rate of the aneurysm from the circulation with microsurgical clipping.

David CA, Vishteh AG, et al. Late angiographic follow-up review of surgically treated aneurysms. J Neurosurg 1999;91(3):396–401.

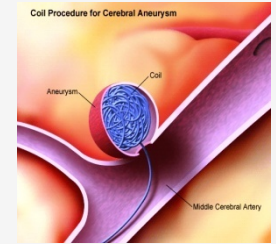
- With respect to endovascular coiling, most series report
 - 40% to 55% complete exclusion,
 - 35.4% to 52% near-complete exclusion
 - 3.5% to 8% incomplete exclusion of the aneurysms from the circulation.

Murayama Y, Nien YL, et al. Guglielmi detachable coil embolization of cerebral aneurysms: 11 years' experience. J Neurosurg 2003;98(5):959–66.



Clip vs coil

Patient factors : Age



- Morbidity and mortality rate in those patients undergoing surgical clipping.

6.5% for patients less than 45 years old,

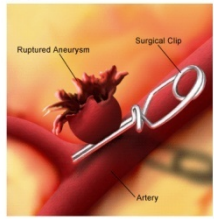
14.4% for patients 45 to 65 years old,

32% for patients greater than 64 years old

Unruptured intracranial aneurysms :risk of rupture and risks of surgical intervention. N Engl J Med 1998;339:1725–33.

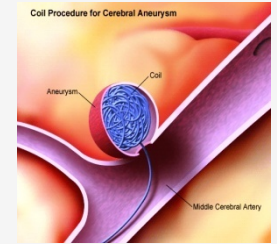
- Similar finding have been reported with endovascular coiling, but the effects seem to be less significant with endovascular coiling in older patients.

Barker FG II, Amin-Hanjani S, et al. Age-dependent differences in short-term outcome after surgical or endovascular treatment of unruptured intracranial aneurysms in the United States, 1996–2000. Neurosurgery 2004;54(1):18–28 [discussion: 28–30].



Clip vs coil

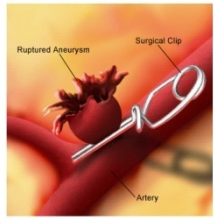
Aneurysm factors : size



- Increased size : increased risk with microsurgical treatment.
- Wirth et al : linear relation with regard to size and complication rate
 - 3% for aneurysms less than 5 mm
 - 7% for 6- to 15-mm aneurysms
 - 14% for aneurysms of 16 to 24 mm.

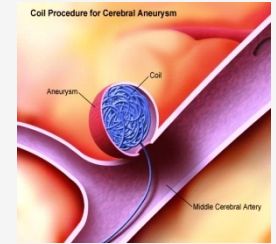
Wirth FP, Laws ER Jr, et al. Surgical treatment of incidental intracranial aneurysms. Neurosurgery 1983;12(5):507–11.

- Endovascular treatment : extremely large and small aneurysms having increased complications.
- Extremely small aneurysms : risk of intraprocedural rupture .
- Giant aneurysms: less favorable dome/neck ratio,
 - Higher incidence of a branch vessel origin of the aneurysm neck,
 - Often intra-aneurysmal thrombus.



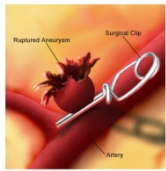
Clip vs coil

Aneurysm configuration

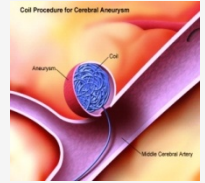


- Surgical complexity is increased
 - Wide-necked
 - Involving major neighboring artery : ensure complete exclusion of the aneurysm with preservation of the parent vessel and its associated branches.
- The most important factor :dome /neck ratio:
 - large, intermediate, and small -the most favorable to least favorable configuration.

Dense packing of the coils achieved with less risk of migration into the parent artery : small dome size, a small neck, and a large d/n ratio, (ideal for complete occlusion with fewer complications)



Clip vs coil : Aneurysm location



- Posterior circulation aneurysms: higher complication rate with microsurgical treatment, most undergo endovascular therapy.

