SREE CHITRA TIRUNAL INSTITUTE
FOR
MEDICAL SCIENCES AND TECHNOLOGY
THIRUVANANTHAPURAM

PROJECT REPORT

NAME	: HEMANT SONWALKAR
PROGRAMME	: D.M. NEURORADIOLOGY
MONTH & YEAR OF SUBMISSION	: NOVEMBER 2004

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Title of the Project:

'Review and Long Term Follow Up Of Endovascularly Treated Intracranial Aneurysms'

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Certificate

I, Dr. Hemant Sonwalkar hereby declare that I have actually carried out the project 'Review and Long term follow up of endovascularly treated intracranial aneurysms' independently under supervision and guidance in the institution.

Thiruvananthapuram Signature ....

November 2003 Hemant Sonwalkar

Forwarded.

Dr. Hemant Sonwalkar carried out the above-mentioned project in the Department of Radiology, SCTIMST, Thiruvananthapuram.

Signature ....

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Sonwalkar

Hemant Sonwalkar

CONTENTS

LIST OF ABBREVATIONS

GDC	–	Guglielmi detachable coil
HEMA	-	Hydroxyethyl methacrylate
ICA	–	Internal Carotid artery
ACA	–	Anterior Cerebral artery
MCA	–	Middle cerebral artery
PCA	–	Posterior cerebral artery
AICA	–	Anterior inferior cerebellar artery
PICA	–	Posterior Inferior Cerebellar artery
ACOM	–	Anterior Communicating artery
PCOM	–	Posterior Communicating artery
SAH	–	Subarachnoid hemorrhage
CCF	–	Caroticocavernous fistula
TIA	–	Transient ischaemic attacks
PAO	–	Parent artery occlusion
PVO	-	Parent vessel occlusion
IDC	-	Immediately Detachable Coils
MDC	-	Mechanically Detachable Coils
BPM	-	Bioabsorbable Polymeric material coils
DMSO	–	Dimethyl sulfoxide
CAMEO	-	Cerebral Aneurysm Multicenter European Onyx
ISAT	-	International Subarachnoid Aneurysm Trial
PVO	–	Parent artery occlusion

GOS	–	Glasgow outcome scale
TCCS	-	Transcranial color-coded duplex sonography
TCCD	-	Transcranial color Doppler
DSA	–	Digital subtraction angiography
TOF	–	Time of flight
3DTOF	–	3 Dimensional Time of flight
SSD	–	Surface shaded display
MRA	–	Magnetic resonance angiography
CEMRA	–	Contrast enhanced Magnetic resonance angiography
CO	–	complete occlusion
DE	–	Dog-ear
RN	–	residual neck
RA	–	residual aneurysm
ACT	-	activated clotting time
GA	–	General anaesthesia
LA	–	Local anaesthesia

INTRODUCTION:

Intracranial aneurysms are common lesions with a prevalence of 0.5% to 6% in adults, according to angiographic and autopsy studies **(1)**. A recent autopsy study of 1000 subjects done in North India states the incidence of aneurysms in Indian population to be approximately 1%, being approximately 1.6% in females and 0.8% in males (**2**). Most intracranial aneurysms are asymptomatic and are never detected. Some are discovered incidentally during neuroimaging and some produce symptoms due to mass effects on adjacent structures. However, the most dreaded complication of intracranial aneurysm is rupture causing subarachnoid hemorrhage (SAH). Subarachnoid hemorrhage is associated with a 32-67% case fatality and a 10-20% long-term dependence in survivors due to brain damage **(3).**

For ruptured aneurysms, early treatment within 24-72 hours has been recommended because the risk of subsequent rupture is high, with 19% risk of rupture in the first 2 weeks after SAH **(4).** Each additional rupture substantially increases the risk of mortality and morbidity. Treatment has also been recommended for most unruptured aneurysms. However, recent study done by International Study of unruptured intracranial aneurysms investigators has created significant uncertainty about the need of treatment in small-unruptured aneurysms. The cumulative rate of rupture of aneurysms that were <10mm in diameter at diagnosis in patients with no history of SAH was <0.05%/year, and in group with history of SAH from another associated aneurysm, the rupture rate was 10 times as high (0.5%). The size and location of aneurysm were significant independent predictors of rupture with aneurysms >25mm in size and those located at basilar top, vertebrobasilar, posterior cerebral or posterior communicating artery being more likely to rupture and thereby requiring treatment **(5).**

The aim of aneurysm treatment is exclusion of the aneurysm from circulation.

Walter Dandy did the first successful surgical clipping of intracranial aneurysm neck in 1937.Microsurgical clipping of intracranial aneurysm had since then been practiced since then with development of new surgical approaches and new clip materials. The outcome of surgical treatment for acutely ruptured intracranial aneurysm has remained fairly constant for the past 20 years, with only 30% of patients regaining their premorbid neurological status **(6)**. This therapeutic modality requires general anesthesia, open craniotomy, brain retraction and manipulation in order to reach the neck of the aneurysm.

Fedor Serbinenko, a Russian neurosurgeon first described endovascular treatment of intracranial aneurysms in early 1970's .He used indigenous detachable latex balloons mounted on catheters for treating aneurysms. 300 cases of temporary balloon occlusion and 162 cases of permanent balloon occlusion were performed. This included 124 cases of intracranial aneurysms. All but 2 patients survived the procedure with a satisfactory condition at discharge **(7).**

Guglielmi et al in 1991 introduced a new technology for controlled delivery of platinum coils via endovascular route within the aneurysm. Eleven experimental saccular aneurysms were created on the common carotid artery of swine and subsequently thrombosed via an endovascular approach, using a very soft detachable coil made of platinum **(8)** .The detachment process was based on the principle of electrolysis with a stainless steel core wire being attached to platinum coils via a electrolytic soft steel midportion. The electrical current passing through the coils during detachment period also promoted thrombosis of aneurysm. A series of 15 patients with age ranging from 21-69 years were treated with significant (70-100%) thrombosis achieved in all 15 patients. No permanent neurological deficit was observed in any of the patients **(9)**.

The capacity for intracranial, intrarterial navigation using soft atraumatic microcatheters and superb visualization with roadmapping facilities available with digital subtraction angiography suites has opened and established endovascular treatment of intracranial aneurysm as a primary modality in tackling intracranial aneurysms. By August 2002, it was estimated that 100,000 patients with intracranial aneurysms had been treated with GDC throughout the world, with approximately 1500 patients being treated per month **(10).** The publication of the initial data from the International Subarachnoid aneurysm trial collaborative group (ISAT) represents a landmark in the evolution of the treatment of cerebral aneurysms, proving that endovascular treatment with detachable coils gave much superior clinical results than surgical clipping at 1 year follow up. The trial created a profound change in management of intracranial aneurysms, with most of the aneurysms in Europe being now treated by endovascular means rather than by clipping.

Criticism of endovascular therapy has resulted from potential for rebleeding from partially occluded aneurysms. Long terms angiographic and clinical follow up of intracranial aneurysms treated by endovascular route are lacking. The present study is a retrospective and prospective study of medium to long-term clinical and angiographic results of endovascular treatment of intracranial aneurysms. The present study also aims to evaluate the factors involved in successful occlusion of intracranial aneurysm.

REVIEW OF LITERATURE:

The primary purpose of the treatment of intracranial aneurysm is to prevent a catastrophic and often fatal hemorrhage; the aim of treatment being to exclude the aneurysm from the circulation. Intravascular embolization of aneurysms may be Endovascular treatment of intracranial aneurysms can be divided into two broad categories, depending upon their size and location: 1) Intravascular occlusion of the aneurysm along with its parent artery and 2) Intravascular occlusion of the aneurysm with preservation of the parent artery. The common material used for aneurysm occlusion includes balloons and coils.

In a landmark article in 1974, Serbinenko described the technique and his results for temporary and permanent balloon occlusion of intracranial arteries using latex balloons **(7)**. Serbinenko used indigenous latex balloons, which could be mounted on angiographic needles and navigated along with blood flow to the intracranial circulation. Since 1911, Matas test for testing the efficiency of collateral circulation before surgical sacrifice was being done by applying manual compression over the neck and performing an angiographic and clinical examination. Stimulation of carotid sinus, compression of both the carotid artery and the jugular vein and imprecise site of compression were few of the problems associated with it (86). Precise evaluation of collateral circulation was done for the first time with safe and temporary inflation of balloon in Internal carotid artery. For permanent occlusion two methods were used: Temporary therapeutic occlusion and permanent therapeutic occlusion. In temporary occlusion, a balloon is intermittently inflated in the parent artery along with coagulant material injection distal to it. This procedure is repeated several times till the aneurysm cavity clots successfully. In permanent occlusion a detachable balloon is used to permanently occlude the aneurysm and / or parent artery. 300 cases of temporary balloon occlusion and 162 cases of permanent balloon occlusion were performed. This included 124 cases of intracranial aneurysms. All but 2 patients survived the procedure with a satisfactory condition at discharge.

In 1981, Hieshima et al described the use of silastic balloons for the endovascular occlusion of intracranial aneurysms while preserving the parent artery (**11**).

Goto et al in 1988 refined the technique of balloon embolization by using a polymerizing agent hydroxyethyl methacrylate (HEMA) as a permanent solidification material in detachable balloons. The viscosity of the material is low enough to be injected through the small-bore catheter. By filling almost 70% volume of the balloon with HEMA, the entire content of the balloon solidifies over a period of 15-60 minutes. Latex might undergo degradation with HEMA, so that it has to be essentially used with silicone balloons **(12).**

Using the technique described by Hieshima, Randall Higashida et al treated 84 patients on intracranial aneurysm with percutaneous balloon deployment without sacrificing the parent artery over a period of 6 years .The presenting symptom was mass effect in 45 patients (53.6%), SAH in 31 patients (36.9%), CCF from ruptured cavernous ICA aneurysm in 6 patients (7.1%), trauma in 1 and transient ischemic attack in 1. In the 84 cases of inoperable high-risk aneurysms embolized by them, complete occlusion was achieved in 77.4% (65/84) cases with deaths in 17.9% (15/84) cases and procedure related neurological deficit in 10.7% cases **(13)**.

In 1984, Berenstein et al. reported their experience in the use of detachable latex balloon for embolization of 9 cavernous ICA aneurysms. Their technique involved trapping of aneurysm by inflating a balloon distal to, and another balloon proximal to, the neck of the aneurysm. They also stressed the importance of pre-embolization temporary balloon occlusion of ICA with a lumen balloon catheter with the patient under systemic heparinization **(14).**

Fox AJ et al used detachable latex balloons for endovascular treatment of 68 unclippable Intracranial aneurysms with parent artery occlusion proximal to the aneurysm in 65cases. Of these patients, 37 had carotid artery aneurysms below the origin of the ophthalmic artery, 21 had aneurysms arising from the supraclinoid portion of the carotid artery, six had basilar trunk aneurysms, and one had a distal vertebral aneurysm.

Of the 65 patients in whom permanent occlusion was effected by detachable balloon, there were nine instances of delayed cerebral events. One of these was a seizure leading to respiratory arrest and resuscitation 3 days following occlusion in a patient who had presented with seizures. The other eight cases were delayed ischemic events; seven were completely reversed and one patient had residual weakness in one leg (1.5% permanent morbidity). Extra cranial-Intracranial bypass procedures were performed in 25 of the 65 cases. All aneurysms of the carotid artery below the level of the ophthalmic artery presented angiographic proof of complete thrombosis. Ten of the twenty-one aneurysms arising from the supraclinoid portion of the carotid artery were completely thrombosed by proximal occlusion alone, without additional trapping procedures. Similarly, in three of the six basilar trunk aneurysms, proximal occlusion alone initiated complete aneurysm thrombosis without trapping. The author concluded that proximal balloon occlusion for unclippable cerebral aneurysm is a convenient, safe, and effective way of producing arterial occlusion in these cases **(15).**

Both the techniques of Selective aneurysm occlusion with preservation of parent artery and parent artery occlusion with balloon were evaluated by Higashida in one of the largest series of intracranial aneurysms balloon occlusion published in 1991. Randall Higashida et al treated 215 aneurysms in 211 patients using detachable silicone micro balloons after preliminary test occlusion. In 127 cases (59.1%), the parent artery was occluded and in 88 cases (40.9%), primary occlusion of aneurysm with preservation of parent artery was achieved.177 cases involved the anterior circulation and 38 cases involved the posterior circulation. Therapy related complications included 21 deaths (9.8%) and 16 strokes (7.4%). In the subgroup of patients treated with parent artery occlusion, 114/127 were in the anterior circulation and 13/127 were in posterior circulation. Complications in this group included 7 strokes (5.5%) and 5 deaths (3.9%). The remaining 115 patients showed marked symptomatic improvement with radiographic evidence of decreased aneurysm size 3-6 months after occlusion. In the subgroup of primary aneurysm occlusion with preservation of parent artery, 63/88 were in anterior circulation and 25/88 involved the posterior circulation. Permanent complications included 16 deaths (18.2%) and nine strokes (10.2%). Radiological follow up showed complete aneurysm occlusion in 66/88 cases (75%).

Thus, procedure related complications were less in cases of parent artery occlusion than in case of selective aneurysm occlusion with preservation of parent artery flow **(16).**

Higashida et al embolized 26 posterior circulation aneurysms in 25 patients with detachable silicone balloons. The aneurysms involved the distal vertebral artery in 5 cases, midbasilar in 6 cases, distal basilar in 11 cases and posterior cerebral artery in 4 cases. Direct balloon embolization of aneurysm with preservation of parent artery was achieved in 17 cases (65%) and parent artery occlusion performed in 9 cases (35%). Complications included 5 deaths, 3 strokes and 3 cases of transient ischemic deficits. Good to excellent angiographic outcome was achieved in 20/26 cases (77%) with poor outcome and subtotal occlusion of aneurysm in 6/26(33%) cases. On long term neurological monitoring, 15 /25 patients continued to remain functionally intact and neurologically stable with 10 deaths on follow up; 5 of which were due to aneurysm rupture (17).

In 1991 Moret at al performed endovascular occlusion of aneurysms selectively in 90 cases with 93 berry aneurysms of which 73 were successfully. There was a 12% complication rate, including 4% mortality and 8% of cases with neurological deficit, and 9 recurrences. The endovascular occlusion was especially successful for carotico ophthalmic and basilar artery aneurysms (87).

Aymard et al examined the long-term outcomes for 21 patients with unclippable posterior circulation aneurysms treated with either unilateral or bilateral parent vessel occlusion of the vertebral artery, with a mean follow-up of 2 years (range, 6 months to 6 years). Six of the patients had fusiform aneurysms, and the remaining 15 had aneurysms that were of saccular morphology. All the occlusions in this series were performed by using latex balloons. Thirteen (61.9%) of 21 patients achieved good outcomes, including angiographic cure and clinical improvement. Twenty-eight percent of the patients had partial thrombosis of their aneurysm. One death and one treatment failure occurred **(18)**.

Larson et al did long-term evaluation of efficacy of balloon occlusion for treatment of 58 patients with carotid artery aneurysms. The aneurysms included 40 intracavernous carotid, 5 petrous carotid, 3 cervical carotid, and 10 ophthalmic segment aneurysms. . Preoperative temporary balloon occlusion of the ICA combined with cerebral blood flow monitoring and induced hypotension was used to determine tolerance for occlusion. Two patients not tolerating test occlusion required an extra cranial-Intracranial bypass procedure, and another patient underwent extra cranial-Intracranial bypass prior to test occlusion because of contra lateral ICA stenosis. In 55 patients, aneurysms were excluded from the circulation by either occluding the proximal ICA or trapping the aneurysm neck. In three patients, the aneurysm was directly obliterated with Intravascular balloons with preservation of the parent ICA. Three patients died during treatment, one from subarachnoid hemorrhage and two from cerebral infarction.

Six patients who developed transient ischemia caused by emboli responded to volume expansion and anticoagulation treatment. Two patients developed a delayed infarction, and one patient developed aneurysm enlargement that required surgical clipping and obliteration. Two patients suffered a delayed subarachnoid hemorrhage, one from a de novo aneurysm arising from the anterior communicating artery and another from a contra lateral A1-A2 junction aneurysm that had enlarged after treatment for the ICA aneurysm **(19).**

ENDOVASCULAR ANEURYSM OCCLUSION DEVICES

Guglielmi et al in 1991 introduced a new technology for controlled delivery of soft platinum coils via endovascular route within the aneurysm. Eleven experimental saccular aneurysms were created on the common carotid artery of swine and subsequently thrombosed via an endovascular approach, using a very soft detachable coil made of platinum. Control angiogram obtained 2 to 6 months postembolization confirmed permanent aneurysm occlusion as well as the patency of parent artery in all the cases. The detachment process was based on the principle of electrolysis with a stainless steel core wire being attached to platinum coils via electrolytic soft steel midportion. The electrical current passing through the coils during detachment period also promoted thrombosis of aneurysm. Thrombosis occurred because of the attraction of negatively charged white blood cells, red blood cells, platelets, and fibrinogen to the positively charged platinum coil positioned within the aneurysm. Platinum appeared to produce the largest clots, which are also directly proportional to the coulombs of electricity delivered. The suppleness and flexibility of platinum coils allow the occlusion of aneurysm without significant deformation of its original shape. The controlled detachment also makes aneurysm occlusion safer **(8)**.

Encouraged by the animal experiments, a series of 15 patients with age ranging from 21-69 years were treated with significant (70-100%) thrombosis achieved in all 15 patients. No permanent neurological deficit was observed in any of the patients **(9).**

Sadato et al introduced a platinum coil with detachment principle based on application of high frequency electric current so that a polyvinyl alcohol junction between the coil and the delivery wire is disrupted by heat within seconds. These coils are called Immediately Detachable Coils (IDC) and were shown to be reliable in experimental animals **(20).**

Tungsten mechanically detachable coils were introduced in France by Balt extrusion, Montmorency in 1994 for embolization of intracranial aneurysms. The spirals are made up of tungsten with 2 parts: a clip fastened to a stainless steel pusher and a titanium dumbbell to attach the spiral to the pusher. Alain Tournade et al used this device in 53 patients with 56 saccular aneurysms with a follow up evaluation over a period of 6-24 months. Complete (100%) occlusion was achieved in 47/56 aneurysms. In this small group, endovascular treatment with mechanically detachable spirals had a success rate of 90% indicating it to be a rapid, reliable and relatively safe technique in treatment of intracranial aneurysms **(21).**

Cognard et al used mechanically detachable tungsten spirals in 57 patients with 60 saccular aneurysms. Endovascular treatment was possible in 55(92%) of these aneurysms with complete occlusion in 33/42 berry aneurysms and 4/13 large/giant aneurysms. The spirals were characterized by rapid detachment and low cost compared to the GDC system with good results **(22).**

Decreased radio opacity with corrosion of tungsten was reported on long term (30 month) follow up of 5 patients with Mechanically detachable spirals by Reul J et al in 1998.The leaching of tungsten into adjacent tissue was confirmed by finding high serum tungsten levels (10-50 times normal) in 2 patients. This study raised questions about the safety of using Mechanically detachable tungsten coils in humans **(23).**

In conjunction with the University of Geneva, William Cook Europe developed a mechanically detachable platinum coil system called the Detach – 18 systems in 1996, which were followed by a Detach – 11 systems. The system differs from GDC in that the pusher wire is aligned proximal to the distal tip of the 2-tip microcatheter. The detachment occurs by rotating the pusher wire torque device 20 times in anticlockwise direction to detach the platinum coils. The safety and reliability of the Detach system was evaluated by Murphy et al in a study of 41 patients with diverse pathologies of which 14 patients underwent parent artery occlusion and 1 basilar top aneurysm was coiled. No device related complication was noted with detachment occurring over 10-25 second. Complete occlusion of vessel occurred in 85% of patients **(24).**

The same group of Murphy et al put forth the results of the European phase 2 clinical trials over the safety of Detach system in 2001 for 60 patients. These included 14 cases of ICA occlusion, 3 cases of vertebral artery occlusion and 1 case of Basilar artery occlusion. Complete occlusion was achieved in 53/60 patients with premature detachment occurring in 1 patient. The study shows that Detach system is a safe and fast detachment occlusion with proven results in large vessel occlusions **(25).**

Mark et al evaluated 3 mechanically detachable coil designs; clamped ball, looped ribbon and interlocking cylinder using in vivo and in vitro testing for studying reliability of coil release, retractability and coil behavior in a microcatheter and concluded that the interlocking coil design is superior to the other two. In the interlocking cylinder design, the coil and the coil pusher are interposed while within the catheter so that the cylinder attached to the coil is not capable of traveling or escaping beyond the cylinder attached to the coil pusher until the device is pushed out of the microcatheter (26). Cekirge et al treated 2 aneurysms of the Basilar tip, 2 of the ICA and 1 of the PICA using interlocking coils. They concluded that the coils are soft and retrievable and afford instantaneous coil release thus providing a safe alternative to the GDC system (27).

