D:\/Nsurg\Vol. 14, No. 2, Jul. - Dec. 2010/Nsurg-1.doc (A) P. 87 – 91

REVIEW ARTICLE

Surgical Management of Intracranial Aneurysms and Subarachnoid Haemorrhage : An Overview

ASHRAF MAHMOOD, UMAR ISMAEEL, AYAZ HAIDER
Department of Neurosurgery, DHQ Teaching Hospital, RMC, Rawalpindi

INTRODUCTION

Egas Moniz discovered an aneurysm by cerebral Angiography in 1933.[1]

Cushing introduced first aneurysmal clip in 1911, Mayfield modified the existing spring clip with cross leg (Schwartz) by making it a smaller, tweezer – like applicator.[2]

An intracranial vascular procedure was first reported with aid of operating microscope which introduced simultaneously magnification and illumination.[3]

Dott in 1933performed 1st planned intracranial surgery for a saccular aneurysm.[4]

Dandy in 1937 clipped the neck of aneurysm with a metallic clip.[5]

Yasirgill of Zurich and Drake of London Ontario, published a lot onaneurysms of anterior & posterior circulation.[6,7]

An elaborated study of natural history of aneurysm was published by the pakarinen in 196.7[8]

SURGICAL CLASSIFICATION OF INTRACRANIAL ANEURYSYMS

1. Morphology

(i) Saccular. (ii) Fusiform. (iii) Dissecting.

2. Size

(i) < 3 mm. (ii) 3 – 6 mm. (iii) 7 – 6 mm.

(iv) 11 – 25 mm. (v) > 25 mm (Giant).

3. Location

A. ***Anterior Circulation Arteries***

i. *Internal Carotid*

a. Carotid Canal.
b. Intracavernous.
c. Paraclinoid (Ophthalmic).
d. Posterior Communicating region.
e. Anterior Choroidal region.
f. Carotid Bifurcation.

ii. *AnteriCerebral*

a. A_1 (mainbranch)
b. Anterior Communicating region
c. A_2 (distal); callosomarginal / distal pericallosal region.

iii. *Middle Cerebral*

a. M_1 (main branch) lenticulostriate/ temporal branch regions.
b. Bifurcation.
c. Peripheral.

B. ***Posterior Circulation Arteries***

i. *Vertebral*

a. Main Trunk.
b. Posterior inferior cerebellar artery region.

ii. *Basilar*

a. Bifurcation.
b. Superior Cerebellar artery region.
c. Anterior inferior cerebeller artery regions.
d. Basilar trunk.
e. Vertebro basilar junction region.

iii. *Posterior Cerebral*

a. P_1 (first branches of basilar – distal to apex).
b. P_2 (distal posterior cerebral).

The definite study of the natural history of aneurysms was published by Pakarinen in 1967.[9]

ETIOLOGY

A. ***Hemoodynamic:***

1. Uneven pulsatile pressure head distribution at apex of bifurcations, branching, or outer aspect of curves, causing local degeneration of internal elastic.
2. Increase flow from.
   a. Distal arteriovenousmalformation.
   b. Aplasia, hypoplasia of contralateral normally present vessel.
3. Increased blood pressure (possibly associated vessel defect).
   a. Coarctation of aorta.
   b. Autosomal dominent polycystic kidney disease.
   c. Fibromuscular dysplasia.

B. ***Genetic:***

Genetic or Possibly genetic syndromes associated with intracranial aneurysms: Ehlers – Danlos.

Syndrome, Marfan's syndrome, Pseudoxan – thomaelasticum, Rendu – Osler – Weber syndrome.

Klippel – trenaunary – Weber syndrome, type – III collagen deficiency.

C. ***Traumatic:***

a. Skull Fractures.
b. Penetrating foreign body.
c. Surgical injury.

D. ***Infectious:***

a. Bacterial (5% mostly streptococcal infection in bacterial endocardits).
b. Fungal.
c. Syphilis.

E. ***Neoplastic:***

a. Metastatic: choriocarcinome, atrial myxoma.
b. Primary neoplasm.
c. Aneurysms associated neoplasm; pituitary adenomas.

F. ***Other disorders, effecting blood vessels***

a. Granulomatous (giant cell) angitis.
b. Systemic lupus erythematosus.
c. Moyamoya disease.
d. Sickle cell anemia

G. ***Radiation – induced seccular aneurysm***

H. ***Atherosclerosis*** most common cause of fusiform aneurysm, posterior circulation most commonly affected.

GRADING SCALES FOR SUBARACHNOID HAEMARRHAGE

The most important factors predicting outcome after SAH, were level of consciousness & presence of hemipresis and/or aplasia.