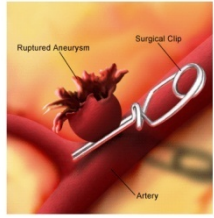
Raaymakers TW, Rinkel GJ, et al. Mortality and morbidity of surgery for unruptured intracranial aneurysms: a meta-analysis. *Stroke* 1998;29(8): 1531–8.

- MCA aneurysms:

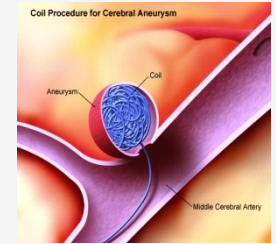
- often originate from one or both of the branching vessels
- often have an associated unfavorable d/n ratio.
 - renders aneurysms unable to be coiled or
 - migration of the coil into the parent vessel or a branch, resulting in a stroke.

- Clipping is still the most safe for most MCA aneurysms.

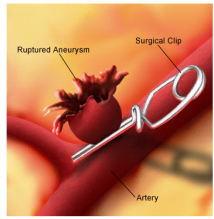
Regli L, Uske A, et al. Endovascular coil placement compared with surgical clipping for the treatment of unruptured middle cerebral artery aneurysms: a consecutive series. *J Neurosurg* 1999;90(6):1025–30.



Clip vs coil Management: UA

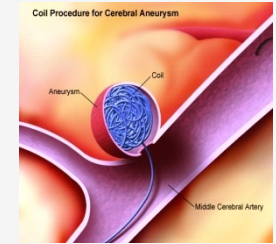


- The advantage of clipping:
effective in changing the natural history of UIA in the short and long term.
- The disadvantage of clipping: risk of treatment is higher than that of coiling.
- The advantage of coiling:
less invasive and safer than clipping,
- The major limitation: lack of durability in changing the natural history compared with clipping.



Clip vs coil

Management: UA



- Anterior circulation aneurysms with a large d/n ratio, endovascular coiling should always be considered as the first line of treatment in those patients with long, intermediate, and short estimated life expectancies, because this treatment provides the patient with relatively effective treatment that is safer than clipping.
- Posterior circulation aneurysms: patients with large and medium d/n ratios should undergo endovascular coiling regardless of the estimated life expectancy, because endovascular coiling provides a safer treatment that is relatively effective
- In some posterior circulation aneurysms with less favorable configurations, where the aneurysm sac involves one of the posterior cerebral branches, clipping may be the only alternative.

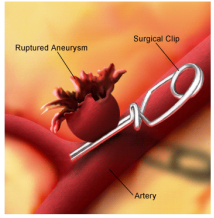
International Study of Unruptured Intracranial Aneurysms (ISUIA)

- 1998 report: retrospective data controversial- 0.05% yearly rupture rate identified for aneurysms <10 mm : considerably lower than the rate in earlier reports
 - If true, the risks of treatment higher than the natural history risk.
- ISUIA: New prospective data
 - **Lancet 362:103-110, 2003:** results associated with endovascular or microsurgical repair.

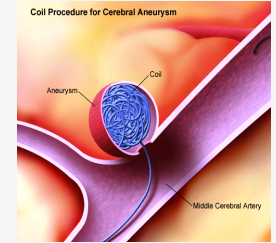
ISUIA

- Patients in Group 2 (Patients who have had a ruptured aneurysm at another location that was isolated, trapped, clipped, or treated through endovascular obliteration) with unruptured intracranial aneurysms less than 7 mm had higher rupture rates than did those in Group 1 ($p < 0.0001$).

For both Group 1 and Group 2 patients the combined morbidity and mortality at 1 year was about 3% higher in the microsurgical group (12.6% for clipping vs. 9.8% for coiling in Group 1 patients and 10.1% vs. 7.1% in Group 2 patients).