Murayama et al introduced Bioabsorbable Polymeric material coils (BPM) with a biologically active coil material for better results in large and giant aneurysms, which frequently show recanalization with GDC coils. BPM's can stimulate cells to regenerate tissue and act as a scaffold for tissue engineering

(28). The short term efficacy and long term safety of the new BPM coils was evaluated by Murayama et al in experimental animals over a 3 month period. He concluded that the Bioabsorbable Polymeric material coils accelerated aneurysm fibrosis and neointima formation without parent artery stenosis (29).

Kallmes et al introduced a new hybrid embolic device consisting of a carrier platinum coil coupled to an expandable hydrogel material, which undergoes a nine fold increase in volume when placed into a physiological environment (30).

Initial clinical experience using Hydro coils (Hydrogel platinum hybrid coils) were evaluated by Cloft et al, who concluded that Hydrocoils provided substantially improved volumetric packing of aneurysm lumen relative to standard platinum coils. This technique can be used in large and giant aneurysms to reduce the rates of recanalization (31).

Moret has pioneered the use of liquid embolic agent Onyx as an embolic agent for aneurysms unsuitable for coil treatment. Onyx is an ethylene vinyl alcohol copolymer dissolved in organic solvent DMSO. When the material comes in contact with an aqueous solution, it precipitates and forms a soft spongy polymer cast, initially with an outer layer, remaining semi-liquid centrally. A prospective observational study was conducted in 20 European centers with 123 aneurysms treated in 119 patients with Onyx known as CAMEO trial. In aneurysms considered unsuitable for coil embolization, Onyx offered complete occlusion in 79% cases and subtotal occlusion in 13%. Aneurysm occlusion rates were superior to reported rates of coil embolization with treatment morbidity being comparable to that of coiling (32).

RELATION BETWEEN ANEURYSM MORPHOLOGY , IMMEDIATE AND FOLLOW UP ANATOMICAL RESULTS FOR COIL EMBOLIZATION:

Zubilaga et al evaluated the relation of the size of aneurysm neck and the completeness of coiling in intracranial aneurysms. A retrospective study of 79 patients of coiled aneurysms was undertaken. Aneurysms were classified as small necked (<=4mm) and large necked (>4mm). Complete aneurysm occlusion was observed in 85% of small-necked aneurysms and only 15.7% of large necked aneurysms.

Aneurysms with a small neck had much better completeness of coiling as compared to large necked aneurysms (33).

Vinuela et al made a prospective study of 403 patients presenting with acute subarachnoid hemorrhage in whom GDC embolization was done within 15 days of bleed. Aneurysms were classified on the basis of their largest diameter as small (<10mm-60.8%), large (10-25mm-34.7%) and giant (>25mm-4.5%) and on the basis of their neck size as small (<4mm-53.6%) and wide (>=4mm-36.2%). Complete aneurysm occlusion was observed in 70.8% of small aneurysms with small neck, 31.2% of small aneurysms with wide neck, 35% of large aneurysms, and 50% of giant aneurysms. A small neck remnant was observed in 21.4% of small aneurysms with small neck, 57.1% of large aneurysms and 50% of giant aneurysms. This indicates that the best results are seen with small aneurysms with small neck, these being most anatomically favorable for holding the coiled mass allowing complete packing (34).

Pre and post treatment angiograms of 72 patients undergoing GDC treatment were retrospectively reviewed by Turjman et al. Morphological Parameters that correlated with the unsatisfactory result of partial occlusion were large aneurysm diameter, volume and neck size and more direct inflow (i.e., Increasingly obtuse aneurysm /parent artery angulations). The two morphological factors most predictive of partial occlusion were large aneurysmal diameter and more direct inflow in the aneurysm sac (35).

A retrospective analysis of 144 patients with 144 cerebral aneurysms that were treated by endovascular technique at the University of Illinois Hospital at Chicago was conducted by Debrun et al. For the initial 25 patients (Group 1), selection for coiling was restricted to nonsurgical candidates or patients in whom coiling was thought to be the best treatment choice, based on medical condition and location of the aneurysm. The remaining patients (Group 2) were selected for coiling based on aneurysm geometry, as determined by pretherapeutic angiography. Aneurysms that were considered to be favorable for coiling included those that had a dome-to-neck ratio of at least 2 and an absolute neck diameter less than 5 mm. The total complete angiographic occlusion rates were 56% in Group 1 (83% in acutely ruptured aneurysms and 48% in nonacute aneurysms) and 77% in Group 2 (72% in acutely ruptured aneurysms and 81% in nonacute aneurysms). Group 1 aneurysms with a dome-to-neck ratio of at least 2 had a complete occlusion rate of 59%, whereas Group 2 aneurysms with a dome-to-neck ratio of at least 2 had a complete occlusion rate of 80%. Group 1 aneurysms with a dome-to-neck ratio less than 2 had a complete occlusion rate of

40%, whereas Group 2 aneurysms with a dome-to-neck ratio less than 2 had a complete occlusion rate of 58%.

Balloon remodeling technique was used in 15 patients with a complete occlusion rate of 80% and thromboembolic events in 3 patients. A 4.0% neck regrowth rate in all aneurysms determined to be completely occluded at the end of the coiling procedure was seen. Growth of aneurysm neck remnants in incompletely occluded aneurysms occurred in 22% of the cases. These aneurysms tended to be large, with an average dome diameter of 15 mm and neck diameter of 4.4 mm, although all except one had a dome-to-neck ratio of at least 2.This study indicates that a larger dome to neck ratio correlates with more complete aneurysm packing. Balloon remodeling technique gives better packing. The rate of regrowth of aneurysm neck was more with large and incompletely packed aneurysms (36).

Kuether et al treated seventy-seven aneurysms over a period of 4.5 years, with an average angiographic follow-up period of 1.4 years. Initially, 40% of aneurysms exhibited complete (100%) occlusion, 52% near complete (90-99%) occlusion, and 8% incomplete (<90%) occlusion. Sixty percent of the aneurysms were small (<11 mm), 37% were large (11-25 mm), and 3% were giant (>25 mm). Immediate embolization results for small aneurysms were that 49% exhibited complete, 44% near complete, and 7% incomplete occlusion. With a minimum of 6 months of follow-up monitoring, complete aneurysm occlusion was observed in 45% of cases. Near complete occlusion was obtained in 48% of cases, with 7% of small aneurysms being incompletely occluded by GDC.

The immediate embolization results for large aneurysms were that 25% exhibited complete, 64% near complete, and 11% incomplete occlusion. With a minimum of 6 months of follow-up monitoring, complete aneurysm occlusion was observed in 41% of cases. Near complete occlusion was obtained in 47% of cases, with 12% of large aneurysms being incompletely occluded by GDC. Near complete occlusion was obtained initially in both cases (100%) of giant intracranial aneurysms at initial and at follow-up examination in this series. This study indicates that complete occlusion was more common in small aneurysms as compared to large aneurysms on immediate and follow up angiograms **(37).**

A prospective evaluation of 182 patients with 203 aneurysms was done over a 3 year period by Cognard et al. Total occlusion was achieved in 40/49 (82%) cases with aneurysm diameter 2-3mm, 47/50 (94%) cases with aneurysm diameter 4-5mm and 31/47 (66%) cases with aneurysm diameter 6-8mm.Total occlusion was achieved in 27/31 (87%) cases with aneurysm sac diameter to neck diameter ratio > 2, 47/57 (82%) with ratio between 1to2 and 14/19 (74%) cases with ratio <=1.With use of remodeling technique in case of aneurysms with ratio <=1, total occlusion rate increases to 87% (13/15). Follow up angiograms performed in 152 aneurysms demonstrated total occlusion in 123 cases (81%), subtotal occlusion in 26 cases (17%) and incomplete occlusion in 3 (2%) cases. The study further substantiates the finding that small aneurysms and the ones with smaller sac to neck ratios show more complete occlusion rates. The use of remodeling technique increased the completeness of occlusion in large and giant aneurysms **(38)**.

Hope et al attempted to identify factors that might be important in predicting success both at the time of treatment and at the time of follow up angiography. The pretreatment, post treatment and follow up angiograms of 63 aneurysms in 58 patients were reviewed. Treatment success was defined as a neck residue of < 2mm.Aneurysm were said to have changed if percentage of occlusion altered by >2.5% or the difference in rest size was >0.25mm.

Best long-term angiographic results were obtained when the primary treatment is successful and with aneurysms having narrow neck **(39).**

Thirty patients with 31 giant or very large aneurysms were considered to show unacceptable risk/benefit ratios for open surgery and were treated using the Guglielmi detachable coil (GDC) method by Gruber et al. Among 23 patients with 24 aneurysms who were available for angiographic follow-up assessment, complete or nearly complete occlusion was observed for 17 aneurysms (71%; angiographic follow-up period, 24.3 ± 19.6 mo, mean ± standard deviation). A single total embolization served as definitive treatment for only 12.5% of the giant aneurysms and 31% of the very large aneurysms (40).

Bavinzski et al retrospectively reviewed 45 Basilar top aneurysms treated using GDC coils. Immediate post procedure angiograms showed 99-100% occlusion in 30/45(67%) cases, >90% in 9/45(20%) cases and 6/45(13%) were < 90% occluded. On follow up angiograms in 19/31(61%) showed stable results and, 12/31(39%) showed coil compaction, only 8 of which could accept additional coils.

In large aneurysms recanalization was seen in 57% of cases where as in small-necked aneurysms a stable angiographic result was seen in 92% of cases (41).

Hayakawa et al studied the long-term durability of GDC embolization of cerebral aneurysms by following up the residual neck remnant post coiling in a series of 455 aneurysms. On immediate postembolization angiograms, 178 (39%) showed the presence of a residual neck. Long term follow up angiograms were obtained in 73 of these aneurysms in 71 patients over a mean duration of 17.3 months. In small aneurysms with small neck, postembolization angiograms revealed progressive thrombosis in 12/24 (50%), unchanged status in 8/24 (33%) and recanalization in 4/24 (17%) .In small aneurysms with wide neck, 6/24 (25%) had progressive thrombosis, 8/24 (33%) remained unchanged and 10/24 (40%) showed recanalization. In large aneurysms 2/15 (13%) were unchanged and 13/15 (87%) showed recanalization. Of the giant aneurysms only 1/10 (10%) remained unchanged and 9/10 (90%) showed recanalization.

The author concluded that of the factors influencing the long-term stability of GDC coiling, the predominant factors are morphological and biological. The morphological factors are the size of the aneurysm and size of the aneurysm neck (42).

A retrospective analysis of 112 cases of ruptured posterior circulation aneurysms treated using GDC coils over a period of 7 years was done by Lempert et al. Parent artery was preserved in 82 patients, of which follow up angiograms were obtained in 76 cases. Complete occlusion (99-100%) immediately after embolization was achieved in 54% patients, 90-99%occlusion achieved in 40% cases and <=90% occlusion achieved in 6% cases. On follow up, 59/76 (77.6%) showed no evidence of recanalization, while 17/76 (22.4%) showed recanalization. Aneurysms showing recanalization were either fusiform or showed neck size >4mm **(43).**

In 2002, the American Heart Association formed a special writing group to summarize the literature and create recommendations on endovascular therapy of ruptured and unruptured Intracranial aneurysms. According to them, the key factors for complete occlusion of aneurysm were the aneurysm diameter and neck size. A neck diameter of <5mm and a ratio of neck diameter to the largest diameter of sac of <0.5 have been associated with better outcomes. Complete occlusion is less frequent for aneurysms >25mm in diameter. All patients whose aneurysms are treated with coil embolization should have follow up catheter angiograms performed at 1 to 6 months after initial treatment. Follow up imaging should occur sooner in patients with aneurysms that are not completely occluded. Subsequent angiography should be performed in patients whose aneurysms remain incompletely occluded (44).

Murayama et al presented his results of coil embolization in 818 patients with 916 aneurysms over a period of 11 years. Group A included the initial 5 year experience with 230 patients with 251 aneurysms and Group B with 588 patients having 665 aneurysms over the next 6 years. The aneurysms were classified as small (4-10mm in diameter) with small neck (<4mm), small with a wide neck (>4mm), large (11-25mm) and giant (>25mm). In Group A patients complete occlusion was achieved in 86.2% (56/65) cases with small aneurysm having small neck, 42.6% (23/54) cases with small aneurysm having wide neck, 39% (32/82) cases with large aneurysms and 12.1% (4/33) cases with giant aneurysms. In Group B patients complete occlusion was achieved in 72.9% (196/269) cases with small aneurysm having small neck, 40.8% (78/191) cases with small aneurysm having wide neck, 41.4% (48/116) cases with large aneurysms and 37.5% (15/40) cases with giant aneurysms. Balloon assisted coiling was done in 49 patients with greatest benefit in small aneurysms with wide neck showing 60% complete occlusion rate as compared to 41.2% without the balloon assisted technique. Long term angiographic follow up was obtained in 53.4% cases (489/916) over a period of 3 months to 8 years. The results were classified as unchanged, further thrombosis (10% decrease in contrast filling as compared to immediate post procedure angiogram), and recanalization (10% increase in contrast filling as compared to immediate post procedure angiogram). The overall recanalization rates were 5.1% for small aneurysm having small neck, 20% with small aneurysm having wide neck, 35.3% cases with large aneurysms and 59.1% cases with giant aneurysms. The recanalization rates in case of residual neck remnant after initial embolization was 7.7%and 20.7% (Group A and Group B) for small aneurysm having small neck, 31.8% and 29.4% (Group A and Group B) with small aneurysm having wide neck, 40% and 44.4% (Group A and Group B) cases with large aneurysms and 71.4% and 60% (Group A and Group B) cases with giant aneurysms.

The best initial and follow up angiographic results were seen in small aneurysms with small neck **(45).**

Friedman et al retrospectively analyzed 83 patients with GDC coil embolization over a period of 10 years. Aneurysm 15 mm or greater in maximum diameter were more likely to be incompletely occluded: only 2 of the 7 aneurysms 15 mm or larger were completely occluded on immediate post procedure angiogram with only 1 remaining occluded on long term follow up. Partial aneurysm thrombosis was present in 2 aneurysms, both of which showed partial occlusion. On follow up angiograms performed in 68 patients over a mean period of 11.6 months, 24 patients (35%) had complete aneurysm occlusion, 18 (26%) had a dog ear remnant, 24 patients (35%) had a residual neck, and 2 patients (2%) had residual aneurysm filling. In 20 patients (29%) angiographic occlusion at longest follow up greater than it was immediately after initial treatment, where as the degree of angiographic occlusion was worse in 10 patients (15%). The angiographic result was unchanged at longest follow up in 38 patients (56%).

The study concluded that aneurysms larger than 15 mm in diameter were more likely to remain incompletely occluded on long term follow up study **(46).**

Sluzewski et al retrospectively evaluated 160 patients with aneurysmal subarachnoid hemorrhage who had undergone coil embolization. Follow up angiography was performed at 6 and 18 months for all the patients. On immediate post procedure angiograms complete occlusion was noted in 113 (71%) patients, near complete occlusion in 35 (22%) patients and incomplete occlusion in 12 (8%) patients. Of the 126 patients in whom a follow up angiograms was performed after 6 months, In 88 (70%) patients, the occlusion was stable; in 31

(25%) patients, the occlusion decreased; and in 7 (6%) patients the occlusion increased. The mean size of the aneurysms that were stable or improved was 9.2 mm. The proportion of aneurysms 15mm or larger that reopened was 15/29 (52%), versus 16/97(16%) of aneurysms less than 15mm.

Stable aneurysm occlusion was more common in aneurysms >15mm in diameter than in aneurysms <15 mm in diameter. If aneurysm occlusion is sufficient at 6 months, the yield of further follow up angiograms is very low **(47).**

Raymond et al evaluated retrospectively 501 aneurysms in 466 patients treated using detachable coils over a period of 10 years for long term angiographic recurrences. Short-term (≤1 year) follow-up angiograms were available in 353 aneurysms (70.5%) and long-term (>1 year) follow-up angiograms, in 277 (55%), for a total of 383 (76.5%) followed up. Recurrences were found in 33.6% of treated aneurysms that were followed up and that appeared at a mean ± SD time of 12.31±11.33 months after treatment. Variables determined to be significant predictors ($P<0.05$) of a recurrence-included aneurysm size ≥10 mm, treatment during the acute phase of rupture, incomplete initial occlusions, and duration of follow-up **(48).**

RELATION BETWEEN ANEURYSM LOCATION AND ANATOMICAL RESULTS:

POSTERIOR CIRCULATION ANEURYSMS:

Raymond et al prospectively studied 31 patients of Basilar bifurcation aneurysms who underwent endovascular coil occlusion, of which 8 were incidentally detected aneurysms and 23 presented with subarachnoid hemorrhage.

Immediate angiographic result was satisfactory in 94% cases with complete occlusion in 42% cases and residual neck / dog-ear in 52% cases. On follow up angiograms done at 6 months, 30% lesions showed complete obliteration, 59% presented with some residual neck, and 11% showed residual sac opacification (49).

Nicholas et al treated 26 patients with 28 posterior circulation aneurysms using electrically detachable coils. These included 19 basilar apex aneurysms, 2 at P1 segment of PCA, 2 at Superior cerebellar artery origin, 1 at midbasilar trunk, 3 at vertebrobasilar junction and 1 at the origin of PICA. 19 patients with 20 aneurysms underwent follow up angiography 1-6 weeks and 6 months postembolization. Total occlusion was achieved in 18/20 (90%) of aneurysms, 90% occlusion was achieved in 1/20 (5%) patient and 75% occlusion achieved in 1 patient (5%) (50).

Bavinzski et al retrospectively reviewed 45 Basilar top aneurysms treated using GDC coils. Immediate post procedure angiograms showed 99-100% occlusion in 30/45 (67%) cases, >90% in 9/45 (20%) cases and 6/45 (13%) were < 90% occluded. On follow up angiograms in 19/31 (61%) showed stable results and, 12/31 (39%) showed coil compaction, only 8 of which could accept additional coils.

In large aneurysms recanalization was seen in 57% of cases where as in small-necked aneurysms a stable angiographic result was seen in 92% of cases **(41).**

Pierot, Moret et al evaluated endovascular treatment in Basilar artery aneurysms with controlled detachable coils in 35 patients over a period of 2 years. The clinical presentation was subarachnoid hemorrhage in 32 patients, incidental in 2 patients and transient ischaemic attack in 1 patient. The aneurysms were located at the basilar bifurcation (23 patients), at the basilar tip between the posterior cerebral artery and the superior cerebellar artery (5 patients), on the basilar trunk (3 patients), and at the vertebrobasilar junction (4 patients). Endovascular treatment using coils was achieved in 34 patients, using Guglielmi detachable coils in 29 patients and mechanical detachable spirals in 5 patients. One patient died during the positioning of the first coil into the aneurysmal sac. Twenty-five of 35 aneurysms (73.5%) were completely occluded. Nine aneurysms (26.5%) were only partially (> 90%) occluded (88).

A retrospective analysis of 112 cases of ruptured posterior circulation aneurysms treated using GDC coils over a period of 7 years was done by Lempert et al. Technical success was achieved in 109/112 cases. Parent artery was preserved in 82 patients, of which follow up angiograms were obtained in 76 cases. Complete occlusion (99-100%) immediately after embolization was achieved in 54% patients, 90-99%occlusion achieved in 40% cases and <=90% occlusion achieved in 6% cases. On follow up, 59/76 (77.6%) showed no evidence of recanalization, while 17/76 (22.4%) showed recanalization. Aneurysms showing recanalization were either fusiform or showed neck size >4mm (43).