Numerous grading systems have been devised including mainly Botterellscale, Hunt& Hess scale, World Federation of Neurological Surgeon scale.[10] Hunt and Hess scale and World Federation of Neurological Surgeon Scales are most often indicated by Neurosurgeons and are as under:

Hunt And Hess Scale:

Grade Description

1. Asymptomatic or minimal headache and slight nuchal rigidity.
2. Moderate to severe headache, nuchal rigidity, no neurological deficit her than cranial nerve palsy.
3. Drowsiness, confusion, or mild focal deficit.
4. Stupor, moderate to severe hemiparesis, possible early decrebrate rigidity & vegetative disturbances
5. Deep coma, decerebrate, moribund appearance.

World Federation of Neurological Surgeons Scale

Grade Description

1. Glasgow coma score 15, no motor deficit.
2. Glasgow coma score 13 to 14, no motor deficit.
3. Glasgow coma score 13 to 14, with motor deficit.
4. Glasgow coma score 7 to 12, with or without motor deficit.
5. Glasgow coma score 3 to 6, with or without motor deficit.

NATURAL HISTORY OF ANEURYSMS

Highest mortality is observed immediately following haemorrhage and diminishes later on. Asymptomatic aneurysms discovered incidentally/existing in patients with multiple aneurysms bleed at rate of 1 – 2%[9] (Eskesen V, Rosenornj, Schmidtk).

The Influence of unruptured intracranial aneurysms on life expectancy in relation to their size and the time of detection and to age.[9] Because the risk of surgery for unruptured aneurysms is low (mortality close to 0% morbidity about 04%), it is recommended that asymptomatic aneurysms should be clipped in most patients.[9]

NEUROLOGICAL COMPLICATIONS OF ANEURYSMAL RUPTURE

These are summarized as below:

1. ***Intracranial pressure elevation (ICP):***

   Increased ICP, after subarachnoid haemarrhage or IntraventricularHaemarrhage is usually due to an increase in CSF outflow resistance. Presumably, erythrocytes and fibrin debris from haemarrhage into subarachnoid space acutely block arachnoid villi.Hydrocephalus is probably due to fibrotic obliteration of CSF pathways at many points.

2. ***Vasospasm***

3. ***Recurrent subarachnoid haemarrhage***

4. ***Hydrocephalus:***

   It may be acute (treated by external ventricular drainage) or chronic with neurological sign (treated by ventriculoperitoneal shunt).

5. ***Focal ischemic neurological deficit***

6. ***Epilepsy:***

7. ***Disability or death***

   Negative work up for aneurysms as a cause of subarachnoid haemarrhage

   Inspite of availability of modern 4 vessel angiography, 3D CT angiography, digital subtraction angiography, magnification, multiple projection, attention to lesion in the spinal canal as a possible source of subarachnoid haemarrhage, in 05 series reported between 1986 and 1989, a source of subarachnoid haemarrhage*could not* be identified between 3.8 to 30% of patients.[13]

Microsurgical Anatomy:

Three basic principles should be remembered in relation to each of the common aneurysmal site.

1. First, these aneurysms arise at branching site on the parent artery.
2. Second, these aneurysms arise at a turn or curve in the artery. These curves by producing local alteration in intravascular hemedynomics exert unusual stresses on apical regions, which receive the greatest force of the pulse wave.
3. Third, the saccular aneurysms point in the direction that blood would have gone if the curve at the aneurysm site were not present. The aneurysm dome or fundus points in the direction of maximal hemodynamic thrust in the preaneurysmal segment of the parent artery. So for neurosurgeon operating on aneurysm, the *proximal and distal arterial control* is of paramount importance.