Management: RA



- Preventing rebleed is top most priority
- Anterior circulation: clipping esp medium or small d/n ratios
 - Except- short life expectancy and/or a poor clinical grade
 - Coiling: large d/n ratio
- Posterior circulation aneurysms: coiling the first choice
 - Clipping: unfavorable d/n ratio, a long life expectancy, and a good clinical grade and is an option in those with a medium d/n ratio

ISAT trial (lancet 2005;360:1267-75)

- Randomized study of 2143 patients ruptured intracranial aneurysms
- The safety of endovascular coiling compared with clipping.
- Prospective, randomized, controlled trial
- Mortality or disability was 30.6 Vs 23.7 in surgical and endovascular gp at one year (p=0.0019)
 - survival free of disability at 1 year is significantly better with coiling.
- Relative and absolute risk reduction in dependency or death is 22.6 vs 6.9 % in surgical and endovascular group.
 - coiling is more likely to result in independent survival at 1 year than clipping; the benefit continues for at least 7 years
- Risk of rebleed was higher in endovascular group at one year

Criticisms on ISAT trial

- Selection biases
 - Premature analysis
 - Only 22.4 % were randomized
- Outcome assessment
 - Modified Rankin Scale used for assessment
- Lack of angiographic data after surgery
- Lack of long term follow up
- Surgical outcome
- Post procedural rebleed and outcome

SAH Presentation

- Worst headache of life.
- Meningeal irritation (e.g.- neck stiffness, Kernig's/Brudzinski's sign, low back pain, bilateral leg pain) :
 - >75% of cases
 - Take several (6-24 hrs) hours to develop
- LOC at the ictus: 45% of patients, often transient; 10% comatose for several days.-d/t raised ICP, ICH, HCP, seizure, low CBF
- Seizures in acute phase:10-25%
- Focal neurologic abnormalities (25%) : hemiparesis, aphasia, hemineglect, cranial nerve palsies, memory loss

SAH Presentation

- Ocular hemorrhages (20-40%) : sub hyaloid pre-retinal/ intra-retinal surrounding fovea / intravitreous hemorrhage (Terson syndrome).
- Hypertension: 50% cases- often labile as ICP increases
- Temperature elevation: secondary to chemical meningitis from subarachnoid blood products- common after the 4th day
- Tachycardia: often for several days.

SAH Grading: Hunt and Hess

- Grade 1 - Asymptomatic or mild headache
 - Grade 2 - Moderate-to-severe headache, nuchal rigidity, and cranial nerve palsy
 - Grade 3 - Mild alteration in mental status (confusion, lethargy) mild focal neurological deficit
 - Grade 4 - Stupor and/or hemi paresis
 - Grade 5 - Comatose and/or decerebrate rigidity
 - Modified classification-
 - Grade 0 – Unruptured aneurysm
 - Grade 1a – no acute meningeal reaction but with fixed neuro deficit
- * Add one grade for HTN/DM/COPD/Severe Atherosclerosis/
angiographic vasospasm

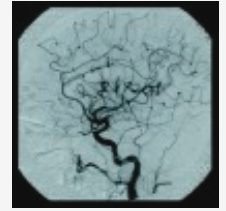
SAH Grading: Fischer scale (based on CT scan)

- To predict the likelihood of symptomatic cerebral vasospasm
- Group 1 - No blood detected
- Group 2 - Diffuse deposition of subarachnoid blood and no layers of blood greater than 1 mm
- Group 3 - Localized clots and/or vertical layers of blood 1 mm or greater in thickness
- Group 4 - Diffuse or no subarachnoid blood, but intracerebral or intraventricular clots are present

SAH WORK-UP : CT SCAN

- Sensitivity decreases with respect to increased time from ictus:
 - 95% within the first 48 hours
 - 80% at 72 hours
 - 50% at 1 week
- Blood localized to the basal cisterns, the sylvian fissure, or the inter hemispheric fissure
- Helps rule out HCP.
- Falsely negative
 - Small hemorrhages
 - Severe anemia