Elkridge et al reviewed the results of 150 patients with basilar tip aneurysms (ruptured - 83, unruptured – 67) treated with GDC coils. In 75% cases >90% coil packing was achieved. Conservative mortality rates included up to 23% for the ruptured aneurysm group and up to 12% for the unruptured aneurysm group; the Rebleeding rate for treated ruptured aneurysms was up to 3.3% and the bleeding rate for unruptured aneurysm was up to 4.1%. Permanent deficit due to stroke in patients with ruptured and unruptured aneurysms occurred in up to 5% and 9% respectively. Vasospasm occurred in 8% of cases. Periprocedural mortality was 2.7%, all occurring in ruptured aneurysms **(51).**

Uda et al evaluated 41 Basilar artery aneurysms of which 18 were Basilar trunk aneurysms, 13 were basilar artery-Superior cerebellar artery aneurysms, 4 were basilar artery –AICA aneurysms and 6 were vertebrobasilar junction aneurysms. Thirty-five out of forty one (89.7%) had excellent clinical outcomes with procedural morbidity and mortality being 2.6% each. Thirty-six out of forty one aneurysms were treated without occluding the parent artery where as parent artery occlusion was done in 5/41 cases. Immediate angiographic result showed complete or near complete occlusion in 35/41 (85.4%) cases. Follow up angiograms obtained in 31 patients showed no recanalization in the 8 completely occluded cases. In the 19 lesions with small neck remnant, 7 (36.8%) showed further thrombosis, 3 (15.8%) remained unchanged, and 9 (47.3%) had recanalization due to coil compaction **(52).**

Leibowitza et al evaluated the perioperative (within 30 days) and follow-up outcomes for patients treated with permanent occlusion of the vertebral artery for vertebrobasilar fusiform and dissecting aneurysms. Thirteen consecutive patients were studied. Two groups were defined for the study. Group I patients underwent PVO to achieve complete thrombosis of the aneurysm. Group II patients underwent PVO to reduce flow to the aneurysm where complete thrombosis was not desirable. All group I aneurysms were shown to be thrombosed on the angiograms obtained at the immediate follow-up examinations. Improvement in outcome scores was achieved by all group I patients. All group II patients had incomplete occlusion of the vertebral artery; however, continued filling of the fusiform aneurysm was still observed. Four patients in-group II died during the follow-up period. Two of these deaths were attributable to the aneurysms. Of the remaining three patients, two experienced clinical worsening and one remained stable. This indicates that patients who undergo permanent vessel occlusion to decrease flow to the aneurysm without complete thrombosis fare worse than patients achieving complete thrombosis of aneurysms (53).

Brilstra et al did a metaanalysis of studies on embolization of intracranial aneurysms with coils. According to the study, results in patients with a Basilar bifurcation aneurysm were in the same range as those in patients with aneurysms located elsewhere. Basilar bifurcation aneurysms are less often completely occluded (45%) than aneurysms than aneurysms not located at the Basilar bifurcation (54).

Lozier et al performed a Medline search for posterior circulation aneurysms and evaluated the data. About 82% aneurysms arose near the basilar apex. Complete aneurysm occlusion (99-100%) was achieved in 47.6%, near complete occlusion (90-99%) in 43.4% and incomplete occlusion was achieved in 9% of cases. In a subset of 234 evaluated patients, 52 recurrences (22.2%) were noted, of which 92% showed a wide neck (55).

Lubicza et al reported the angiographic results and the clinical outcomes for eight patients treated by embolization for peripheral cerebellar artery aneurysms. In five cases, selective embolization of the aneurysmal sac was performed using GDCs. Two large peripheral cerebellar artery aneurysms and one small aneurysm with a wide neck were treated by parent vessel occlusion. Endovascular treatment resulted in five complete occlusions, two neck remnants, and one residual aneurysmal flow. Clinical evaluation showed that all patients achieved good or excellent recovery. Imaging follow-up revealed seven complete occlusions and one residual aneurysmal flow (56).

P2 segment aneurysms develop between the junction of the posterior communicating artery with the posterior cerebral artery (PCA) and the posterior part of the midbrain in the ambient cistern. Clinical and preprocedural data from 10 patients, referred for endovascular treatment of P2 segment aneurysms, were retrospectively studied for prognostic factors influencing postoperative neurologic deficits caused by ischemia of the PCA distal territory by Hallacq et al. Endovascular parent artery occlusion at the level of the aneurysmal neck was possible in nine cases. Control angiography after embolization showed that the aneurysm did not fill, and the distal PCA refilled via leptomeningeal anastomoses. One asymptomatic aneurysm could not be catheterized because of vascular tortuosity. No neurologic deficit occurred after treatment. Clinical presentations and grades were typical. No embryologic or anatomic configuration (e.g., basilar tip arrangement, P2 position relative to the choroidal fissure, aneurysmal size or type [berry, fusiform, or serpentine]) was predictive of bad outcomes. Occlusion of P2 segment was safe, because the aneurysm occurred after the thalamoperforating vessels arose from the P1 segment **(57).**

ANTERIOR CIRCULATION ANEURYSMS:

Bavinzski et al studied endovascular treatment of cavernous ICA aneurysms in 42 patients with 48 aneurysms. The 48 aneurysms were divided into two subgroups by location: 23 were at the C-3 portion (clinoidal) of the carotid artery (small, saccular aneurysms with an epidural, partly intracavernous location) and 25 originated at the C4-5 segment (large or giant often fusiform aneurysms with a true intracavernous location).. Sixteen of the 25, C4- 5 segment aneurysms (all large or giant) were treated by balloon occlusion of the parent artery, four (with narrow necks) were treated with Guglielmi detachable coils (GDCs), and five were not treated (asymptomatic or minimally symptomatic). Twelve of 13, C-3 segment aneurysms were treated with GDCs. Ten C-3 segment aneurysms were not treated.

All aneurysms treated by carotid occlusion thrombosed. Twelve of the 17 aneurysms treated with GDCs were 100% filled by the coils, four were 80% to 95% filled, and one was only 40% filled. Seven of the 100% filled aneurysms remained completely occluded, two showed slight coil compaction, and in three, follow-up angiography was not available. Among the incompletely filled aneurysms, two remained unchanged, one showed progressive thrombosis, a fourth revealed coil compaction, and in one, follow-up angiography was not available **(58).**

Kremer et al compared outcome in anterior and posterior circulation aneurysms presenting with Hunt and Hess grade 4 and 5 SAH. Forty poor-grade patients admitted between 1993 and July 1998 were treated by endovascular approach within 23 days after aneurysm rupture. Eighteen had aneurysms in the Anterior Circulation, 22 in the Posterior circulation. Mean treatment delay was 4 days (median – 2 days) after rupture. One patient showed multiple aneurysms. In 36 cases, aneurysms were occluded by Guglielmi detachable coils; in 4 cases, by parent vessel balloon occlusion. Given comparable incidence of vasospasm in poor-grade patients, a tendency toward better treatment outcome was found in patients with aneurysms in the posterior circulation than in the anterior circulation **(59).**

Eckard et al presented the angiographic and clinical outcome for 9 cases of peripheral intracranial aneurysms treated by parent artery occlusion over a 4-year period**.** The aneurysms were located on branches of the right posterior inferior cerebellar artery (n = 2), the right superior cerebellar artery (n = 1), the right anterior inferior cerebellar artery (n = 1), the right posterior cerebral artery (n = 3), the left middle cerebral artery (n = 1), and the left anterior cerebral artery (n = 1). Parent vessel occlusion was performed using micro coils after test injection with amobarbital (Amytal) in eight of the nine cases (one patient was comatose and could not be tested before occlusion). Angiography immediately after the procedure showed aneurysmal occlusion in every patient. Follow-up arteriography, performed in six patients 2 to 12 months after treatment, documented continued aneurysmal occlusion in every case **(60).**

A retrospective review of 70 patients with 73 paraclinoid aneurysms (8 ruptured, 65 unruptured) over a period of 9 years was done by Park et al. Immediate angiographic outcomes for 73 paraclinoid aneurysms demonstrated complete occlusion in 53 (72.6%), near-complete occlusion in 6 (8.2%), and partial occlusion in 14 (19.2%). Nine aneurysms required more than one coiling session to complete treatment; 8 of these aneurysms required two sessions and 1 required four, for a total of 84 endovascular procedures. Follow-up angiograms could be obtained in 49 patients with 52 paraclinoid aneurysms. During the follow-up period, 6 aneurysms demonstrating partial occlusion and 3 demonstrating near-complete occlusion showed spontaneous progression of thrombosis to complete occlusion. Twelve aneurysms initially demonstrating complete occlusion (5 aneurysms), near-complete occlusion (3 aneurysms), or partial occlusion (4 aneurysms) showed coil compaction requiring retreatment **(61).**

PRESENTATION, COMPLICATIONS AND CLINICAL OUTCOME :

Vinuela et al made a prospective study of 403 patients presenting with acute subarachnoid hemorrhage in whom GDC embolization was done within 15 days of bleed. Three hundred and forty two patients (84.9%) improved or remained neurologically unchanged, 36 (8.9%) experienced postembolization clinical deterioration, and 25 (6.2%) died within 1 week of the GDC procedure.

Out of the 25 deaths, 7 were related to GDC technical complications and 18 were associated with the severity of the initial SAH.

On the basis of aneurysm location, there were 8.1% morbidity and 6.4% mortality rates in anterior circulation aneurysms and 9.6% morbidity and 6.1% mortality rates in posterior circulation aneurysms. Good clinical outcome with improvement or same neurological status as on presentation was seen in 76/82 (92.7%) cases with Hunt and Hess grade 1 SAH, 96/105 (91.4%) cases with Hunt and Hess grade 2 SAH, 101/121 (83.5%) cases with Hunt and Hess grade 3 SAH, 55/69 (79.7%) cases with Hunt and Hess grade 4 SAH, and 14/26 (53.8%) cases with Hunt and Hess grade 5 SAH **(34).**

Raymond et al prospectively studied 31 patients of Basilar bifurcation aneurysms who underwent endovascular coil occlusion, of which 8 were incidentally detected aneurysms and 23 presented with subarachnoid hemorrhage.

In patients presenting with SAH, Glasgow outcome score of 1 was seen in 18 patients, GOS 2,3 and 4 in 1 patient each and GOS 5 in 2 patients. One patient died during the procedure with one developing permanent neurological deficit.

In incidentally detected basilar aneurysms treated with GDC coils, all had good clinical outcome **(49).**

Malisch et al evaluated midterm clinical outcome (follow up period >=2 years) in 61 patients who underwent GDC coiling as a definitive treatment. The results were classified as excellent in 46 patients (75%), good in 7 patients (11%), fair in 3 patients (5%), poor in 1 patient (2%) or dead in 4 patients (7%). The midterm post GDC coiling rebleeding rate was 0% for small aneurysms, 4% (1 case) for large aneurysms, and 33% (5 cases) for giant aneurysms. Of the 9 patients presenting with severe SAH (Hunt and Hess grade 4/5) treated in acute stage, 7 died, one had a poor midterm clinical outcome and one had a fair outcome. Patients whose aneurysms were incidentally detected (20 patients) had the greatest chance (100%) of having an excellent or good outcome. Patients presenting with grade 1 / 2 had a 91% chance of having an excellent or good midterm clinical outcome (29 of 32 patients). Patients presenting with grade 3 SAH had an 86% chance of having an excellent or good clinical outcome,(6 of 7 patients). Patients presenting with mass effect from their aneurysms had a 63% chance of an excellent or good midterm clinical outcome (12 of 19 patients).The clinical symptoms were found to improve in 53% patients , remain unchanged in 26%patients and worsen in 21% patients. The mass effect on cranial nerves is more likely to improve (67%) than the mass effect on the brain parenchyma (40%) **(62).**

A prospective evaluation of 182 patients with 203 aneurysms was done over a 3 year period by Cognard et al. Long term clinical outcome was excellent/good (Glasgow outcome scale1/2) in 13/13 cases with Hunt - Hess grade 0 SAH, 70/76 cases with Hunt - Hess grade 1 SAH, 12/17 cases with Hunt - Hess grade 2 SAH, 7/11 cases with Hunt - Hess grade 3 SAH and 3/3 cases with Hunt - Hess grade 4/5 SAH. In case of unruptured aneurysms, the long-term clinical outcome was excellent/good in 42/47 cases of coiled aneurysms (32).

Eskridge et al reviewed the results of 150 patients with basilar tip aneurysms (ruptured - 83, unruptured – 67) treated with GDC coils. In 75% cases >90% coil packing was achieved. Conservative mortality rates included up to 23% for the ruptured aneurysm group and up to 12% for the unruptured aneurysm group; the rebleeding rate for treated ruptured aneurysms was up to 3.3% and the bleeding rate for unruptured aneurysm was up to 4.1%. Permanent deficit due to stroke in patients with ruptured and unruptured aneurysms occurred in up to 5% and 9% respectively. Vasospasm occurred in 8% of cases. Periprocedural mortality was 2.7%, all occurring in ruptured aneurysms (51).

Bavinzski et al studied endovascular treatment of cavernous ICA aneurysms in 42 patients with 48 aneurysms. Ophthalmoplegia resolved or improved in nine of 12 patients treated with parent artery occlusion. One thromboembolic stroke and three transient ischemic attacks occurred perioperatively, for a permanent morbidity of 3.5% and a transient morbidity of 9%. There was no mortality. Mean clinical follow-up was 33 months (58).

Kuether et al treated 77 aneurysms over a period of 4.5 years. The average clinical follow-up period was 2.2 years. For unruptured aneurysms, 85% of patients returned to independent status. Of patients of Hunt and Hess Grade I/II status, 81% were independent; of patients of Grade III status, 100% were independent; and, of patients of Grade IV/V status, 50% were independent. The procedure-related morbidity rate was 9.1%, with a 7.8% risk of death from aneurysm perforation, stroke, or delayed hemorrhage. No completely occluded aneurysm hemorrhaged after GDC treatment (follow-up period, 1.9 yr). Of near complete occlusions, 2.6% hemorrhaged after embolization, at a rate of 1.4%/yr (follow-up period, 1.9 yr). Of the 26% of patients presenting with symptoms of mass effects, 35% experienced complete resolution of their symptoms, whereas an additional 40% experienced improvement in mass effect symptoms. Of patients of Hunt and Hess Grade I or II status, 80% recovered to independent status. The outcome for the five patients of Grade III status was even better, with 100% showing good clinical results. Of patients of Grade IV or V status, 50% recovered to independent status **(37).**

Gruber et al evaluated 30 patients with 31 giant or very large aneurysms were considered to show unacceptable risk/benefit ratios for open surgery and were treated using the Guglielmi detachable coil (GDC) method. About 73.3% of the patients experienced excellent to good recoveries (Glasgow Outcome Scale scores of 4 or 5), with a 13.3% procedure-related morbidity rate and a 6.7% procedure-related mortality rate. Two hemorrhaging episodes occurred after GDC treatment (annual bleeding rate - 2.5%). Symptoms related to aneurysmal mass effect were improved for 45.5% of the patients presenting with signs of neural compression (40).

Bavinzski et al retrospectively reviewed 45 Basilar top aneurysms treated using GDC coils. Good to excellent clinical result was obtained in 33/45 patients, poor result being seen in 12 patients. The mortality and permanent morbidity rates directly related to the intervention were 2.2% and 4.4% respectively (41).

Kremer et al compared outcome in anterior and posterior circulation aneurysms presenting with Hunt and Hess grade 4 and 5 SAH. Forty poor-grade patients admitted between 1993 and July 1998 were treated by endovascular approach within 23 days after aneurysm rupture. Eighteen had aneurysms in the Anterior Circulation, 22 in the Posterior circulation. Mean treatment delay was 4 days after rupture and median, 2 days. One patient showed multiple aneurysms. In 36 cases, aneurysms were occluded by Guglielmi detachable coils; in 4 cases, by parent vessel balloon occlusion. Given comparable incidence of vasospasm in poor-grade patients, a tendency toward better treatment outcome was found in patients with aneurysms in the posterior circulation than in the anterior circulation (59).

A retrospective analysis of 112 cases of ruptured posterior circulation aneurysms treated using GDC coils over a period of 7 years was done by Lempert et al. Excellent clinical outcome (Glasgow outcome scale=1) was seen in 100% patients with Hunt and Hess grade1 at presentation, 88% with Hunt and Hess grade 2, 78% with Hunt and Hess grade 3, 46% with Hunt and Hess grade 4.Overall, at latest follow up, 74% patients showed good recovery (GOS 1), 9% had moderate disability (GOS 2), 5% were permanently disabled (GOS 3), 1% were vegetative (GOS 4) and 11% were dead.

Rebleeding was seen in 1 patient (0.9%) with 90% embolization on follow up .A permanent morbidity rate of 2.8% was reported **(43).**

The ISAT group enrolled 2143 patients with ruptured intracranial aneurysms and randomly assigned them to neurosurgical clipping (1070) or endovascular treatment by detachable platinum coils (1073). Clinical outcomes were assessed at 2months and at 1 year with interim ascertainment of rebleeds and death. Out of the 801patients allocated endovascular treatment, 190 (23.7%) were dependent or dead at 1 year compared with 243 of 793(30.6%) allocated neurosurgical treatment. The relative and absolute risk reduction in dependency or death after allocation to an endovascular versus neurosurgical treatment were 22.6% (95%CI 8.9-34.2) and 6.9% (2.5-11.3), respectively.

The risk for rebleeding after 1 year was 2/1276 and 0/1081 patient years for patient allocated endovascular and neurosurgical treatment, respectively.

At 1 year follow up, 76.3% of endovascularly treated aneurysms showed good clinical outcome compared to 69.4% of surgically treated aneurysms **(63).**

Johannes et al prospectively studied 11 consecutive patients who presented with acutely ruptured aneurysms and were in very poor neurological condition after resuscitation (World Federation of Neurosurgical Societies Grade V) but did not have a significant intracerebral hemorrhage. These patients received endovascular treatment with Guglielmi detachable coils. Two patients (18%) died because of uncontrollable intracranial pressure 5 and 7 days after the hemorrhage, respectively. Two patients had early rebleeding after the coiling and required further treatment. The mean follow-up time of the surviving patients was 18 months (range, 12-23 mo). There was no difference in outcome according to the Glasgow Outcome Scale at 6 months and at latest follow-up. Six patients (55%) had favorable outcomes, and five patients (45%) had unfavorable outcomes **(64).**

During 6 years, 29 patients with 31 very large or giant (20–55-mm) cerebral aneurysms were initially treated with detachable coils by Sluzewski et al. Twenty-three (79%) of 29 patients had a good clinical outcome at a median follow-up of 50 months. In four (50%) of eight patients, symptoms of mass effect improved after coiling.(47).

Friedman et al retrospectively analyzed 83 patients with GDC coil embolization over a period of 10 years. Sixty four patients (77%) had a Glasgow outcome scale of 4-5,9 (11%) had a score of 2-3, and 10 (12%) died. Over all, each GDC occlusion procedure was accompanied with a mortality rate of 0.8%, a permanent neurologic morbidity rate of 0.8%, and a temporary or non-neurologic morbidity rate of 11.6%.

No patient with aneurysm coiling had rebleeding during the follow up period suggesting that the degree of aneurysm occlusion may not be an important factor in preventing rebleeding in the short term **(46).**

Weir et al retrospectively reviewed records of 27 consecutive Hunt and Hess grade 4/5 patients with 29 aneurysms treated within 72 hours of SAH using GDC system. No rebleeding occurred in any patient over a follow up period of 6-44 months. Sixteen patients (59%) died within 30 days of SAH with good clinical outcome seen in 8 patients (30%). At the time of coiling, 25/27 (92%) patients had vasospasm, and 7 required endovascular treatment because of worsening clinical status. Although the morbidity and mortality rates are still high, grade 4/5 patients can successfully undergo coil embolization despite their poor medical condition and a high frequency of vasospasm at the time of treatment **(65).**

Park et al performed a retrospective review of 70 patients with 73 paraclinoid aneurysms (8 ruptured, 65 unruptured) over a period of 9 years. The final clinical outcomes demonstrated a GOS score of 5 (good recovery) in 56 patients (88.9%), a GOS score of 4 (moderate disability) in 2 (3.2%), and a GOS score of 3 (severe disability) in 1 (1.6%). Morbidity and mortality rates related to 84 endovascular procedures were 8.3 and 0%, respectively. There were no recurrent or new subarachnoid hemorrhages in 63 patients in whom clinical follow-up could be performed during a mean clinical follow-up period of 14.4 months (61).

A total of 4060 patients with unruptured intracranial aneurysms were assessed by the International study of unruptured intracranial aneurysms trial - 1692 did not opt for aneurysm repair, 1917 had open surgery, and 451 had endovascular repair. Cumulative 5 year rupture rates for anterior circulation were 0%, 2.6%, 14.5% and 40% for aneurysm sizes<7mm, 7-12mm, 13-24mm and >=25mm respectively. The cumulative 5-year rupture rates for posterior circulation aneurysms were 2.5%, 14.5%, 18.4% and 50% respectively for the same size categories. These rates were often equaled or exceeded by the risks associated with surgical or endovascular repair of comparable lesions. A morbidity and mortality rate of 9.1 and 9.5% in the group of aneurysms subjected to endovascular repair was seen which seems favorable for older patients since the endovascular results are not dependent on the age of the patient. However, data about long term follow up of embolized aneurysms is needed **(66).**

Henke et al retrospectively reviewed 1811 intracranial aneurysms in 1579 patients treated with coil occlusion. Of these 90-100% occlusion of 86.5% of aneurysms was achieved. The clinical outcome profile at primary discharge according to Glasgow outcome scale was as follows: grade 1 - 74.6%, grade 2 - 6.7%, Grade 3 - 11.1%, grade 4 - 3.1% and grade 5 - 4.5%.

The occlusion rate (90-100%) was 83.4% for unruptured aneurysms (777), and was 88.9% for ruptured aneurysms (1034) in the series.