Anatomic principles of Aneurysmal Surgery

1. The parent artery should be exposed *proximal* to aneurysm.
2. If possible, the side of parent vessel opposite the side of aneurysm should be exposed *before* dissecting the neck of aneurysm.
3. The aneurysmal neck should be dissected *before* the fundus.
4. All perforating branches should be separated from the aneurysmal neck prior to passing the clip around the aneurysm.
5. Progressive withdrawal/suction of CSF from the subachronoid space should be used as a measure to relax the brain preferably. The mean arterial pressure should be reduced upto 90 – 105 mm Hg at the time of clipping, and can be again allowed to rise after the successful application of the clip at the neck of aneurysm to elicit and deal accordingly any ooze in periclipped aneurysmal site.
6. If rupture occurs during microdissection, bleeding should first be controlled by applying small cotton pledget and concomitantly reducing mean arterial pressure. If this fails, a temporary clip can be applied to the proximal already exposed artery but only for a *brief* time.
7. A clip with spring mechanism allows to be removed, reposition and reapplied.
8. The clip should not kink or obstruct the major vessel and no perforating branches are included.

9. Abroad based neck aneurysm may need bipolar coagulation to reduce the neck size (controversial).

OPERATIVE APPROACHES

95% of aneurysm are found at one of the five sites, all of which are located in close proximity to the circle of Willis.

These sites are:

1. The anterior communicating (ACOM) area.
2. The Internal Carotid Artery (ICA) between the posterier communicating (PCOM) and the anterior choroidal arteries.
3. The internal carotid bifurcation.
4. The proximal bifurcation of Middle Cerebral Artery (MCA).
5. The basilar bifurcation.

A. The frontotemporal craniotomy with slight modification is mostly suitable for all these aneurysm arising from the anterior circle of Willis.

B. Small frontotemporal flap centred at the *pterion* may be used for ICA aneurysm and can be modified per-op for different aneurysm of MCA, ICA, ACOM and extended as:

   a. Subtemporal approach for an aneurysm of basilar apex.
   b. Anteriorsubtemporal exposure for upper basilar aneurysm.
   c. Combined supra &infratentorial pre sigmod approach to basilar artery.

IMAGING OF INTRACRANIAL ANEURYSM

1. In the past plain radiography was the first radiological investigation undertaken in patients suspected of having intracranial aneurysm and these were reviewed for displacement of pineal body or choroid plexus secondary to an intracerebral or subarachnoid haemarrhage. Very rarely calcification was seen in the walls of a giant aneurysm. In a small percentage, bony eresions of the clivus, pituitary fossa, or sphenoid wing indicated a giant aneurysm.
2. High resolution computed tomography Angiography (CTA).

   Recently this is the procedure of choice for the detection of subarachnoid haemarrhage, localization of intracranial aneurysm.[11-13] Lilliquistb, Lintquist M Computed tomography in the evaluation of Subarachnoid Haemarrhage.

The CT scan can be performed in first 24 hours of the attack. It can be done without and with IV contrast.

Ultrathin slices specially at circle of Willis are taken.[11]

Unenhanced CT scan

This will demonstrate Subarachnoid Haemarrhage areas of increased density in the subarachnoid spaces along the skull base, Sylvian fissure, within the sulci, along the falx, tentorium & even in interhemispheric fissure.

The location of subachronoid hammrhage mostly suggest the site of bleeding aneurysm.

Enhanced CT Scan

These are performed after the view of unenhanced CT scan by giving I/V contrast bolus. Aneurysm greater than 5mm can be seen.[11]

Contraindications

1. Sensitivity to I/v contrast.
2. Renal shut down.

Transfemoral Cerebral Angiography

This may be the final step and can be performed immediately preceding surgery. Selective injection of 6-10 ml of contrast into common carotid and vertebral arteries may reveal circle of Willis.

Arterial, capillary and venous phases help in proper localization of aneurysm.

Magnetic Resonance Imaging (MRI), Magnetic Resonance Angiography (MRA)

MRI and MRA have become very useful diagnostic tools in addition to CT Scan and angiography.

Limitations:

1. MRI donot identify fresh subarachnoid haemarrhage.
2. It is difficult to subject acutely sick aneurysm patient in MRA suit.[3] Vasospasm may reduce the specificitly of cerebral aneurysm / parent vessel in MRA. Inspite of this MRI and MRA are excellent studies to detect unruptured aneurysm.

Time – of flight (TOF) or phase contrast (PC) are two techniques utilized in MRA. Both can be two or three dimensional acquisition. MRA study is a non invasive, cost effective way to detect the presence of aneurysm larger than 3 mm in diameters. It is also a highly useful for *post operative follow-up* to see the result.[11,12]

Address for Correspondence:
Assistant Professor
Department of Neurosurgery
DHQ Teaching Hospital, RMC, Rawalpindi
drashraf1964@yahoo.com.

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