SAH WORK-UP : DSA



- Gold standard: for evaluation of cerebral aneurysm (80-85% sensitivity)
- Can provide surgical information:
 - Cerebrovascular anatomy, aneurysm location & source of bleeding,
 - Aneurysm size/shape/orientation of dome and neck
 - Relation to the parent/perforating arteries
- If negative (10-20%): repeat test 3-4 weeks later
- May be useful to evaluate for possible cerebral vasospasm
- 3-D reconstruction: invaluable-
 - dome-to-neck ratio
 - parent artery or branch orientation to neck
 - enhances surgical view for clip placement and vessel reconstruction

SAH WORK-UP : CTA

- Reported to detect aneurysms larger than 3 mm
- Sensitivity of 95% and 83% specificity.
- Provide sufficient anatomic detail esp relation to near by bony structure

SAH WORK-UP: MRA

- Role is under evaluation
- Limitations : to detect PICA and ACom aneurysm
- Risk/benefit ratio still favors conventional angiography
- Can detect aneurysms >3 mm with 86% sensitivity
- Useful
 - Monitoring the status of small, unruptured aneurysms
 - Evaluate the degree of intramural thrombus in giant aneurysms
 - Screening high risk patients: including 1st degree relative of patients with IC aneurysm
- False +ve in approx. 16%

SAH: MANAGEMENT ISSUES

- Rebleeding
- Hydrocephalus
- Delayed ischemic neurological deficit (DIND)
- Hyponatremia / hypovolemia
- DVT / Pulmonary embolism
- Seizures
- Determining the source of bleeding

SAH: ORDERS ON ADMISSION

- Admission in ICU with monitored bed
- Vital parameter and neurological status check 1 hrly
- Bed rest with head end elevated by 30 degree, low external stimulation
- Nursing : strict I-O charting / daily weights / DVT pumps at LL / urinary catheterization / NG tube
- IVF : Aggressive fluid therapy to head off cerebral salt wasting.
- NS + 20 meq KCl/L @ 2 ml/kg/hr
- Avoid IM medication / enema / NSAID

SAH: ORDERS ON ADMISSION

- Prophylactic anticonvulsants : 3% have seizure- most authorities recommend for 1 week post-op :
 - Phenytoin mc.
 - Levetiracetam now being increasing used
- Mild sedation (propofol/midazolam/lorazepam)
- Analgesic : fentanyl (lower ICP and doesn't cause histamine release unlike morphine)
- Steroid : effect on brain edema is controversial, usually given prior to craniotomy
- Stool softener / anti-emetics / antacids.
- **Contraindicated for fear of impaired coagulation** – aspirin / dextran / heparin / repeated administration of hetastarch

SAH: NIMODEPINE

- Nimodipine 60 mg PO/NG/ IVq 4 hrs, initiated within 96hrs of SAH
- **BRANT : British aneurysm nimodipine trial** shown 22% vs. 33% incidence of cerebral infarction compared to placebo
- Blocks the 'slow channel' of calcium influx
- **Reduces the contraction of smooth muscles and may prevent vasospasm**
- **Possible beneficial effects are –**
 - improved RBC rheology
 - prevention of calcium entry in ischemic cells
 - anti platelet aggregation
 - dilatation of collateral lepto meningeal arteries
- Side effects are –
 - systemic hypotension
 - renal failure
 - pulmonary edema

SAH: PREVENTION OF REBLEED

- Early treatment (coiling/surgery).
- Bed rest does not prevent.
- Antifibrinolytic therapy – **Tranexamic acid** reduces the risk
Loading dosage of 1 gm bolus followed by 1 gm q 6 hrs until aneurysm is secured (max 72 hrs)
- **Contraindicated:** Epsilon aminocaproic acid (EACA) – competitively blocks activation of plasminogen to plasmin.
 - More incidence of HCP/DIND on prolonged use.
 - Increased risk of cerebral infraction