Patients with Hunt and Hess grade 1,2 and 3 had occlusion rates of 90-100% in 93.1% cases, whereas only 85.7% patients with Hunt and Hess grade 4 and 5 had 90-100% occlusion rates.

The ischemic complication rate was 9%, and the hemorrhagic complication rate was 3%. The early procedural morbidity rate was 5.3%, and the procedural mortality rate was 1.5%. The management mortality rate was 4.4% **(67).**

OUTCOME IN SPECIAL GROUPS:

Sedat et al treated 52 patients in the age range of 65-85 years over a 6-year period. A comparison was also made with 143 patients <65 years old treated with endovascular techniques during the same period.

In elderly patients, the outcome was favorable in 48% of patients with a mortality rate of 23%. Patients with lesion >=10mm had an unfavorable outcome in 77% cases. Patients with Hunt and Hess grade 1/ 2 had a favorable outcome in 77% cases where as the outcome was favorable in only 16% cases with Hunt and Hess grade 4/5 on presentation. Angiographic complete occlusions was achieved in 48.5% cases and >=95% occlusion in 8% cases. Coil compaction was seen in 4 patients (7.5%) patients. Rebleed was not seen in any patient post embolization. Thromboembolic complications were 13% in elderly patients compared to <4% in young patients. Patients with high clinical grade at presentation fared poorly in elderly population with favorable outcome in only 16% cases as compared to 41% cases in younger subgroup **(68).**

Lubicz et al reviewed 68 patients with SAH in the age range of 65-80 years were treated with endovascular methods. Endovascular occlusion resulted in complete occlusion in 47/68 (69%), neck remnant in 15/68 (22%) and incomplete occlusion in 6/68 (9%) of patients. Thromboembolic complications were seen in 8/68 (9%) of patients. Outcome was good/excellent in 40/68 (59%) patients, and a fair or poor clinical outcome in 14/68 (20.5%) patients. Patients with Hunt and Hess grade 4/5 treated within 72 hours of presentation had a poor outcome or death in 79% cases (15/19). The remaining 4 patients with Hunt and Hess grade 4/5 treated after 3-6 weeks had good recovery (69).

ASSISTED COILING OF INTRACRANIAL ANEURYSMS :

Moret et al pioneered the balloon remodeling technique for wide necked intracranial aneurysms with long term angiographic and clinical results in 56 patients of intracranial aneurysms. Thirty-seven (70%) of the patients presented with subarachnoid hemorrhage. Twenty-five (45%) of the aneurysms were located at the vertebrobasilar artery, 24 (43%) at the internal carotid artery, and seven at the level of smaller arteries. Final results (i.e. the last follow-up angiography or results at the end of the treatment for the cases that have not yet had follow-up) consisted of total occlusion in 40 cases (77%), sub-total occlusion in nine cases (17%), and incomplete occlusion in three cases (6%). Rupture of the aneurysmal sac occurred during the procedure in three cases, all of which were asymptomatic in the follow-up. Thus, morbidity due to the technique was 1/52 (0.5%) and mortality was 0/56 patients (89).

Levy et al presented two cases of ophthalmic artery aneurysms that would not hold the Guglielmi detachable coils on the initial attempt. One aneurysm was 7 mm and one 4 mm, both with wide necks relative to the aneurysm sac. By using a balloon-assisted technique and blocking the parent artery with a nondetachable balloon, the coils could be safely placed in these aneurysms without herniation when the balloon was deflated. Both patients exhibited embolic symptoms after the procedure, one with a mild but permanent deficit **(70).**

Debrun et al presented a retrospective analysis of 144 patients with 144 cerebral aneurysms that were treated by endovascular technique at the University of Illinois Hospital at Chicago. Balloon remodeling technique was used in 15 patients with a complete occlusion rate of 80% and thromboembolic events in 3 patients (36).

In a study by Lefkowitz et al, Balloon-assisted Guglielmi Detachable Coiling was done for 23 patients of wide necked aneurysms of which 57% were large in size. Complete (100%) aneurysm embolization was achieved in 19 patients (83%), and 95 to 100% embolization was achieved in 4 patients (17%). Twenty-two patients (96%) were at their preprocedural neurological baseline after the procedure. There were three complications in the study, 2 developing a procedure related thromboembolic event and 1 developing a delayed vasospasm following SAH. No patient required additional treatment or developed a recurrent aneurysm neck or lumen over a 10-month follow up period **(71).**

Eight hundred and eighteen patients harboring 916 aneurysms were treated with GDC coils over a period of 11 years by Murayama et al. Balloon assisted coiling was done in 49 patients with greatest benefit in small aneurysms with wide neck showing 60% complete occlusion rate as compared to 41.2% without the balloon assisted technique. The overall recanalization rate with the GDC system improved from 26.1% to 17.2% after the introduction of soft coils, 3D coils and balloon-assisted technique (45).

During a 5-month period, 19 patients with 22 aneurysms were treated with Neuroform stent by Fiorella et al. Twenty-five stents were deployed. Five patients had multiple stents placed. Five patients had ruptured aneurysms at the time of treatment. The indications for use were broad-necked aneurysms (n = 13; average neck length, 5.1 mm; average aneurysm size, 9 mm), fusiform or dissecting aneurysms (n = 3), salvage and/or bailout (n = 1), and giant aneurysms (n = 2). Technical problems included difficulty in deploying the stent (n = 6), inability to deploy the stent (n = 1), stent displacement (n = 2), inadvertent stent deployment (n = 1), and coil stretching (n = 1). Twenty-one of the 22 aneurysms were treated. Four aneurysms were stented without additional treatment, and 17 aneurysms were stented and coiled. Of the coiled aneurysms, complete or nearly complete (more than 95%) occlusion was achieved in 6 aneurysms, and partial occlusion was achieved in 11. Two clinically significant adverse events occurred, both of which were sequelae of Periprocedural thromboembolic complications. One patient died after thrombolysis was attempted. The other patient made an excellent functional recovery after undergoing successful thrombolysis of a thrombosed basilar artery stent **(72).**

Henke et al retrospectively reviewed 1811 intracranial aneurysms in 1579 patients treated with coil occlusion. The use of 3D and fibered coils resulted in a higher occlusion rate. Balloon remodeling and stent deployment resulted in an increase in complication rate. Stent deployment was done in 39 cases with 90-100% occlusion in 69.2% cases and complications in 35.9% cases. Balloon remodeling was used in 26 cases with 90-100% occlusion in 61.5% cases and complications in 38.5% cases. 3D coil was used in 502 cases with 90-100% occlusion achieved in 69.9% cases and a low complication rate of 18.7%. The author used Trispan device in 49 cases with occlusion rate of 90-100% in only 28.6% cases and complication rate of 12.2% **(67)**.

Fifty-six patients were identified as having wide-necked intracranial aneurysms suitable for stent-assisted coiling by Benitez et al. A total of 49 aneurysms in 48 patients were treated with this procedure. In eight cases, stent deployment failed. Forty-one of the aneurysms were initially stented, followed by coil placement. Six aneurysms were stented only, and one aneurysm was initially coiled, followed by stent placement. Total (100%) occlusion was achieved in 28 cases, 99% occlusion in 7 cases, > 90% occlusion in 4 cases, < 90% occlusion in 3 cases, and 0% occlusion in 6 cases. The majority of the patients had an acute occlusion rate of 99 to 100%. There were five deaths (8.9%), one of which occurred secondary to a stroke after the procedure (1.8%). Four patients (7%) experienced thromboembolic events, three of which were considered to have been secondary to the procedure (5.3%). In addition, there were two femoral pseudoaneurysms. The overall complication rate was 10.7% **(73).**

ALTERNATE IMAGING MODALITIES FOR FOLLOW UP IMAGING OF INTRACRANIAL ANEURYSMS :

Sixty-eight consecutive patients with intracranial aneurysms were included in the prospective study comparing DSA and contrast enhanced MRA done by Boulin et al. Eighty DSA and CEMRA was obtained and good concordance was seen in 72 cases with discordance in 8 cases. MRA missed 7 cases of aneurysms <3mm in size whereas 1 case of small aneurysm was picked by MRA which was misinterpreted as loop by DSA. The author concludes that MRA is satisfactory for detection of aneurysms remnant >3mm in size and can be considered an option for follow up imaging of coiled intracranial aneurysms **(74).**

Fifty-eight patients with 71 cerebral aneurysms previously treated with GDCs were evaluated by Cottier et al with and without contrast enhanced MRA and compared with DSA for detection and characterization of aneurysm residues.

Residual aneurysms were revealed in 36 DSA studies (51%). Six minor remnant necks (≤ 3 mm) were not detected with either 3D TOF MR angiography or contrast-enhanced 3D TOF MR angiography, whereas all aneurysm remnants detected with MR angiography were seen with DSA. The addition of contrast material at 3D TOF MR angiography did not improve the ability of MR angiography in depicting a residual neck. Thus, the sensitivity of MR angiography compared with DSA was 83%, specificity 100%, positive predictive value 100%, and the negative predictive value 85% for depicting an aneurysm remnant. In two cases, both 3D TOF MR angiography and contrast-enhanced 3D TOF MR angiography depicted residual flow in the aneurysms, but underestimated the remnant size in comparison with findings at DSA **(75).**

Schuknecht et al evaluated the ability of transcranial color-coded Doppler sonography to 1) Identify Guglielmi detachable coils (GDCs) within intracranial aneurysms, 2) Show endovascular aneurysmal occlusion and patency of parent and branch arteries, 3) Determine the flow velocities within parent arteries and major branches before and after treatment, and 4) Assess persistence of aneurysmal occlusion. 43 aneurysms in 40 patients

GDC coils were identified in 41/43 aneurysms with lack of intraaneurysmal flow detected in 42/43 aneurysms. Patency of the parent artery and of the branches was shown in 40 /43 and 42/43 cases respectively. Follow-up TCCD showed the coils to be unchanged in 23/26 cases with recanalization and reappearance of a flow signal separate from the parent artery seen in 3 large aneurysms. The conclusion of the study was that TCCD is a reliable, noninvasive means to assess parent artery and major branch patency and to reveal a lack of hemodynamic compromise in the vicinity of aneurysms after endovascular therapy. On follow-up examinations, TCCD was able to detect signs of aneurysmal recanalization in large aneurysms **(76).**

Turner et al evaluated the sensitivity and specificity of transcranial color-coded duplex sonography (TCCS) and the effect of an Ultrasonographic contrast agent in the long-term surveillance of intracranial aneurysms treated with Guglielmi detachable coils. Overall, 34/46 aneurysms were evaluated with contrast agent Levovist and 12/46 aneurysms were evaluated without the use of contrast. TCCD was able to correctly identify19/20 aneurysms with complete occlusion (sensitivity, 95%; specificity, 84%). It also correctly identified all 16 of the aneurysms with moderate to gross residue as visualized on DSA and 5 aneurysms only after contrast enhancement (sensitivity, 100%; specificity, 97%). Only 4/10 aneurysms with minor residue could be correctly identified with Contrast enhanced TCCD. The study indicates that contrast enhanced TCCD is a good imaging tool for detection and follow up of medium to large sized aneurysm residues **(77).**

AIMS AND OBJECTIVES :

PRIMARY OBJECTIVE:

To evaluate the factors affecting immediate and long-term radiological and clinical outcomes in endovascularly treated intracranial aneurysms.

SECONDARY OBJECTIVE:

To study the natural history of endovascularly treated intracranial aneurysms.

To compare the clinical presentation of aneurysm with the angiographic and clinical outcome.

MATERIALS AND METHODS:

A total of 80 aneurysms in 78 patients were treated over a period of 18 years with the first case done on 15/05/1986 and the last case included in the study done on 07/07/04. These included 37 males and 41 females with age range from 7-72 years and a mean age of 47 years. Majority of the treated patients (66%) were in their fifth and sixth decades.

A complete detailed diagnostic cerebral angiography preceded the decision regarding aneurysm treatment in each case. In selected cases of complex anatomy, CT angiography was done.

The location of aneurysm in relation to the parent vessel was analyzed and aneurysms were categorized in terms of its anatomical location, geometric arrangement, size of the fundus and the neck and presence of thrombus within its lumen. The anatomical location of aneurysm in ICA territory was done according to the Bouthillier classification of ICA segments **(78)**.. In terms of geometry the aneurysm was classified into truncal, sidewall, bifurcation and terminal. In terms of the size the aneurysms were classified as small (<10mm), large (10-25mm) and giant (>25mm) **(34,37,40,41)**. The neck was classified as small<=4mm and large>4mm **(33,34,42,45).** The size of the aneurysm was calculated using a precalibrated metal ball kept on the skull vault on the side of the aneurysm. The presence of vasospasm in cases of subarachnoid hemorrhage was evaluated. In case of multiple aneurysms, correlation between the location of SAH on CT and aneurysm morphology was used to pinpoint the bled aneurysm. The neck vessels were evaluated for the presence of atherosclerotic changes and patency. The presence of associated lesions like AVM, tumor etc was also looked for.

Before taking for endovascular treatment, the neurologist did a detailed neurological evaluation of each case. In cases of subarachnoid hemorrhage an initial classification of patients according to Hunt and Hess classification (79) and Glasgow outcome scale (80) was also done as follows:

HUNT AND HESS SCALE:

1 - no symptoms or minimal headache and slight nuchal rigidity

2 - moderate to severe headache, nuchal rigidity, and no neurologic deficit other than cranial nerve deficit

3 - drowsiness, confusion or mild focal neurologic deficit

4 - stupor, moderate to severe hemiparesis, possible decerebrate rigidity and vegetative disturbances

5 - deep coma, decerebrate rigidity and moribund appearance

GLASGOW OUTCOME SCALE:

1 - good recovery with resumption of normal activity

2 - moderate disability but independent

3 - severely disabled but conscious but dependent on others for support

4 - persistent vegetative state

5 - death

In aneurysms presenting with mass effect a detailed evaluation of their clinical deficit was performed and documented. A team of closely consulting neuroradiologist, neurologist and neurosurgeons did decision regarding the most appropriate form of treatment in individual cases. The patient and close family members of the patient were explained about the different treatment modalities available and the advantages and disadvantages of each of them. An informed consent was obtained from the patient after explaining the risks of endovascular procedure.

Depending on the morphology and location of the aneurysms, decision regarding parent artery occlusion or selective aneurysm coiling was undertaken. In cases where parent artery occlusion was planned, a temporary balloon occlusion test was carried out to evaluate the cross circulation across the circle of Willis and to predict post permanent occlusion deficits. After inflating the temporary occlusion balloon in cervical ICA in a heparinized patient, Repeated neurological testing was carried out every 5 minutes to look for any deficits for a minimum period of 20-30 minutes. A hypotensive challenge after lowering the blood pressure by 30% of baseline blood pressure was also done in few cases for duration of 10-15 minutes. The various material used for parent artery occlusion was as follows :

Material used	No. of cases
Balloons	9
Coils	13
Coils + balloons	5
Coils + glue	1
Glue	1
Total	29

The various balloons used for permanent occlusion of major vessels are as follows: Gold valve balloon, Balt Ingenor balloons and Gold Balt balloon. The various coils used were the Guglielmi Detachable coils (GDC-10 and/orGDC-18; Target therapeutics), mechanically detachable coils (Detach-11 and/or Detach-18), and fibered Platinum coils. N-butyl Cyanoacrylate was used in 2 cases.

Endovascular coiling was done under GA in each case. With a modified Seldinger technique, arterial sheaths were placed in both the Femoral arteries. A baseline activated clotting time (ACT) was obtained and before coil embolization intravenous Heparin was given at the dose of 50-100IU/kg body weight to obtain an ACT between 2-2.5 times of baseline. The ACT was subsequently repeated every 20-30 minutes and the Heparin doses adjusted accordingly. Diagnostic study was repeated and optimal radiographic projection depicting the neck of the aneurysm obtained. The diagnostic catheter was exchanged for a guiding catheter and a microcatheter was introduced carefully into the aneurysm sac in working projection under roadmap. A micro wire was needed in selected cases. In cases of unfavorable anatomy additional techniques like balloon remodeling was done in 6 cases with stent remodeling done in 1case. The various coils used were as follows:

Coils	No. Of cases
GDC	43
Cook	5
Cook + GDC	2
GDC + Hilal	1
Total	51

The detachable coils used were Guglielmi Detachable coils (GDC-10 and/orGDC-18; Target therapeutics) and mechanically detachable coils (Detach-11 and/or Detach-18). The aim of coil placement was to pack the aneurysm as densely as possible, until not one more coil could be safely placed without protruding in the parent vessel. All vital parameters of the patient were monitored during and after the procedure. The details of the procedure were noted down in the patient Performa. A detailed neurological examination of the patient was done after coming out of anesthesia. The initial degree of occlusion is defined angiographically as 100% minus the amount of residual aneurysm filling. The outcome was broadly categorized as follows **(67)**:

100% - complete filling of the aneurysm or parent artery occlusion.

90-99% - minor neck remnant or residual aneurysm base perfusion.

<90% - major neck remnant or residual perfusion between coils

<70% - >half of the aneurysm sac is filled with coils; however perfusion of aneurysm fundus remains.

<50% - <half of the aneurysm sac is filled with coils

Failed endovascular attempt.

Morphological results was also classified as:

1. Complete obliteration
2. Dog ear
3. Residual neck
4. Residual aneurysm

The degree of luminal packing was subjectively noted on a scale of 0-6, Follow up angiograms were compared with immediate post procedure angiograms and then assigned to one of the three categories **(69)**:

1) Further thrombosis, when the amount of contrast agent filing the aneurysm decreased.

2) Unchanged, when a similar degree of aneurysm occlusion was found on multiple projections.

3) Recanalization, when the amount of contrast material filling the aneurysm increased.

A detailed evaluation of cerebral circulation was also done at follow up. The areas where special attention was given were the collateralization in case of parent artery occlusion and status of normal artery arising close to the aneurysm in case of aneurysm coiling.

with occlusion of the fundus, body, and neck of the aneurysm earning 0-2 units each (0=no coils or a single loop, 1= loose packing with contrast staining visible on angiography, and 2= tight packing without visible contrast staining) **(39).**

After the procedure, the patient was shifted to ICU and closely monitored for any change in neurological status or sudden alteration in hemodynamic state. In case of recently ruptured intracranial aneurysms triple H therapy was aggressively implemented in cases of vasospasm along with Nimodepine for a period of 3 weeks after bleed. The clinical outcome of patient immediately as well as on follow up was evaluated using the Glasgow outcome.

A detailed neurological examination was done for the patient on follow up at an interval of 3 months for the first year and thereafter yearly in uncomplicated cases. The patient's disability status was also noted down as per the Glasgow outcome scale and noted in the Performa.

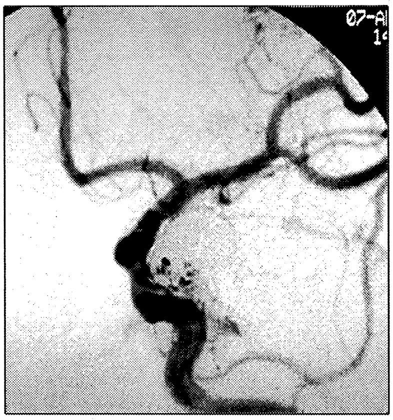
Follow up angiograms were done after a minimum period of 1-6 months. It is of critical importance to exactly repeat the optimal view for aneurysm observation in follow-up angiograms, for consistency in the assessment of occlusion rates. In cases of complete occlusion no further angiograms were done. In cases with residual neck/residual aneurysm yearly follow up was done using either conventional angiography or TCCD, CT angiography or MR angiography.

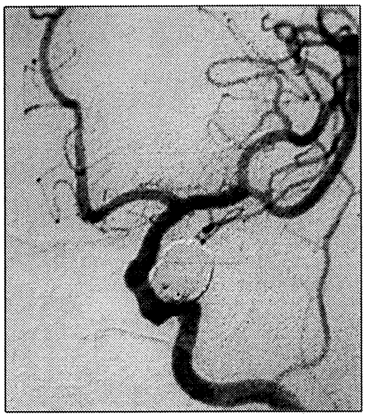
The degree of occlusion on follow up, defined angiographically as 100% minus the amount of residual aneurysm filling was noted. Morphological results and degree of luminal packing was again noted on follow up angiography.

CAVERNOUS ICA ANEURYSM

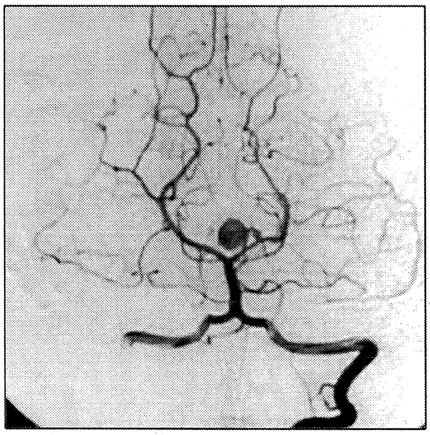
DOG EAR AND SPARSE FILLING ON IMMEDIATE POSTPROCEDURE ANGIOGRAM

COMPLETE OCCLUSION ON FOLLOW UP ANGIOGRAM

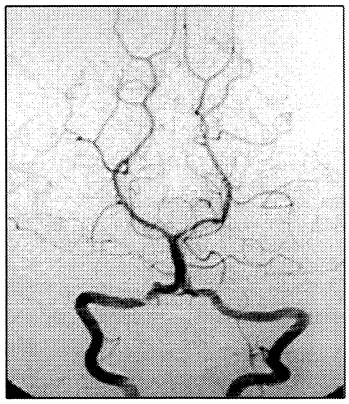


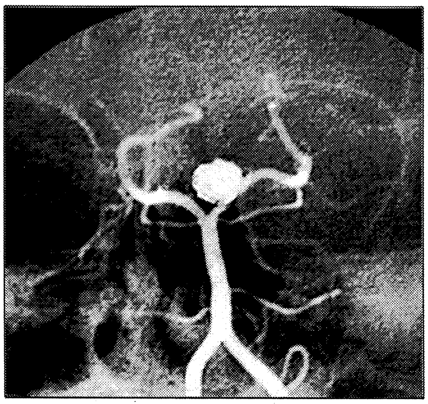


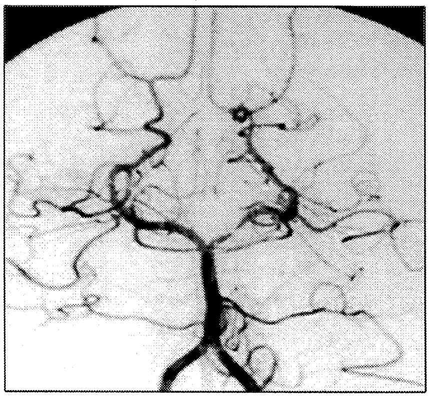
LEFT P1 SEGMENT ANEURYSM WITH COMPLETE OCCLUSION



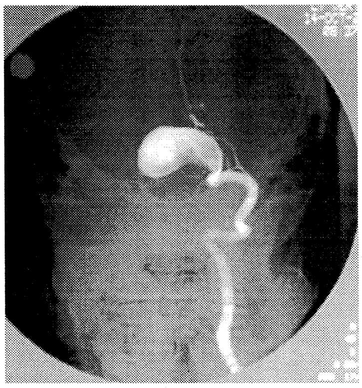
COMPLETE OCCLUSION ON FOLLOW UP



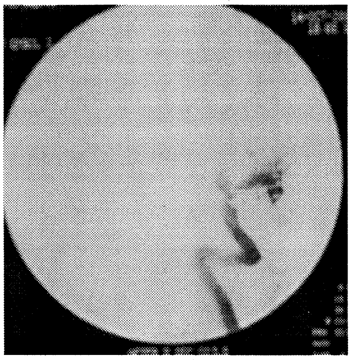


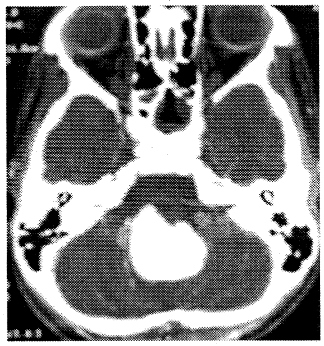


FUSISACCULAR LEFT VERTEBRAL ANEURYSM

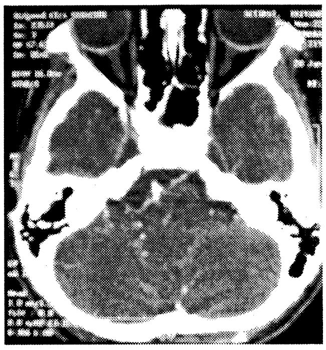


PARENT ARTERY OCCLUSION

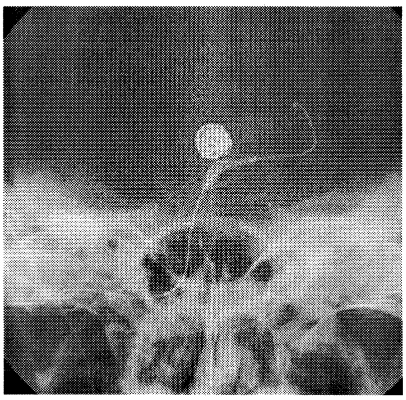




FOLLOW UP CTA –COMPLETE OCCLUSION

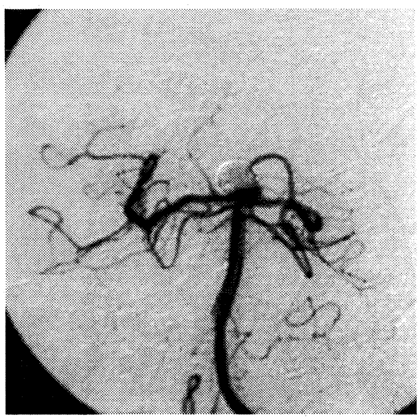


COMPLETE OCCLUSION USING REMODELLING



BASILAR TOP ANEURYSM

RESIDUAL NECK ON FOLLOW UP



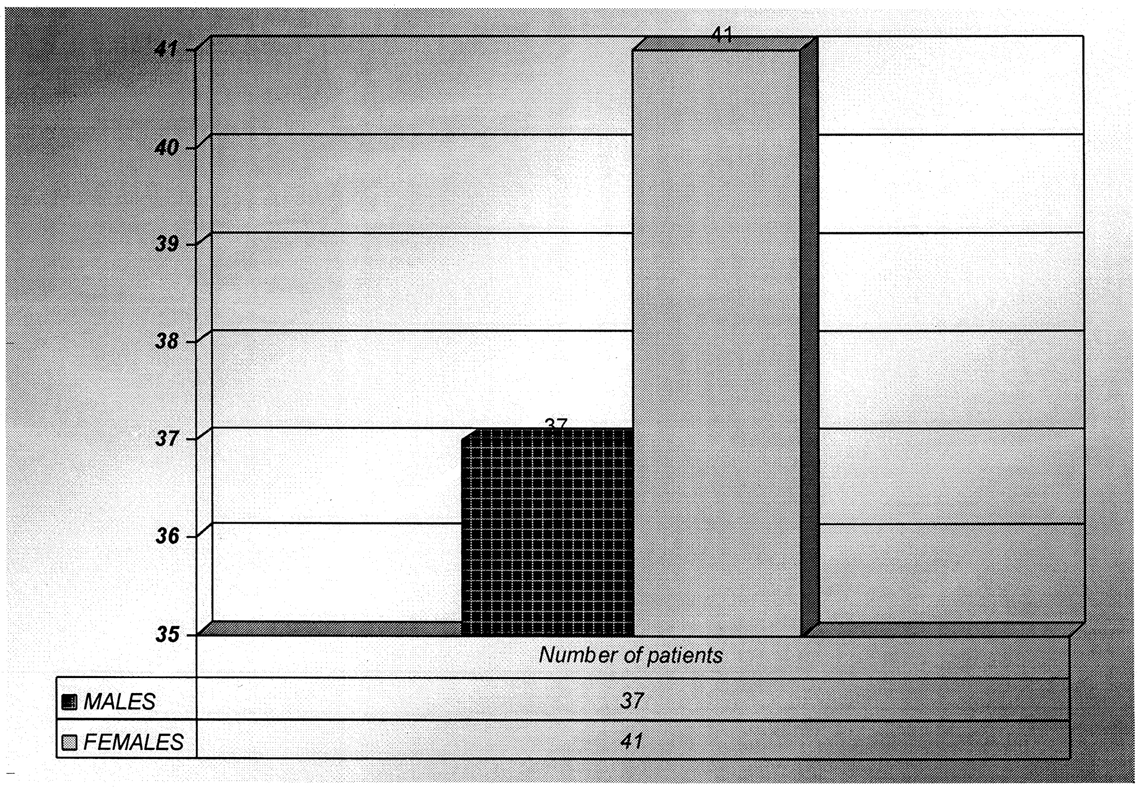
RESULTS

A total of 80 aneurysms in 78 patients were treated over a period of 18 years with the first case done on 15/05/1986 and the last case included in the study done on 07/07/04.

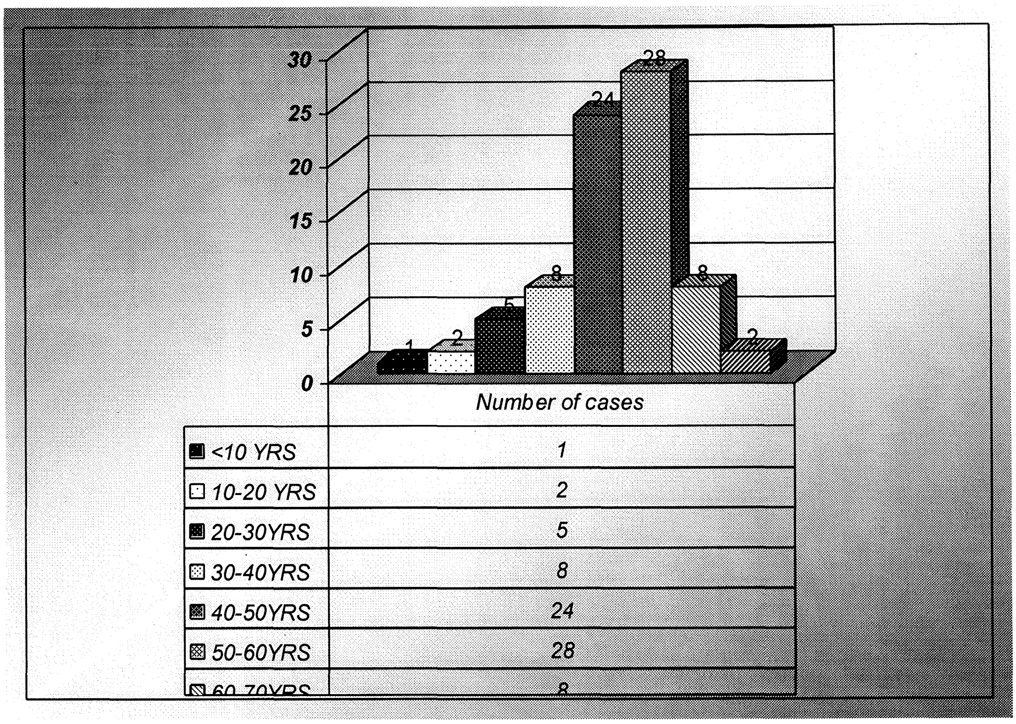
Table 1: Sexwise Distribution Of Aneurysms

TOTAL NO. OF PATIENTS	78
TOTAL NO. OF ANEURYSMS	96
TOTAL NO. OF TREATED ANEURYSMS	80

The Sexwise distribution of all the patients was as follows:



Patient age ranged from 7-72 years with a mean age of 47 years. The age distribution of the patients was as follows:



The aneurysms were also age wise classified in 2 major categories; patients with age <50 yrs and those with age >50 yrs. The immediate and long term clinical outcome of the patients was as follows:

Table 2: Relation Of Age And Clinical Outcome

AGE RANGE	NO.	GOS AT DISCHARGE			NO.	GOS AT FOLLOW UP		
<50yrs	40	1	25		25	1	23	
		2	5			2	2	
		3	2					
		4	1					
		5	7					
>=50yrs	38	1	28		24	1	20	
		2	3			2	3	
		3	1			4	1	
		4	2					
		5	4					

For patients with age<50 yrs the clinical outcome was good (Glasgow outcome scale 1&2) in 30/40 patients (75%) cases at discharge and in 25/25 (100%) cases available for long term clinical follow up. For patients with age >=50 yrs, the immediate clinical outcome was good in 31/38 cases (81%) with good outcome on long term follow up in 23/24 (95%) cases.

The clinical results were equally good for young and elderly patients.

The sidewise distribution of the Treated aneurysms was as follows:

Table 3 :Sidewise Distribution Of The Treated Aneurysms

SIDE	NO. OF ANEURYSMS
RIGHT	23
LEFT	33
BOTH	9
MIDLINE	14
TOTAL	80

The aneurysms were also grouped according to their geometry in relation to the parent artery as sidewall, bifurcation, terminal and truncal aneurysms. The distribution of the various aneurysms was as follows:

Table 4: Anatomical Classification Of Aneurysms

LOCATION	NO. OF ANEURYSMS
SIDEWALL	43
BIFURCATION	11
TERMINAL	13
TRUNCAL	13
TOTAL	80

The location wise distribution of the treated aneurysms was also classified as anterior-rising from carotid circulation and posterior-arising from the vertebrobasilar circulation. The distribution is as follows:

Table 5: Location Wise Distribution Of The Treated Aneurysms

LOCATION WISE DISTRIBUTION OF ANEURYSMS			
ANTERIOR CIRCULATION	52	COILING	34
		PAO	18
POSTERIOR CIRCULATION	28	COILING	17
		PAO	11

The specific location wise distribution of aneurysms was done as per the Bouthillier classification on intracranial aneurysms **(78).**

Table 6: Specific Locationwise Distribution Of Aneurysms

LOCATION WISE DISTRIBUTION OF ENDOVASCULARLY TREATED INTRACRANIAL ANEURYSMS			
LOCATION	**COILING**	**PAO**	**TOTAL**
ICA- CAVERNOUS SEGMENT	13	13	26
ICA- COMMUNICATING SEGMENT	6	1	7
ICA- OPHTHALMIC SEGMENT	5	1	6
ICA- LACERAL SEGMENT	0	1	1
ICA- PETROUS SEGMENT	0	2	2
ICA-MCA GRAFT	1	0	1
MCA BIFURCATION	3	0	3
A1-ACOM JUNCTION	6	0	6
VERTEBROBASILAR	1	5	6
BASILAR TOP	13	0	13
BASILAR TRUNK	0	2	2
PCA	3	4	7
TOTAL	**51**	**29**	**80**

Location wise, the largest individual group of aneurysms was the Cavernous segment aneurysms seen in 26/80 (32.5%) cases followed by the basilar bifurcation aneurysms in 13/80 (16.2%) cases. The cavernous segment aneurysms were equally distributed in the coiling and parent artery occlusion groups. The Basilar artery aneurysms were all selected for coiling.

The distribution of the cases of coiled aneurysms sparing the parent artery, according to their location and the relation with immediate angiographic and clinical outcome is as mentioned in the following table:

Table 7: Location Of Coiled Aneurysm And Immediate Outcome

LOCATION	**COILING**	**IMMEDIATE ANGIOGRAPHIC OUTCOME**	**GLASGOW OUTCOME SCALE AT DISCHARGE**
ICA- CAVERNOUS SEGMENT	13	100% 1 90-99% 9 <90% 1 <70% 2	1 11 2 1 3 1
ICA- COMMUNICATING SEGMENT	6	100% 2 90-99% 3 <90% 1	1 2 2 1 3 1 4 2
ICA- OPHTHALMIC SEGMENT	5	100% 1 90-99% 3 <90% 1	1 4 5 1
ICA-MCA GRAFT	1	100% 1	1 1
MCA BIFURCATION	3	100% 3	1 2 4 1
A1-ACOM JUNCTION	6	90-99% 6	1 3 4 1 5 2
BASILAR TOP	13	100% 6 90-99% 6 <90% 1	1 10 2 1 5 2
VERTEBROBASILAR	1	90-99% 1	1 1
BASILAR TRUNK	0		
PCA	3	100% 2 90-99% 1	1 1 5 1*
TOTAL	**51**	**100% 16 31%** **90-99% 29 56.8%** **<90% 4 7.8%** **<70% 2 3.9%**	**1 33 64%** **2 3 5.8%** **3 2 3.9%** **4 4 7.8%** **5 6 11.7%**

*1 patient with 2 aneurysms involving Bilateral PCA

The basilar top aneurysms showed a good angiographic outcome (90-100% packing) in 12/13 cases (92%). Immediate clinical outcome was also good in Basilar top aneurysms in 11/13 cases (84%) with 2 deaths occurring in the post procedural period, 1 following aneurysm rupture and other following a massive myocardial infarction due to comorbid ischemic heart disease.

The Cavernous ICA aneurysms that underwent coiling also showed good immediate angiographic (10/13-76%) and clinical results (92%) .The number of cases with residual aneurysms on immediate angiogram was also highest for the cavernous ICA group as compared to others.

The overall result of coiled aneurysm showed satisfactory (90-100%) occlusion in 45/51(88%) cases with satisfactory clinical outcome (GOS 1 & 2) in 36/51(69.8%) cases. The distribution of the cases parent artery occlusion for intracranial aneurysms according to their location and the relation with immediate angiographic and clinical outcome is as mentioned in the following table:

Table 8 : Relation Of Cases Of Parent Artery Occlusion And Immediate Outcome

LOCATION	NUMBER	IMMEDIATE ANGIOGRAPHIC OUTCOME			GLASGOW OUTCOME SCALE AT DISCHARGE		
ICA- CAVERNOUS SEGMENT	13/14*	CO	8		1	8	
		RF	5		2	3	
					3	2	
ICA- COMMUNICATING SEGMENT	1	CO	1		2	1	
ICA- OPHTHALMIC SEGMENT	1	CO	1		1	1	
ICA- LACERAL SEGMENT	1	CO	1		5	1	
ICA- PETROUS SEGMENT	2	CO	2		1	1	
					5	1	
VERTEBROBASILAR	5	CO	3		1	4	
		RF	2		5	1	
BASILAR TRUNK	2	CO	1		2	1	
		RF	1		4	1	
PCA	4	CO	4		1	4	
TOTAL	**29**	**CO**	**21**	**72.4 %**	**1**	**18**	**62 %**
		RF	**8**	**27.5 %**	**2**	**5**	**17 %**
					3	**2**	**6.8 %**
					4	**1**	**3.4 %**
					5	**3**	**10.3 %**

PAO was unsuccessful in 1 Cavernous ICA aneurysm.

In the largest group comprised by Cavernous ICA aneurysms, complete occlusion was achieved in 8/13 (61%) cases with residual filling on immediate angiogram in 5/13 (38%) cases. Excellent clinical and angiographic results were obtained in PCA aneurysms with complete occlusion achieved in 4/4 (100%) cases with GOS grade 1 at discharge.

CLINICAL PRESENTATION:

The cases of aneurysms were classified according to their status as ruptured and unruptured. The diagnosis of ruptured aneurysm was done on the basis of presence of SAH as detected by CT, MRI, LP or definite signs of meningism. In case of extradural-ruptured aneurysms the diagnosis was made on the basis of clinical signs and symptoms and angiographic appearance.

Table 9: Status Of Aneurysms At Presentation

PRESENTATION	NO. OF PATIENTS
RUPTURED	35
UNRUPTURED	39
POST PROCEDURE*	4
TOTAL	78

*The post procedure group included 2 cases with previous partial coiling done from a different center, 1 case of post clipping pseudoaneurysm and 1 case of aneurysm developing in a case of ICA-MCA bypass graft aneurysm.

The ruptured and unruptured aneurysms were almost equally distributed in our series with 35 and 37 cases respectively. No significant relation was found between the ruptured and unruptured groups in terms of immediate or follow up anatomical or clinical results.

The most common clinical presentation of intracranial aneurysms was headache seen in 56/78 cases. The frequency of the common clinical presentations in cases of intracranial aneurysms is as follows:

Table 10: Clinical Presentation At Presentation

CLINICAL PRESENTATION	**NUMBER OF PATIENTS**
HEADACHE	56
LOSS OF CONSCIOUSNESS	27
VOMITING	29
SEIZURES	6
CRANIAL NERVE DEFICITS	34
THROMBOEMBOLIC EPISODES	12
INCIDENTAL	6
WARNING LEAKS	11

Amongst the patients with ruptured intracranial aneurysms, subarachnoid hemorrhage was noted in 27/78 cases. No significant relation was found between the coiled case presenting with and without SAH and the anatomical outcome.

The only significant relationship was between the presence or absence of SAH and the immediate clinical outcome.

The frequency of the various comorbid conditions in patients suffering from intracranial aneurysms was as follows:

Table 11: Frequency Of Comorbid Conditions At Presentation

COMORBID CONDITION	NO. OF PATIENTS
Hypertension	26
Diabetes	8
Coronary artery disease	7
Operated Otitis media	2
Thyroid disorders	2
Congenital heart disease	1
Asthma	1
SLE, Rheumatoid arthritis	1
Intracranial AVM	2

The most frequent associated comorbid condition was hypertension in 26/78 patients followed by diabetes in 8/78 cases.