Ventriculostomy

- Acute HCP or significant intraventricular blood.
- Allows drainage of CSF as well as ICP monitoring.
- May increase the risk of rebleed.
- Symptomatic improvement found in 30% immediately
- H&H grade >3 : if there is some improvement with ventriculostomy, prognosis may be favourable
- Controversy: use of ventriculostomy in acute HCP increases or possibly decreases incidence of shunt dependency

SAH : VASOSPASM

- Non localizing finding –
 - New or increasing headache
 - Alteration of level of consciousness
 - Disorientation
 - Meningismus
- Focal neurological sign –
 - Cranial nerve palsy
 - Focal neurological deficit
 - Anterior cerebral artery syndrome (mc)- frontal lobe findings predominate (abulia, grasp/suck reflex, urinary incontinence, drowsiness, slowness, delayed response, confusion
 - Middle cerebral artery syndrome- hemiparesis, monoparesis, aphasia, ideomotor apraxia

VASOSPASM : TIME COURSE

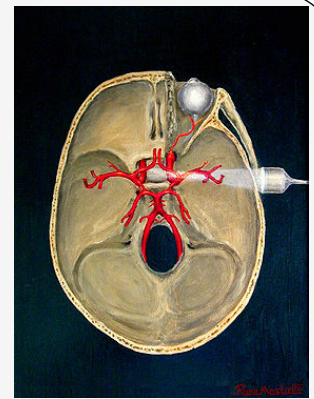
- Onset is almost never before day 3
- Max frequency on day 6-8
- Clinical CVS usually resolves by day 12 post SAH
- Radiological CVS usually resolves slowly over 3-4 weeks
- Onset is usually insidious but in 10% may have abrupt and severe deterioration

VASOSPASM: DIAGNOSIS

- Clinical Criteria – Delayed onset of persistent neuro deficit onset 4-20 days post SAH
- Deficit appropriate to involved arteries
- R/O other causes of deterioration –
 - Rebleeding
 - HCP
 - Cerebral edema
 - Seizure
 - Metabolic disturbances viz hyponatremia
 - Hypoxia
 - Sepsis

VASOSPASM

Trans Cranial Doppler (TCD)



www.farmingdaleheart.com/vascular-testing

- Aaslid & colleague (1980)
- Principle : as an artery narrows, blood flow velocity within it increases
- May precede clinical symptoms by 24-48 hrs

Mean MCA velocity	MCA : ICA (Lindegaard Ratio)	Interpretation
< 120 cm/sec	< 3	Normal
120- 200 cm/sec	3-6	Mild vasospasm
> 200 cm/sec	> 6	Severe vasospasm

VASOSPASM: IADSA

- Vasospasm appear as concentric narrowing which can be focal/segmental/diffuse.
 - mild (<25%),
 - moderate (25-50%)
 - severe (>50%)

VASOSPASM: PREVENTION

- Preventing post SAH hypovolemia & anemia
- Smooth muscle relaxants :- CCB didn't succeed in counteracting vasospasm but may provide neuro-protectant effect
- Endothelin receptor antagonist , clazosentan (ETa)
- Direct mechanical arterial dilatation : balloon angioplasty (60-80% clinical improvement)
- Indirect arterial dilatation : utilizing hyperdynamic therapy

VASOSPASM : MANAGEMENT

- Removal of potential vasospasmogenic agents : blood clot
 - mechanical removing during surgery
 - subarachnoid irrigation with thrombolytic agents viz rt-PA at surgery or cisternal catheters or intrathecally

(Findlay JM et al : RCT of intraoperative, intracisternal TPA for prevention of vasospasm)
- CSF drainage via serial LP/EVD/post op. cisternal catheter
- Sympatholytics / Cervical sympathectomy
- Intra-arterial or intra-theal papaverine / verapamil
- Alpha ICAM 1 inhibition (Ab)