Table 12: Relation Between Sah At Presentation And Clinical Status At Discharge

SAH ON CT Vs GOS at DISCHARGE

Crosstab

			GOS AT DISCHARGE		Total
			.00	1.00	
SAHONCT	.00	Count	21	3	24
		% within SAHONCT	87.5%	12.5%	100.0%
	1.00	Count	15	12	27
		% within SAHONCT	55.6%	44.4%	100.0%
Total		Count	36	15	51
		% within SAHONCT	70.6%	29.4%	100.0%

Glasgow outcome scale of 1and 2 were considered as good outcome (0) and 3,4 and 5 considered as poor outcomes (1). A Pearson Chi-square test value of 0.013 was obtained suggestive of a statistically significant relation.

The distribution of the various patients according to their Hunt and Hess grading and the immediate Glasgow outcome status at discharge is presented in the following table:

Table 13: Relation Between Severity Of Sah And Clinical Outcome At Discharge

HUNT & HESS	NO. OF PATIENTS	GLASGOW OUTCOME SCALE	NO. OF PATIENTS
GRADE 1	15	1	12(80%)
		2	1(6.6%)
		3	1(6.6%)
		5	1(6.6%)
GRADE 2	5	4	3(60%)
		5	2(40%)
GRADE 3	7	1	3(42%)
		2	1(14.2%)
		4	1(14.2%)
		5	2(28.5%)
GRADE 4	0	0	
GRADE 5	0	0	
TOTAL	27	1	15
		2	2
		3	1
		4	4
		5	5

No patient belonging to Hunt and Hess grade 4/5 were included in the present series. The patients presenting with Grade 1 SAH had much better immediate clinical outcome as compared to those presenting in Grade 2 or Grade 3 SAH.

The distribution of the patients with SAH according to their Fisher Grading on CT and the Glasgow outcome status at discharge is presented in the following table:

Table 14: Relation between severity of sah on ct and clinical outcome at discharge

FISHER GRADE ON CT	NO. OF PATIENTS	GLASGOW OUCOME SCALE	NO. OF PATIENTS
GRADE I	3	1	1
		2	1
		5	1
GRADE II	16	1	8
		2	1
		3	1
		4	3
		5	3
GRADE III	1	5	1
GRADE IV	7	1	6
		4	1
NO. OF PATIENTS WITH SAH	27		

Most of the patients with SAH were in Fisher grade 2 (16/27 – 59%). No significant relationship or consistent pattern was noted between the Fisher grade and clinical outcome of the patient.

Cranial nerve symptoms were seen in 24/26 cases of cavernous ICA aneurysms with equal distribution in the coiled and parent artery occlusion group. The clinical results of these aneurysms are summarized below:

Table 15: Change In Cranial Nerve Symptoms In Treated Aneurysms

CRANIAL NERVE SYMPTOMS IN CAVERNOUS ICA ANEURYSMS				
PROCEDURE DONE	NO.	CRANIAL NERVE SYMPTOMS AT PRESENTATION	CRANIAL NERVE SYMPTOMS AT FOLLOW UP	
PAO	13	12/13	DECREASE	5
			SAME	3
			FU NOT AVAILABLE	4
COILING	13	12/13	DECREASE	3
			SAME	4
			FU NOT AVAILABLE	5
TOTAL	26	24/26	DECREASE	8(33.3%)
			SAME	7(20.5%)
			FU NOT AVAILABLE	9(37.5%)

Follow up was available in 15 cases with a decrease in symptoms in

33.3% cases and same complaints in 20.5% cases. No deterioration of cranial nerve complaints was seen in any of the followed patient. The follow up results were better for aneurysms with parent artery occlusion (5/8-62.5%) as compared to those who underwent coiling (3/7-42.8%).

ANEURYSM MORPHOLOGY:

All the cases of coiled intracranial aneurysms underwent a detailed angiographic evaluation before the procedure. The aneurysms were classified on the basis of their neck as narrow necked and wide necked. All fusiform aneurysms were included in the wide necked category. The relation between the neck of the aneurysm and immediate angiographic results are as mentioned below:

Table 16 : Relation Between Neck Width And Immediate Angiographic Result

NECK WIDTH		**NO. OF ANEURYSMS**	**IMMEDIATE ANGIOGRAPHIC RESULT**			
			PACKING %	**NO.**	**ANGIO RESULT**	**NO.**
<4mm	NARROW	28	100%	11	CO	15
			90-99%	17	DE	11
			<90%	0	RN	2
>=4mm	WIDE	23	100%	6	CO	8
			90-99%	11	DE	4
			<90%	4	RN	8
			<70%	2	RA	3

The narrow necked aneurysm showed good immediate result (90-100% packing) in all the cases (28/28-100%) with complete occlusion in 15/28 cases (53%) cases. Amongst the wide necked aneurysms, good packing was achieved in 17/23 (73%) cases with complete occlusion in 8/23 (34.7%) cases.

Neck size vs Degree of Packing

Table 17: Relation Between Neck Width And Immediate Degree Of Packing

Crosstab

			DGPACKNG		
			.00	1.00	Total
NECK	.00	Count	28		28
		% within NECK	100.0%		100.0%
	1.00	Count	17	5	22
		% within NECK	77.3%	22.7%	100.0%
Total		Count	45	5	50
		% within NECK	90.0%	10.0%	100.0%

A Pearson chi square test gave a significance of 0.012 indicating a statistically significant relationship between the neck of aneurysm and the degree of packing.

Neck size vs immediate angiographic results

Table 18: Relation Between Neck Width And Immediate Angiographic Result

Crosstab

			IMEDRSLT		
			.00	1.00	Total
NECK	.00	Count	26	2	28
		% within NECK	92.9%	7.1%	100.0%
	1.00	Count	12	11	23
		% within NECK	52.2%	47.8%	100.0%
Total		Count	38	13	51
		% within NECK	74.5%	25.5%	100.0%

A statistically significant relation was also noted between the neck size and the immediate angiographic outcome with a Pearson chi square test value of 0.001.

The relation between neck width and the Glasgow outcome at discharge is as follows:

Table 19: Relation Between Neck Width And Immediate Clinical Reult

NECK WIDTH		NO. OF PATIENTS*	**GLASGOW OUTCOME AT DISCHARGE**	
<4mm	NARROW	27	1	20
			2	2
			3	1
			4	1
			5	3
>=4mm	WIDE	23	1	16
			2	1
			3	1
			4	3
			5	2

1 Patient had 2 aneurysms

A good Glasgow outcome scale (Grade 1&2) was seen in 22/27 (81.8%) cases of narrow necked aneurysms and 17/23 (73.9%) cases of wide necked aneurysms. The mortality for narrow necked aneurysms was 3/27 (11%) and for wide necked aneurysms 2/23 (8.6%).

The clinical outcome and mortality for both narrow and wide necked aneurysms was nearly equal in our series. No significant relation was found between the aneurysm neck and the complication rate, immediate and long term clinical outcomes.

The immediate and long-term angiographic outcomes of cases of coiled aneurysms were compared in relation to their neck size as follows:

Table 20: Relation Between Neck Width And Immediate And Long Term Angiographic Outcome

		IMMEDIATE RESULTS				FOLLOW UP RESULTS				CHANGE IN STATUS		
NECK	TOTAL	CO	DE	RN	RA	CO	DE	RN	RA	UN	TH	RE
NARROW	13	5 (38%)	5	3	0	6 (46%)	2	3	1	6 (46%)	3 (23%)	3 (23%)
WIDE	10	4 (40%)	3	2	1	3 (30%)	2	2	3	5 (50%)	0	5 (50%)
TOTAL	23	9	8	5	1	9	4	5	4	11	3	8

KEY TO THE TABLE:

CO- Complete occlusion

DE- Dog ear

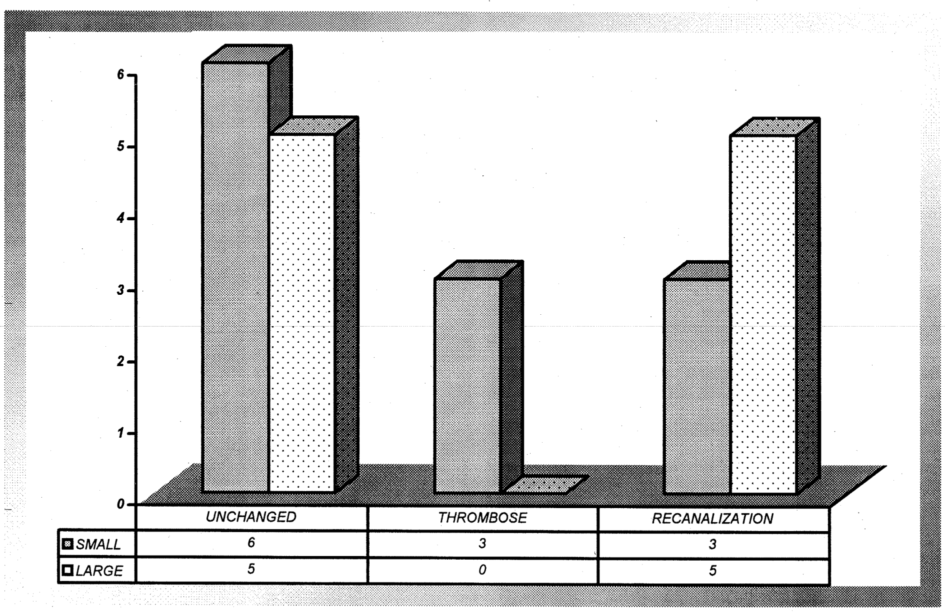
RN- Residual neck

RA- Residual aneurysm

UN- unchanged

TH- thrombosis

RE- regrowth



On angiographic follow up available in 23 patients, satisfactory angiographic outcome (complete occlusion and dog ear) was seen in 8/13 (61.5%) narrow necked aneurysms and 5/10 (50%) wide necked aneurysms. Aneurysm recanalization was noted in 3/13 (23%) narrow necked aneurysm and 5/10 (50%) wide necked aneurysms on follow up angiograms.

No statistically significant relationship was noted between aneurysm neck and long term angiographic result.

The aneurysms were classified on the basis of their largest dome diameter as small, large and giant. The relation between the luminal size of the aneurysm and immediate angiographic results are as mentioned below:

Table 21: Luminal Diameter And Immediate Angiographic Results

LUMINAL DIAMETER		**NO. OF ANEURYSMS**	**IMMEDIATE RESULT**			
			PACKING %	**NO.**	**ANGIO RESULT**	**NO.**
<10mm	SMALL	23	100%	12	CO	16
			90-99%	11	DE	6
			<90%	0	RN	1
10-25mm	LARGE	26	100%	5	CO	7
			90-99%	16	DE	9
			<90%	4	RN	8
			<70%	1	RA	2
>25mm	GIANT	2	90-99%	1	RN	1
			<70%	1	RA	1

Complete occlusion on follow up was noted in 16/23(69.5%) small sized aneurysms and 8/28 (28%) large and giant aneurysms. Satisfactory degree of occlusion (90-100%) was achieved in 23/23(100%) cases of small sized aneurysm and 21/26(80%) cases of large sized aneurysms.

Considering Complete occlusion and dog-ear as satisfactory result, a statistically significant relationship was tried establishing between the lumen size and the immediate angiographic results.

Table 22: Luminal Diameter And Immediate Angiographic Results

Crosstab

			IMEDRSLT		Total
			.00	1.00	
LUMEN	.00	Count	22	1	23
		% within LUMEN	95.7%	4.3%	100.0%
	1.00	Count	16	10	26
		% within LUMEN	61.5%	38.5%	100.0%
Total		Count	38	11	49
		% within LUMEN	77.6%	22.4%	100.0%

A statistically significant relation was established between the size of the aneurysm and the immediate angiographic result with a Pearson chi square value of 0.004.

No statistically significant relation was achieved between the degree of packing and luminal size of the aneurysm.

The luminal size and the immediate clinical results are compared in the following table as Follows:

Table 23: Luminal Diameter And Immediate Clinical Results

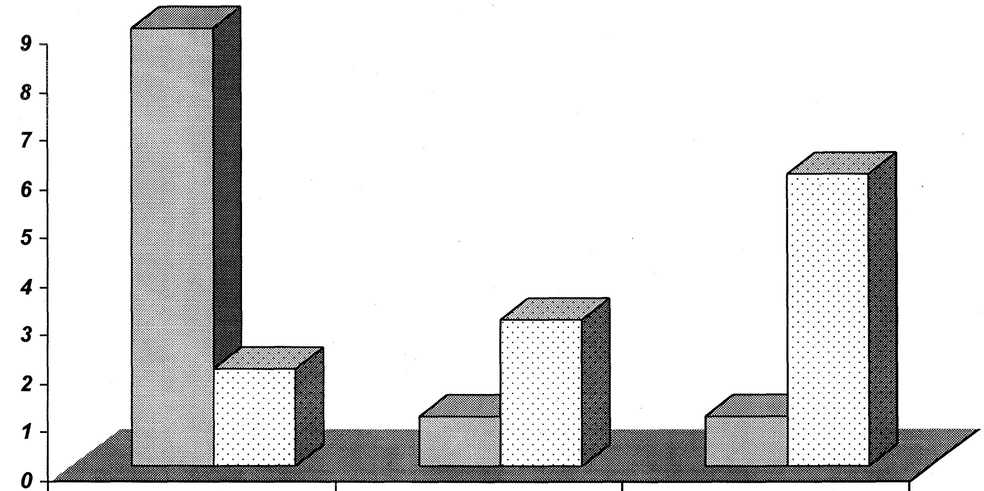
LUMINAL DIAMETER		NO. OF PATIENTS*	GLASGOW OUTCOME AT DISCHARGE	
			GOS	NO.
<10mm	SMALL	23	1	16
			2	1
			4	3
			5	3
10-25mm	LARGE	26	1	17
			2	4
			3	1
			4	1
			5	3
>25mm	GIANT	2	1	1
			3	1

A satisfactory Glasgow outcome scale score of 1 and 2 was obtained in 17/23 (73%) of small sized aneurysm and 20/26 (76%) of large sized aneurysms. No statistical relation was established between the lumen diameter and the immediate clinical outcome.

The relationship between the luminal size and the immediate and long term angiographic outcome is stated in the below mentioned table:

Table 24: Luminal Diameter And Immediate And Long Term Angiographic Outcome

		IMMEDIATE RESULTS				FOLLOW UP RESULTS				CHANGE IN STATUS		
LUMEN	TOTAL	CO	DE	RN	RA	CO	DE	RN	RA	UN	TH	RE
SMALL	11	7 (63.6%)	2	2	0	7 (63.6%)	2	2	0	9 (81%)	1 (9%)	1 (9%)
LARGE	11	1 (9%)	5	4	1	3 (27.2%)	2	2	4	2 (18%)	3 (27%)	6 (54.5%)
TOTAL	22	8	7	6	1	10	4	4	4	11	4	7



	UNCHANGED	THROMBOSE	RECANALIZATION
SMALL	9	1	1
LARGE	2	3	6

Follow up was available in 22/50 cases of coiled intracranial aneurysms with complete occlusion achieved in 7/11 (63.6%) of small aneurysms and 1/11 (9%) of large sized aneurysms on immediate post procedure angiography. Aneurysm status was unchanged in 9/11 (81%) of small aneurysms and 2/11 (18%) cases of large aneurysms on follow up. Recanalization was noted in 1/11 (9%) small aneurysms and 6/11 (54.5%) large sized aneurysms.

Considering complete occlusion and dog-ear as satisfactory angiographic results, the statistical relationship was calculated between the lumen size and the final angiographic result.

Table 25: Relation Between Luminal Diameter And Follow Up Angiographic Results

Crosstab

			FNLRESLT			Total
			.00	1.00	2.00	
LUMEN	.00	Count	9	2	1	12
		% within LUMEN	75.0%	16.7%	8.3%	100.0%
	1.00	Count	2	6	3	11
		% within LUMEN	18.2%	54.5%	27.3%	100.0%
Total		Count	11	8	4	23
		% within LUMEN	47.8%	34.8%	17.4%	100.0%

A Pearson chi square test value of 0.024 (<0.05) suggestive of a statistically significant relationship between the lumen size and final angiographic result was obtained.

No statistically significant relationship was obtained between the lumen size and degree of packing on follow up angiogram.

The small aneurysms were further divided into those with narrow neck (<4mm) and those with wide neck (>=4mm) and the immediate angiographic results and complications tabulated as follows:

Table 26: Relation Between Neck Size In Small Sized Aneurysms And Clinical And Angiographic Results

SMALL ANEURYSMS	No.	Percentage Occlusion		Immediate Angiographic results		COMPLICATIONS	
WITH NARROW NECK	17	100%	8	CO	10	1 (5.8%)	vasospasm
		90-99%	9	DE	6		
				RN	1		
WITH WIDE NECK	6	100%	4	CO	6	1 (16.6%)	perforation
		90-99%	2			2 (33.3%)	Coil migration
Total	23	100%	12	CO	16	4	
		90-99%	11	DE	6		
				RN	1		

The small sized aneurysms showed no significant difference between the narrow necked and wide necked aneurysms in terms of percentage of packing and immediate angiographic result.

The Large aneurysms were also further divided into those with narrow neck (<4mm) and those with wide neck (>=4mm) and the immediate angiographic results and complications tabulated as follows:

Table 27: Relation Between Neck Size In Large Sized Aneurysms And Clinical And Angiographic Results

LARGE ANEURYSMS	No	PERCENTAGE OCCLUSION		IMM. ANGIO RESULTS		COMPLICATIONS
WITH NARROW NECK	11	100%	3	CO	5	5
		90-99%	8	DE	5	
				RN	1	
WITH WIDE NECK	15	100%	2	CO	2	3
		90-99%	8	DE	4	
		<90%	4	RN	7	
		<70%	1	RA	2	
Total	26	100%	5	CO	7	8
		90-99%	16	DE	9	
		<90%	4	RN	8	
		<70%	1	RA	2	

Large aneurysms with a narrow neck showed a satisfactory packing (90-100%) in 11/11 (100%) cases and those with a wide neck showed a satisfactory occlusion in 10/15 (66.6%) cases. Complete occlusion and dog-ear indicating a satisfactory result was also more frequently seen in cases with narrow necked cases (10/11) than in wide necked cases (6/15).

The relation between the sac/ neck ratio and the immediate angiographic result is stated in the below mentioned table:

Table 28: Relation Between Sac/Neck Ratio And Immediate Angiographic Outcome

RESULTS IN COILED SACCULAR ANEURYSMS			
SAC/NECK RATIO	NO. OF PATIENTS		
<2	14	100%	6
		90-99%	7
		<90%	1
>2	33	100%	11
		90-99%	19
		<90%	2
		<70%	1

- 1 Patient had 2 aneurysms

Satisfactory packing (90-100%) was achieved in 13/14 (92%) cases of aneurysm with sac/neck ratio <2 and in 30/33 (90%) cases of aneurysms with sac/neck ratio>2. No statistically significant relation was established between the sac/neck ratio and the immediate and follows up angiographic and clinical results.

Table 29: Distribution Of Complication Associated With Selective Coiling Of Intracranial Aneurysms

COMPLICATIONS ASSOCIATED WITH COILING			
MINOR	4/50	3	THROMBOEMBOLISM
		1	DISSECTION
MAJOR	11/50	4	THROMBOEMBOLISM
		3	COIL PROLAPSE/MIGRATION
		2	RUPTURE
		2	VASOSPASM
TOTAL PATIENTS	15/50	7	THROMBOEMBOLISM
		3	COIL PROLAPSE/MIGRATION
		2	RUPTURE
		2	VASOSPASM
		1	DISSECTION

MINOR – LEAVING NO NEUROLOGICAL DEFICIT OR MINOR DEFICIT NOT INTERFERING WITH DAILY ACTIVITIES

MAJOR – LEAVING PERSISITENT NEUROLOGCAL DEFICIT OR DEATH

We were able to obtain follow up angiographic results in 16/29 (55%) cases of parent artery occlusion with the immediate and follow up angiographic and clinical results as mentioned in the table below:

Table 30 Parent Artery Occlusion Cases And Immediate And Long Term Follow Up

RESULTS OF PARENT ARTERY OCCLUSION						
LOCATION	**NO.**	**GOS AT PRESENTATION**	**IMMEDIATE RESULT**	**AVERAGE FOLLOW UP IN DAYS**	**FOLLOW UP RESULT**	**GOS AT FOLLOW UP**
CAVERNOUS ICA	9	1 4 2 3 3 2	CO 4 RF 5	1494	CO 8 RF 1	1 7 2 2
OPHTHALMIC ICA	1	1 1	CO 1	554	CO 1	1 1
PETROUS ICA	1	1 1	CO 1	2264	CO 1	1 1
BASILAR TRUNK	1	1 2	RF 1	214	CO 1	1 1
VERTEBRAL	1	1 1	RF 1	95	CO 1	1 1
PCA	3	1 3	CO 3	483	CO 3	1 2 2 1
TOTAL	16	1 11 68% 2 3 18% 3 2 13%	CO 9 56% RF 7 44%	319	CO 12 75% RF 4 25%	1 13 81% 2 3 19%

Complete occlusion was seen in 9/16 (56%) cases on immediate post procedure angiography, which progressed to 12/16 (75%) on follow up. Residual filling was seen in 7/16 (44%) cases on immediate post procedure angiogram, which decreased to 3/16 (19%) cases on follow up. The Glasgow outcome scale was good (1&2) in 14/16 (87.5%) cases immediately post procedure that progressed to 16/16 (100%) on follow up.

In the largest group of aneurysms treated by parent artery occlusion comprised by Cavernous ICA aneurysms, Complete occlusion was noted in 4/9 (44%) cases immediately after occlusion which progressed to 8/9 (88%) cases on follow up.

The status of the cranial nerve symptoms on follow up was available in 8/12 cases with results as follows:

Table 31: Status Of Cranial nerve Deficits In Cases Of Parent Artery Occlusion

CRANIAL NERVE SYMPTOMS IN CAVERNOUS ICA ANEURYSMS				
PROCEDURE DONE	**NO.**	**CRANIAL NERVE SYMPTOMS AT PRESENTATION**	**CRANIAL NERVE SYMPTOMS AT FOLLOW UP**	
PAO	13	12/13	DECREASE	5
			SAME	3
			FU NOT AVAILABLE	4

The cranial nerve symptoms on follow up clinical evaluation decreased in 5/13 (38%) cases with same status seen in 3/13 (23%) cases. No case of aggravation of cranial nerve symptom was detected on follow up evaluation.

Table 32: Complications Associated With Parent Artery Occlusion

COMPLICATIONS ASSOCIATED WITH PARENT ARTERY OCCLUSION			
MINOR	2/29	2	HYPOPERFUSION
MAJOR	6/29	3	HYPOPERFUSION
		2	THROMBOEMBOLISM
		1	VASOSPASM
TOTAL PATIENTS	8/29	5	HYPOPERFUSION
		2	THROMBOEMBOLISM
		1	VASOSPASM

MINOR – LEAVING NO NEUROLOGICAL DEFICIT OR MINOR DEFICIT NOT INTERFERING WITH DAILY ACTIVITIES

MAJOR – LEAVING PERSISITENT NEUROLOGCAL DEFICIT OR DEATH.

DISCUSSION

The most dreaded complication of intracranial aneurysms remains rupture. Acute rupture of intracranial aneurysm remains a catastrophic event in spite of early timing of endovascular coiling, surgical clipping and aggressive medical management. The goal of aneurysm treatment remains exclusion of aneurysm sac and neck from circulation. Endovascular treatment is being increasingly used for this purpose and has replaced surgical coiling as the first line of treatment for intracranial aneurysms in many places. The long-term efficacy of coiling has not yet been established, this being a relatively new technique. A strict protocol of follow up imaging and clinical assessment was set up for endovascularly treated patients in our institute for evaluating the long term results of endovascular treatment.

A total of 80 aneurysms in 78 patients were treated over a period of 18 years with 47% being males and 53% females.

Anterior circulation aneurysms were more frequent in our study than the posterior circulation aneurysms constituting 65% and 35% cases respectively. In the first few years after introduction of Endovascular treatment of intracranial aneurysms, there was a tendency to refer posterior circulation aneurysms for coiling in many centers considering the difficulty in treating Basilar top aneurysms by open surgery due to the location in front of the brainstem and intimate relation with adjacent perforating vessels **(18, 49, 51).** However, with refinement in endovascular techniques and better outcomes, the referral base has widened so that the subsequent studies like ISAT (95% anterior circulation aneurysm), Henkes et al (67.4% anterior circulation aneurysms) had more anterior circulation aneurysms than posterior circulation aneurysms **(63,67).** In a meta analysis of the literature on coil occlusion of intracranial aneurysms from 1990 to 1997 published by Brilstra et al, the frequency of locations for 1250 aneurysms was as follows: anterior circulation - 56%, Posterior circulation- 44%, basilar bifurcation – 35% and ICA 28% **(82).** This coincided with the frequency found in our series for the anterior and posterior circulation aneurysms with the frequency of Basilar bifurcation aneurysms and ICA aneurysms which were selected for coiling being 47.1% and 25% respectively.

Patient age ranged from 7-72 years with a mean age of 47 years. The mean age in our series corresponded with the mean age in Meta analysis of aneurysms series done by Brilstra et al, where the mean age was 51years **(82).** Patients with age<50 years and those with age >50 years were distributed almost equally with 40 and 38 patients respectively. The clinical results were equally good for young and elderly patients with 75% and 81% cases showing good outcome at discharge and 100% and 95% of followed up cases showing good outcome respectively. The results for elderly patients were in contrast to the results of Sedat et al and Lubicz et al where the immediate clinical outcome was 48% and 59% respectively **(68, 69).** However, the above-mentioned authors had included the patients above 65 years and with ruptured intracranial aneurysms in contrast to our series where ruptured and unruptured aneurysms in patients above 50 years were included. Our series had only 3 cases with ruptured intracranial aneurysms with age >65 years.

LOCATION: The two most frequent locations for treated intracranial aneurysms in our series were for cavernous ICA and Basilar top, the results for which are discussed below.

CAVERNOUS ICA ANEURYSMS:-

26 cases of Cavernous ICA aneurysms were treated endovascularly with 13 cases being treated with parent artery occlusion and 13 cases by coiling with sparing of parent artery. Satisfactory occlusion was achieved on immediate post procedure angiogram in 8/13 (61%) cases of parent artery occlusion and 10/13 (77%) cases of selective aneurysm coiling. On follow up angiogram, 8/9 (88%) cases of parent artery occlusion achieved complete occlusion while 3/5 (60%) cases of aneurysm coiling showed complete occlusion on follow up. Residual aneurysm was seen in 2/5 (40%) cases of followed coiled cases of selective cavernous ICA aneurysm coiling. 24/26 (92%) cases of Cavernous ICA aneurysms presented with cranial nerve symptoms. The symptoms decreased in 8/15 (53.3%) cases available for follow up while in rest 7/15 (46.6%) cases the symptoms were static. An immediate increase in cranial nerve deficit was noted in 1 case of parent artery occlusion, which subsequently decreased.

In endovascularly treated aneurysm, thromboembolism was noted in 3 cases with a dissection seen in 1 case causing occlusion of parent artery. In cases of parent artery occlusion, hypo perfusion causing neurological deficits was seen in 2 cases. On long term angiographic follow up, flow related aneurysm in the contralateral artery was noted in 2 cases of parent artery occlusion indicating the need for preserving the native vessel with use of remodeling technique wherever safely possible.

Our results coincided with that of Bavinzski et al **(58)** who performed endovascular treatment of cavernous ICA aneurysms in 42 patients with 48 aneurysms. Sixteen of the 42 aneurysms (all large or giant) were treated by balloon occlusion of the parent artery while the remaining 17 were treated with selective coiling. All aneurysms treated by carotid occlusion thrombosed. Twelve of the 17 (70%) aneurysms treated with GDCs were 100% filled by the coils, four (23%) were 80% to 95% filled, and one was only 40% filled. Seven of the 100% filled aneurysms remained completely occluded, two showed slight coil compaction, and in three, follow-up angiography was not available.

A systematic review of studies reporting on results of coiling and parent vessel occlusion in cavernous ICA aneurysms was done by Irene et al over a period of 1974 to 1999.After reviewing 35 studies, Complete occlusion on follow up was reported in 97.5% (153/157) cases of parent artery occlusion with satisfactory occlusion (>90%) seen in 80% (52/65) of coiled case. Diplopia, if present before treatment, improved in nearly all patients treated by coiling and in 81% cases treated by means of balloon occlusion **(83).**

The above-mentioned data suggest that both balloon occlusion and endovascular coiling are reasonably safe and result in occlusion of the aneurysm in the majority of patients having Cavernous ICA aneurysms with good resolution of symptoms. Parent artery occlusion gave better occlusion rates than endovascular coiling. However, the decrease in symptoms and protection from rebleed was almost equal in both cases. The more frequent use of onyx, remodeling techniques and stent assisted coiling will help us to preserve the parent artery in more cases.

BASILAR TOP ANEURYSM:

13 cases of basilar top aneurysms were treated, all by endovascular coiling with parent artery sparing. 12/13 (92%) showed satisfactory angiographic result with good immediate clinical outcome in 10/13 (76%) cases. Complete occlusion was seen in 7/13 (53.8%) cases, dog-ear in 3/13(23%) and residual neck in 1/13 (7%) case on immediate post procedure angiogram. Complications were seen in 3 cases with one being a hematoma along neck venous line and 2 deaths. Coil perforation of aneurysm causing rebleed during the procedure was seen in one patient while another died due to associated coronary artery disease causing a massive myocardial infarction in the post procedural period. On follow up angiograms available in 8 cases, good result was seen in 7/8 (88%) cases with residual aneurysm following coil compaction in 1/8 (12%). Residual aneurysm was seen in a large aneurysm with incomplete packing at the time of treatment when the patient had presented with SAH. Further coiling was deferred due to severe associated comorbid illness.

Raymond et al prospectively studied 31 patients of Basilar bifurcation aneurysms who underwent endovascular coil occlusion, of which 8 were incidentally detected aneurysms and 23 presented with subarachnoid hemorrhage. Immediate angiographic result was satisfactory in 94% cases with complete occlusion in 42% cases and residual neck/ dog-ear in 52% cases. On follow up angiograms done at 6 months, 30% lesions showed complete obliteration, 59% presented with some residual neck, and 11% showed residual sac opacification **(49).**

Bavinzski et al retrospectively reviewed 45 Basilar top aneurysms treated using GDC coils. Immediate post procedure angiograms showed 90-100% occlusion in 39/45 (87%) and 6/45 (13%) were < 90% occluded. On follow up angiograms in 19/31 (61%) showed stable results and, 12/31 (39%) showed coil compaction, only 8 of which could accept additional coils. In large aneurysms recanalization was seen in 57% of cases where as in small-necked aneurysms a stable angiographic result was seen in 92% of cases **(41).**

Eskridge et al reviewed the results of 150 patients with basilar tip aneurysms (ruptured - 83, unruptured – 67) treated with GDC coils. In 75% cases >90% coil packing was achieved. Conservative mortality rates included up to 23% for the ruptured aneurysm group and up to 12% for the unruptured aneurysm group; the Rebleeding rate for treated ruptured aneurysms was up to 3.3% and the bleeding rate for unruptured aneurysm was up to 4.1%. Permanent deficit due to stroke in patients with ruptured and unruptured aneurysms occurred in up to 5% and 9% respectively. Vasospasm occurred in 8% of cases. Periprocedural mortality was 2.7%, all occurring in ruptured aneurysms **(51).**

Brilstra et al did a Meta analysis of studies on embolization of intracranial aneurysms with coils. According to the study, results in patients with a Basilar bifurcation aneurysm were in the same range as those in patients with aneurysms located elsewhere. Basilar bifurcation aneurysms are less often completely occluded (45%) than aneurysms than aneurysms not located at the Basilar bifurcation (54).

Lozier et al performed a Medline search for posterior circulation aneurysms and evaluated the data. Overall, 82% aneurysms arose near the basilar apex. Complete aneurysm occlusion (99-100%) was achieved in 47.6%, near complete occlusion (90-99%) in 43.4% and incomplete occlusion was achieved in 9% of cases. In a subset of 234 evaluated patients, 52 recurrences (22.2%) were noted, of which 92% showed a wide neck (55).

The results of our study corresponded with the results of Raymond et al, Bavinzski et al, Lozier et al and Eskridge et al in terms of immediate angiographic result and complication rates. The result however did not correspond to the Meta analysis by Brilstra et al who reported a 45% rate of incomplete occlusion. The reason was the exclusion by Brilstra et al of aneurysms with 90-99% occlusion into the complete occlusion category.

Basilar bifurcation aneurysms give a satisfactory immediate and long-term angiographic result with good protection from rebleeding after endovascular occlusion.

MORPHOLOGY AND IMMEDIATE RESULTS:

In the early phase of clinical use, the GDC system was used mainly for surgically difficult aneurysms or in patients with poor neurological or medical conditions **(81)**. Since 1995, the most important factor regulating it's use has been aneurysm morphology and patient clinical and neurological status **(36, 40,43).**

NECK SIZE:

All the cases of coiled intracranial aneurysms underwent a detailed angiographic evaluation before the procedure. The aneurysms were classified on the basis of their neck as narrow necked and wide necked. All fusiform aneurysms were included in the wide necked category.

The narrow necked aneurysm showed good immediate result (90-100% packing) in all the cases (28/28-100%) with complete occlusion in 15/28 (53%) cases cases, dog-ear in 11/28 (39%) cases and residual neck in 2/28 (7%) cases. Amongst the wide necked aneurysms, good packing (90-100%) was achieved in 17/23 (73%) cases with complete occlusion in 8/23 (34.7%) cases. A statistically significant relationship was noted between the neck size and the degree of packing and immediate angiographic outcome. Narrow necked aneurysms showing a much better result.

A good Glasgow outcome scale (Grade 1 & 2) was seen in 22/27 (81.8%) cases of narrow necked aneurysms and 17/23 (73.9%) cases of wide necked aneurysms. The mortality for narrow necked aneurysms was 3/27 (11%) and for wide necked aneurysms 2/23 (8.6%). The clinical outcome and mortality for both narrow and wide necked aneurysms was nearly equal in our series. No significant relation was found between the aneurysm neck and the complication rate, immediate and long term clinical outcomes.

Zubilaga et al evaluated the relation of the size of aneurysm neck and the completeness of coiling in intracranial aneurysms. A method using the average reported caliber of the major intracranial vessels was applied to determine the aneurysm neck sizes on the diagnostic angiograms. A retrospective study of 79 patients of coiled aneurysms was undertaken. Aneurysms were classified as small necked (<=4mm) and large necked (>4mm). Complete aneurysm occlusion was observed in 85% (17/20) of small-necked aneurysms and only 15.7% (8/51) of large necked aneurysms. Aneurysms with a small neck had much better completeness of coiling as compared to large necked aneurysms (33).

Turjman et al retrospectively reviewed Pre and post treatment angiograms of 72 patients undergoing GDC treatment. Complete occlusion was achieved in 17/29 cases of narrow necked aneurysm and 11/43 cases of wide necked aneurysms. One of the Morphological Parameters that correlated with the unsatisfactory result of partial occlusion was large neck size. The author also tries to explain why neck size has received most attention as a predictor of aneurysm occlusion. This is a direct reflection on the specific characteristics of the GDC system and the biomechanical interaction of these coils with their surroundings once released in the aneurysm sac. Because GDCs do not appear to induce immediate and pronounced formation of firm and adherent thrombus that might help fix their position within the sac, they are liable to remain unstable in presence of a wide neck, leading to possible herniation into the parent artery (35).

Hope et al attempted to identify factors that might be important in predicting success both at the time of treatment and at the time of follow up angiography. The pretreatment, post treatment and follow up angiograms of 63 aneurysms in 58 patients were reviewed. The only factor to achieve significance in predicting success at the time of treatment was neck size (P = 0.002, with 86% success for aneurysm neck <=4mm and 50% success for aneurysm neck >4mm). No change was noted on follow up angiograms in 18/30 cases, progressive thrombosis in 6/30 cases and recanalization in 6/30 cases of narrow necked aneurysms. In contrast, the wide necked aneurysms showed no change in 7/31case, thrombosis in 6/31 cases and regrowth in 11/31 cases (39).

Bavinzski et al analyzed the results of basilar artery bifurcation aneurysms treated by GDC coils. Out of the total 45 cases of basilar top aneurysms evaluated, 18 had narrow neck while 27 had wide neck. Complete or near complete occlusion was achieved in 16/18 (88%) of narrow necked aneurysms and 12/27(44.4%) wide necked ones (41).

Lempert et al described the clinical and angiographic outcome in endovascular therapy of ruptured posterior circulation cerebral aneurysms using GDC coils in 109 cases. The final occlusion rate in the subset of aneurysms with neck size <4 mm was significantly higher compared with those with neck size between 4-6mm and those with neck size >6mm (43).

Aneurysm neck size was a statistically significant factor deciding the degree of packing and the immediate angiographic outcome in our study correlating with the results of the above mentioned studies (33,35,39,41,43).

LUMEN SIZE:

The aneurysms were also classified according to the largest dome diameter as small, large and giant. Complete occlusion on follow up was noted in

16/23 (69.5%) small sized aneurysms and 8/28 (28%) large and giant aneurysms. Satisfactory degree of occlusion (90-100%) was achieved in 23/23 (100%) cases of small sized aneurysm and 21/26 (80%) cases of large sized aneurysms. A statistically significant relation was established between the size of the aneurysm and the immediate angiographic result with a Pearson chi square value of 0.004.

A satisfactory Glasgow outcome scale score of 1 and 2 was obtained in 17/23 (73%) of small sized aneurysm and 20/26 (76%) of large sized aneurysms. No statistical relation was established between the lumen diameter and the immediate clinical outcome.

Fernando Vinuela et al made a prospective study of 403 patients presenting with acute subarachnoid hemorrhage in whom GDC embolization was done within 15 days of bleed. Aneurysms were classified on the basis of their largest diameter as small (<10mm - 60.8%), large (10-25mm - 34.7%) and giant (>25mm - 4.5%) and on the basis of their neck size as small (<4mm - 53.6%) and wide (>=4mm - 36.2%). Complete aneurysm occlusion was observed in 70.8% of small aneurysms with small neck, 31.2% of small aneurysms with wide neck, 35% of large aneurysms, and 50% of giant aneurysms. A small neck remnant was observed in 21.4% of small aneurysms with small neck, 57.1% of large aneurysms and 50% of giant aneurysms. This indicates that the best results are seen with small aneurysms with small neck, these being most anatomically favorable for holding the coiled mass allowing complete packing **(34).**

Kuether et al treated 77 aneurysms over a period of 4.5 years. Immediate embolisation results for small aneurysms were that 49% exhibited complete, 44% near complete, and 7% incomplete occlusion. These results were almost similar to our results of complete occlusion in 69.5%, near complete occlusion in 26% and residual neck in 4.3% cases of small aneurysms. The immediate embolisation results for large aneurysms were that 25% exhibited complete, 64% near complete, and 11% incomplete occlusion compared to 26.9%, 34.6% and 38.3% respectively in our series. Near complete occlusion was obtained initially in both cases (100%) of giant intracranial aneurysms on initial examination **(37)**.

Thirty patients with 31 giant or very large aneurysms were considered to show unacceptable risk/benefit ratios for open surgery and were treated using the Guglielmi detachable coil (GDC) method by Gruber et al. A single total embolisation served as definitive treatment for only 12.5% of the giant aneurysms and 31% of the very large aneurysms (40). A single embolisation procedure served as definite treatment in 50% (1/2) of giant aneurysms and 26.9% (7/26) of large aneurysms in our series.

The results were also comparable to that of Murayama et al in 818 patients with 916 aneurysms over a period of 11 years. The patients were divided into 2 groups. Group A included the initial 5 year experience with 230 patients with 251 aneurysms and Group B with 588 patients having 665 aneurysms over the next 6 years. In Group A patients complete occlusion was achieved in 66% (79/119) cases with small aneurysm, 39% (32/82) cases with large aneurysms and 12.1% (4/33) cases with giant aneurysms. In Group B patients complete occlusion was achieved in 59.5% (274/460) cases with small aneurysm, 41.4%

(48/116) cases with large aneurysms and 37.5% (15/40) cases with giant aneurysms (45).

The results of this study also corresponds with our results of complete occlusion seen in 16/23 (69.5%) and 7/23 (26.9%) cases for small and large aneurysms respectively. The results in giant aneurysms were probably not correlating because of the small number of cases in our series.

Malisch et al evaluated midterm clinical outcome (follow up period >=2years) in 61 patients who underwent GDC coiling as a definitive treatment. The midterm post GDC coiling rebleeding rate was 0% for small aneurysms, 4% (1 case) for large aneurysms, and 33% (5 cases) for giant aneurysms. Aneurysm size had a significant effect on the midterm clinical outcome with patients having small aneurysms and large aneurysms having a 93% and 95% incidence of excellent or good outcome respectively. In contrast 50% of patients with giant aneurysms had excellent or good outcomes and 40% died from post GDC hemorrhage **(62).**

NECK SIZE + LUMEN DIAMETER:

The small aneurysms and large aneurysms were further divided into those with narrow neck (<4mm) and those with wide neck (>=4mm) and the immediate angiographic results were compared. The small sized aneurysms showed no significant difference between the narrow necked and wide necked aneurysms in terms of percentage of packing and immediate angiographic result. Large aneurysms with a narrow neck showed satisfactory packing (90-100%) in 11/11

(100%) cases and those with a wide neck showed a satisfactory occlusion in 10/15 (66.6%) cases. Complete occlusion and dog-ear indicating a satisfactory result was also more frequently seen in cases with narrow necked cases (10/11) than in wide necked cases (6/15).