VASOSPASM : MANAGEMENT

- Protection of CNS from ischemic injury :
 - - CCB
 - - NMDA receptor antagonist (selfotel / eliprodil / cerestat)
 - - Free radical scavengers (tirilazad mesylate / nicaraven)
- Improvement of rheological properties of intravascular blood to enhance perfusion
 - - plasma / albumin / LMW dextran / PFC / mannitol
 - - hematocrit: controversial 30-35% - good compromise between lowered viscosity without overlay reducing O₂ carrying capacity
- Extracranial – intracranial bypass around zone of vasospasm

VASOSPASM MX: UNDER TRIAL

- Nicardipine prolonged release implants (NPRIs):
 - Intra-op in cisterns where thick clots were located.
 - Decreased incidence
 - Kasuya H et al: Application of nicardipine prolonged release implants: Analysis of 7 consecutive patients with SAH. Neurosurgery 56 (5): 895-902.2005
- Clazosentan:
 - Selective Endothelin Ia receptor antagonist.
 - Reduces frequency and severity of vasospasm.
 - Vajkoczy et al. J. Neurosurgery 03: 9-17, 2005
- Statins: Simvastatin 80 mg/day, Pravastatin 40 mg/day
 - Reduction in radiographic vasospasm, DIND and mortality.
 - Silberg VAH et al: Do statins improve outcome and reduce incidence of vasospasm after aneurysmal SAH: A meta-analysis. Stroke 39: 2622-26, 2008



TRIPLE “H” THERAPY

HYPERTENSION

1. Dopamine : start at 2.5 mcg/kg/min and titrate up to 15-20 mcg/kg/min
2. Dobutamine : start at 5 mcg/min titrate to 20 mcg/kg/min
3. Phenylephrine : start at 5 mcg/min titrate up to 10 mcg/kg
4. Norepinephrine : start at 1-2 mcg/min & then increase by 10 mcg/min

HYPERVOLEMIA

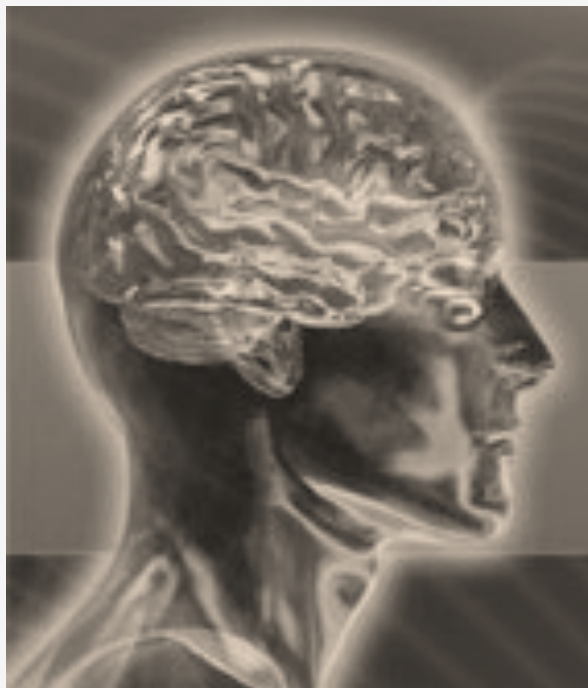
1. IVF : NS @ 200 -250 ml / hr
2. Albumin / plasma
3. DDAVP : antidiuretic , 2-4 mcg SQ q D in divided doses

HEMODILUTION

1. Target hematocrit : < 33%
2. Blood transfusion for Hct < 25%

Complication of hyperdynamic therapy

- Intra cranial – cerebral edema
 - raised ICP
 - hemorrhagic infarction in the area of ischemia
- Extra cranial – pulmonary edema (17%)
 - cardiac failure
 - dilutional hyponatremia (3%)
 - MI (2%)
- Complication related to catheter –
 - catheter related sepsis (13%)
 - subclavian vein thrombosis (1.3%)
 - pneumothorax (1%)
 - hemothorax



Thank you