Vinuela et al made a prospective study of 403 patients presenting with acute subarachnoid hemorrhage in which GDC embolization was done within 15 days of bleed. Aneurysms were classified on the basis of their largest diameter as small (<10mm-60.8%), large (10-25mm-34.7%) and giant (>25mm-4.5%)and on the basis of their neck size as small (<4mm - 53.6%) and wide (>=4mm - 36.2%). Complete aneurysm occlusion was observed in 70.8% of small aneurysms with small neck, 31.2% of small aneurysms with wide neck, 35% of large aneurysms, and 50% of giant aneurysms. A small neck remnant was observed in 21.4% of small aneurysms with small neck, 57.1% of large aneurysms and 50% of giant aneurysms. This indicates that the best results are seen with small aneurysms with small neck, these being most anatomically favorable for holding the coiled mass allowing complete packing (34).

Murayama et al presented his results of coil embolization in 818 patients with 916 aneurysms over a period of 11 years. Group A included the initial 5 year experience with 230 patients with 251 aneurysms and Group B with 588 patients having 665 aneurysms over the next 6 years. In Group A patients complete occlusion was achieved in 86.2% (56/65) cases with small aneurysm having small neck, 42.6% (23/54) cases with small aneurysm having wide neck, 39% (32/82) cases with large aneurysms and 12.1% (4/33) cases with giant aneurysms.

In Group B patients complete occlusion was achieved in 72.9% (196/269) cases with small aneurysm having small neck, 40.8% (78/191) cases with small aneurysm having wide neck, 41.4% (48/116) cases with large aneurysms and 37.5% (15/40) cases with giant aneurysms **(45).**

SAC/NECK RATIO:

In cases of saccular aneurysms, A parameter independent of precise measurement of aneurysm neck and dome diameter was also evaluated by us in the form of sac to neck ratio. 47 saccular aneurysms treated with coiling were divided in two categories: those with a sac/neck ratio <2 and those with sac/neck ratio >2. Satisfactory (90-100%) occlusion was achieved in 13/14 (92%) cases with sac/neck ratio<2 and in 30/33(90%) cases with sac/neck ratio>2. No significant difference was noted between the two categories.

A retrospective analysis of 144 patients with 144 cerebral aneurysms that were treated by endovascular technique at the University of Illinois Hospital at Chicago was conducted by Debrun et al. For the initial 25 patients (Group 1), selection for coiling was restricted to nonsurgical candidates or patients in whom coiling was thought to be the best treatment choice, based on medical condition and location of the aneurysm. The remaining patients (Group 2) were selected for coiling based on aneurysm geometry, as determined by pretherapeutic angiography. Group 1 aneurysms with a dome-to-neck ratio of at least 2 had a complete occlusion rate of 59%, whereas Group 2 aneurysms with a dome-to-neck ratio of at least 2 had a complete occlusion rate of 80%. Group 1 aneurysms with a dome-to-neck ratio less than 2 had a complete occlusion rate of 40%, whereas Group 2 aneurysms with a dome-to-neck ratio less than 2 had a complete occlusion rate of 58% **(36).**

A prospective evaluation of 182 patients with 203 aneurysms was done over a 3 year period by Cognard et al. Total occlusion was achieved in 27/31 (87%) cases with aneurysm sac diameter to neck diameter ratio > 2, 47/57 (82%) with ratio between 1to2 and 14/19 (74%) cases with ratio <=1. **(38).**

FOLLOW UP RESULTS:

Follow up imaging was obtained in 38/79 (48.1%)aneurysm cases over an average period of 388 days (Range: 35-4244 days). These included 33 patients with follow up catheter angiography, 2 patients with MR angiography, and 1 patient with CT angiography and 2 patients with transcranial Doppler.

In 2002, the American Heart Association formed a special writing group to summarize the literature and create recommendations on endovascular therapy of ruptured and unruptured intracranial aneurysms. All patients whose aneurysms are treated with coil embolization should have follow up catheter angiograms performed at 1 to 6 months after initial treatment. Follow up imaging should occur sooner in patients with aneurysms that are not completely occluded. Subsequent angiography should be performed in patients whose aneurysms remain incompletely occluded **(44).**

Sluzewski et al retrospectively evaluated 160 patients with aneurysmal subarachnoid hemorrhage who had undergone coil embolization. They found no benefit of 18 month follow up angiography in patients with complete or near complete aneurysm occlusion at 6 months. Changes in the occlusion rate between 6 and 18 months and at extended follow up did not occur. If aneurysm occlusion is sufficient at 6 months, the yield of further follow up angiograms is very low **(47).**

Raymond et al evaluated retrospectively 501 aneurysms in 466 patients treated using detachable coils over a period of 10 years for long-term angiographic recurrences. Recurrences were found in 33.6% of treated aneurysms that were followed up and that appeared at a mean ± SD time of 12.31 ± 11.33 months after treatment **(48).**

The utility of alternate imaging modalities for follow up imaging of endovascularly treated intracranial aneurysms has been evaluated by various authors **(74,75,76,77)**. In a study by Cottier et al, the sensitivity of MR angiography compared with DSA was 83%, specificity 100%, positive predictive value 100%, and the negative predictive value 85% for depicting an aneurysm remnant. For depiction of aneurysm remnant >3mm in diameter, MRA with or without contrast is a safe and noninvasive imaging modality. Schuknecht et al studied the utility of Transcranial Doppler for follow up of coiled intracranial aneurysms. He concluded that TCCD is a reliable, noninvasive means to assess parent artery and major branch patency and to reveal a lack of hemodynamic compromise in the vicinity of aneurysms after endovascular therapy. On follow-up examinations, TCCD was able to detect signs of aneurysmal recanalization in large aneurysms.

Initial and follow up angiograms were compared in 22/51 (43.1%) cases of coiled intracranial aneurysms. Complete and near complete occlusion was seen in 15/22 (68.1%) cases with a stable result in 50% cases and recanalization seen in 31.8% cases over the follow up period.

On post procedure angiograms, Small sized aneurysms (<=10mm dome diameter) showed complete occlusion in 7/11 (63.6%) cases of with stable occlusion noted in 9/11 (81%) of cases and progressive thrombosis seen in 1/11 (9%) case on follow up angiograms. In large sized aneurysms (10-25mm), complete occlusion was noted in only 1/11 (9%) case on immediate post procedure angiogram with near complete occlusion seen in 5/11 (45%) cases. On follow up imaging, stable unchanged result was seen in only 2/11 (18%) cases with recanalization seen in 6/11 (54.5%) cases. Thus, the recanalization rate was much higher for large sized aneurysm (54.5%) than for small sized aneurysm (9%).

In case of narrow necked aneurysms (neck <=4mm), complete and near complete occlusion was seen in 9/12 (75%) cases with 6/12 (50%) al cases showing stable status and 3/12 (25%) showing recanalization on follow up imaging. Wide necked aneurysms showed complete and near complete occlusion in 6/10 (60%) cases with stable result seen in 5/10 (50%) cases and recanalization in 5/10 (50%) cases on follow up imaging. Aneurysm with wide neck showed slightly higher rate of recanalization (50%) compared to narrow necked aneurysms (25%).

The results were comparable to that obtained by Kuether et al. who treated 77 aneurysms over a period of 4.5 years, with an average angiographic follow-up period of 1.4 years. Immediate embolization results for small aneurysms were that 49% exhibited complete, 44% near complete, and 7% incomplete occlusion. With a minimum of 6 months of follow-up monitoring, complete aneurysm occlusion was observed in 45% of cases. Near complete occlusion was obtained in 48% of cases, with 7% of small aneurysms being incompletely occluded by GDC. The immediate embolization results for large aneurysms were that 25% exhibited complete, 64% near complete, and 11% incomplete occlusion. With a minimum of 6 months of follow-up monitoring, complete aneurysm occlusion was observed in 41% of cases. Near complete occlusion was obtained in 47% of cases, with 12% of large aneurysms being incompletely occluded by GDC **(37).**

Hayakawa et al obtained long term follow up angiograms in 73 aneurysms in 71 patients over a mean duration of 17.3 months. In small aneurysms, postembolization angiograms revealed progressive thrombosis in 18/48 (37.5%), unchanged status in 16/48 (33.3%) and recanalization in 14/48 (29.1%) cases .In large aneurysms 2/15 (13%) were unchanged and 13/15 (87%) showed recanalization. Of the giant aneurysms only 1/10 (10%) remained unchanged and 9/10 (90%) showed recanalization. The author concluded that of the factors influencing the long-term stability of GDC coiling, the predominant factors are morphological and biological. The morphological factors are the size of the aneurysm and size of the aneurysm neck. The aneurysms with wide neck were found to be exposed to a greater shear stress than narrow necked aneurysms **(42).**

The results were also comparable to that of Murayama et al in 818 patients with 916 aneurysms over a period of 11 years. The patients were divided into 2 groups. Group A included the initial 5 year experience with 230 patients with 251 aneurysms and Group B with 588 patients having 665 aneurysms over the next 6 years. In Group A patients complete occlusion was achieved in 66% (79/119) cases with small aneurysm, 39% (32/82) cases with large aneurysms and 12.1% (4/33) cases with giant aneurysms. In Group B patients complete occlusion was achieved in 59.5% (274/460) cases with small aneurysm, 41.4% (48/116) cases with large aneurysms and 37.5% (15/40) cases with giant aneurysms. Long term angiographic follow up was obtained in 53.4% cases (489/916) over a period of 3 months to 8 years. The overall recanalization rates were 12.5% for small aneurysm, 35.3% cases with large aneurysms and 59.1% cases with giant aneurysms **(45).**

Friedman et al retrospectively analyzed 83 patients with GDC coil embolisation over a period of 10 years. On follow up angiograms performed in 68 patients over a mean period of 11.6 months, 24 patients (35%) had complete aneurysm occlusion, 18 (26%) had a dog ear remnant, 24 patients (35%) had a residual neck, and 2 patients (2%) had residual aneurysm filling. In 20 patients (29%) angiographic occlusion at longest follow up greater than it was immediately after initial treatment, where as the degree of angiographic occlusion was worse in 10 patients (15%). The angiographic result was unchanged at longest follow up in 38 patients (56%) **(46).**

Sluzewski et al retrospectively evaluated 160 patients with aneurysmal subarachnoid hemorrhage who had undergone coil embolization. Follow up angiography was performed at 6 and 18 months for all the patients. On immediate post procedure angiograms complete occlusion was noted in 113 (71%) patients, near complete occlusion in 35 (22%) patients and incomplete occlusion in 12 (8%) patients. Of the 126 patients in whom a follow up angiograms was performed after 6 months, In 88 (70%) patients, the occlusion was stable; in 31 (25%) patients, the occlusion decreased; and in 7 (6%) patients the occlusion increased (47).

Raymond et al evaluated retrospectively 501 aneurysms in 466 patients treated using detachable coils over a period of 10 years for long-term angiographic recurrences. Recurrences were found in 33.6% of treated aneurysms that were followed up. Variables determined to be significant predictors ($P<0.05$) of a recurrence-included aneurysm size ≥10 mm, treatment during the acute phase of rupture, incomplete initial occlusions, and duration of follow-up (48).

Thornton et al presented a metaanalysis of 1397 patients, of whom 1370 underwent postoperative angiography demonstrating 1569 clipped aneurysms Residual filling was found in 82 aneurysms (5.2%) on immediate postoperative angiography (84).

The long-term angiographic recurrences were found more often in large sized aneurysms than small sized ones. The long-term stability of the coiled mass is also related to the neck size, presumably because hemodynamic forces are able to act on a larger surface area of the coil ball at the neck of the aneurysm. The use of remodeling techniques and stent assisted coiling might be of help in altering the prognosis of wide necked aneurysms. However, A statistical relation could not be established due to the small numbers involved.

The study is also limited by other factors like variability of the aneurysms studied, materials available over years and the methods used. Out of the total 78 patients, only 48.1% cases were available for imaging follow up, out of which only 41% cases underwent follow up angiograms.

COMPLICATIONS :

Complications were divided into minor and major. The minor complications were considered as those that left no neurological deficits or associated with minor deficits not interfering with daily activities. The major complications included persistent neurological deficits interfering with daily activities and death.

The aneurysms treated with parent artery occlusion were associated with minor complications in 2/29 (6.8%) cases and major complications in 6/29 (20%) cases.

The aneurysm group treated with selective endovascular coiling was associated with minor complications in 4/50 (8%) cases and major complications in 11/50 (22%) cases.

A statistically significant relation could not be established due to the small number of cases.

Death occurred in 10 cases in the present series with 6 occurring in the coiling group and 4 occurring in parent artery group. This included 5/6 coiled cases and 2/4 cases with parent artery occlusion presenting with ruptured intracranial aneurysms. The major cause of death was myocardial infarction in the immediate post treatment period in patients with comorbid coronary artery illness. Aneurysm rupture during coiling was seen in 3 cases with death occurring in 2 cases. The cases with thromboembolism and vasospasm were ruptured aneurysms with vasospasm seen on angiograms. In spite of an unremarkable temporary balloon occlusion test, one case of parent artery occlusion developed a massive post occlusion infarct and death.

Vinuela et al made a prospective study of 403 patients presenting with acute subarachnoid hemorrhage in whom GDC embolization was done within 15 days of bleed. 342 patients (84.9%) improved or remained neurologically unchanged, 36 (8.9%) experienced postembolization clinical deterioration, and 25 (6.2%) died within 1 week of the GDC procedure. Out of the 25deaths, 7 were related to GDC technical complications and 18 were associated with the severity of the initial SAH.

On the basis of aneurysm location, there were 8.1% morbidity and 6.4% mortality rates in anterior circulation aneurysms and 9.6% morbidity and 6.1% mortality rates in posterior circulation aneurysms (34).

Eskridge et al reviewed the results of 150 patients with basilar tip aneurysms (ruptured - 83, unruptured – 67) treated with GDC coils. Conservative mortality rates included up to 23% for the ruptured aneurysm group and up to 12% for the unruptured aneurysm group%. Permanent deficit due to stroke in patients with ruptured and unruptured aneurysms occurred in up to 5% and 9% respectively.Vasospasm occurred in 8% of cases. Periprocedural mortality was 2.7%, all occurring in ruptured aneurysms (51).

Bavinzski et al studied endovascular treatment of cavernous ICA aneurysms in 42 patients with 48 aneurysms. Ophthalmoplegia resolved or improved in nine of 12 patients treated with parent artery occlusion. One thromboembolic stroke and three transient ischemic attacks occurred perioperatively, for a permanent morbidity of 3.5% and a transient morbidity of 9%. There was no mortality (58).

Kuether et al treated 77 aneurysms over a period of 4.5 years. The average clinical follow-up period was 2.2 years. The procedure-related morbidity rate was 9.1%, with a 7.8% risk of death from aneurysm perforation, stroke, or delayed hemorrhage (37).

Gruber et al evaluated 30 patients with 31 giant or very large aneurysms were considered to show unacceptable risk/benefit ratios for open surgery and were treated using the Guglielmi detachable coil method. Overall, 73.3% of the population experienced excellent to good recoveries (Glasgow Outcome Scale scores of 4 or 5), with a 13.3% procedure-related morbidity rate and a 6.7% procedure-related mortality rate. Two hemorrhaging episodes occurred after GDC treatment (annual bleeding rate-2.5%). Symptoms related to aneurysmal mass effect were improved for 45.5% of the patients presenting with signs of neural compression (40).

A retrospective analysis of 112 cases of ruptured posterior circulation aneurysms treated using GDC coils over a period of 7 years was done by Lempert et al. Excellent clinical outcome (Glasgow outcome scale=1) was seen in 100% patients with Hunt and Hess grade1 at presentation, 88% with Hunt and Hess grade 2, 78% with Hunt and Hess grade 3, 46% with Hunt and Hess grade 4.Overall, at latest follow up, 74% patients showed good recovery (GOS 1), 9% had moderate disability (GOS 2), 5% were permanently disabled (GOS 3), 1% were vegetative (GOS 4) and 11% were dead.

Rebleeding was seen in 1 patient (0.9%) with 90% embolization on follow up .A permanent morbidity rate of 2.8% was reported (43).

During 6 years, 29 patients with 31 very large or giant (20–55-mm) cerebral aneurysms were initially treated with detachable coils by Sluzewski et al. Twenty-three (79%) of 29 patients had a good clinical outcome at a median follow-up of 50 months. In four (50%) of eight patients, symptoms of mass effect improved after coiling (47).

Friedman et al retrospectively analyzed 83 patients with GDC coil embolization over a period of 10 years. Sixty-four patients (77%) had a Glasgow outcome scale of 4-5, 9 (11%) had a score of 2-3, and 10 (12%) died. Over all, each GDC occlusion procedure was accompanied with a mortality rate of 0.8%, a permanent neurologic morbidity rate of 0.8%, and a temporary or non-neurologic morbidity rate of 11.6% (46).

Henke et al retrospectively reviewed 1811 intracranial aneurysms in 1579 patients treated with coil occlusion. The ischemic complication rate was 9%, and the hemorrhagic complication rate was 3%. The early procedural morbidity rate was 5.3%, and the procedural mortality rate was 1.5%. The management mortality rate was 4.4% (67).

S Claiborne Johnston et al evaluated 68 surgically treated patients and 62 patients treated with endovascular techniques for the procedure risk and clinical follow up evaluation. A larger proportion of patients in surgical group (25%) developed significant neurological deterioration (Rankin scale score change of >2) as compared to the endovascular group (8%). Total lengths of stay and hospital charges were also more for the surgical group than the endovascular group. At a mean follow up of 3.9 years surgical patients were more likely to report persistent new symptoms or disability since treatment (34%) compared to endovascular group (8%) (85).

A total of 2621 patients with unruptured intracranial aneurysms in 53 participating centers were evaluated for their natural history without any treatment and following surgical clipping in the first phase of International study of unruptured intracranial aneurysms presented in 1998. The aneurysms were divided into two groups: group 1 with no history of subarachnoid hemorrhage from a different aneurysm and group 2 with a history of treated ruptured intracranial aneurysm different from the present one. The overall surgery related morbidity and mortality was 17.5% in-group 1 and 13.6% in-group 2 at 30 days and was 15.7% and 13.1% at 1 year, which was significantly greater than the risk of rupture (91).

In the second phase of the study, 1917 patients were treated with surgery and clinically evaluated after 1 year. The results in the second phase of the study were slightly better with 1 year overall morbidity and mortality being 12.6% and 10.1% for group 1 and group 2 respectively. Predictors for poor surgical outcome were age of patients > 50 years, large aneurysm size, location in posterior circulation, history of ischemic cerebrovascular disease, and presence of aneurysm symptoms other than rupture (66).

A mild decrease in complication rate was noted in our series with experience so that the complication rate decreased from 23% for cases before and including 2000 to 21.8% for cases after 2000. Vineeta et al have shown that the risk of complications with coil embolisation of unruptured aneurysms appears to decrease dramatically with physician experience (90). The present study did not show the same dramatic results because of the variability in case complexities and variable techniques chosen in the present study.

No case of rebleed was noted in our series, which was similar to the results seen, by Sedat et al, Friedman et al and Nicholas et al (68, 46, 50). The rebleeding rates after aneurysm coiling in literature for ruptured intracranial aneurysms varied from 0 by Friedman et al, 1.45% by Sluzewski et al, 0.9% by Lempert et al, 2% by Bavinzski et al, 1% by Cognard et al and 3.3% by Eskridge et al (46, 47, 43, 41, 38, 51). In cases of unruptured intracranial aneurysms, the rebleeding rates varied from 0 by Sluzewski et al, 2.6% by Uda et al to 4.1% by Eskridge et al (47, 52, 51).

The complication rate in our series is comparable to that of other series during their initial phase. Although not statistically significant, the mortality rate was more frequent in ruptured aneurysms than unruptured aneurysms.

CONCLUSION

1. A statistically significant relationship was noted between the neck size and the immediate angiographic outcome, with narrow necked aneurysms showing good packing and completeness of coiling.
2. The long-term angiographic recurrences were found more often in large sized aneurysms than small sized ones.
3. Both balloon occlusion and endovascular coiling are reasonably safe and result in occlusion of the aneurysm in the majority of patients having cavernous ICA aneurysms with resolution of symptoms from cranial nerve compression in majority of cases.
4. No cases of rebleed in endovascularly treated intracranial aneurysm was noted suggesting that even partial occlusion of intracranial aneurysm gave good protection from rebleed.
5. Endovascular treatment of intracranial aneurysms is a safe and effective treatment modality with reasonable morbidity and mortality.

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