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Medium Term Follow up after Endovascular Embolization of Intracranial Aneurysms

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Abstract: Background: Endovascular treatment of Intracranial aneurysms (IAs) is associated with less invasiveness and lower morbidity compared with microsurgical clipping. **Aim:** to assess incidence of recanalization after endovascular management of intracranial aneurysms by at least 6 months follow-up as well as to assess the need for re-embolization. **Methods:** The study included 89 patients presenting with intracranial aneurysms whether ruptured or unruptured referred to the interventional neuroradiology unit for endovascular treatment. All procedures performed at Nasser institute hospitals on a monoplane angiography system (Philips Allura FD imaging system). All patients were treated by endovascular embolization between 2017 and 2020 with follow up angiography to the following management protocol. **Results:** In our study 5 cases from 89 cases developed procedure related complication (5.6%) in the form of: 1 case developed intraprocedural rupture (1.1%), 4 cases developed thromboembolic complications. (4.5%). Six months at least follow up control conventional angiography was done to assess recanalization and the need for re-embolization was reported. Follow up period ranged from 7 to 14 months with mean of 10.75 ± 1.89 months. During the follow up period 21 (24%) patients had recanalization after the endovascular management. During the follow up period none of the recanalized aneurysms presented with rebleeding after treatment. Recanalization was observed in 25 % of ruptured aneurysms and 17 % of unruptured aneurysms. Recanalization was observed in 22% of small aneurysms, and aneurysms and 37% of large aneurysms. Recanalization was observed in 18% of aneurysms with favourable SNR, and in 30 % of aneurysms with unfavourable SNR. **Conclusion:** there were a higher incidence of recurrence in ruptured aneurysms, , aneurysms more than 10 mm, and wide neck aneurysm, however it was not statistically significant. That may be attributed to small number of cases and the short period of the study. Our study also showed that there was no influence of using the remodeling techniques in on the recurrence of the endovascularly treated aneurysms this also may be due to small number of cases treated with remodeling technique in our study. In our study some risk factors affecting the recanalization such as the location of the aneurysm could not be assessed due to small number of cases in some locations

Keywords: Endovascular Embolization, Intracranial Aneurysms, Follow up

Introduction: Intracranial aneurysms (IAs) are localized dilations of the cerebral arterial wall and are prone to rupture, resulting in bleeding. The overall prevalence of unruptured IAs is between 2% and 3.2% in the general population with a male to female ratio of 1:2. It is the leading cause of hemorrhagic stroke, responsible for 85% of spontaneous subarachnoid hemorrhages (SAH). **(1).**

Occlusion of intracranial aneurysms with controlled detachable coils was developed in 1991 **.** This technique has gradually overtaken surgical clipping as the first line management of a ruptured aneurysm in light of the results of the International Subarachnoid Aneurysm Trial (ISAT), which compared the two techniques **(2).**The study showed 6.9% absolute risk reduction in the favor of endovascular coiling.

Endovascular treatment is associated with less invasiveness and lower morbidity compared with microsurgical clipping **(3)** However, recanalization of aneurysms is a disadvantage of such a modality **(4).**

Many factors, including complete initial embolization, stent-assisted coiling, dense packing, and flow diverters, can reduce the recanalization rate **(5).** The large size of aneurysm, wide neck, rupture status, and intraluminal thrombosis are risk factors of recanalization of aneurysms**(6).**

The most meaningful definition of recanalization is recanalization of a volume within the aneurysm large enough to permit retreatment with either endovascular or surgical means (i.e., recanalization classified as major recurrences" by Raymond and colleagues) **(7).**

Aim: to assess incidence of recanalization after endovascular management of intracranial aneurysms by at least 6 months follow-up as well as to assess the need for re-embolization.

Methods:

The study included 89 patients presenting with intracranial aneurysms whether ruptured or unruptured referred to the interventional neuroradiology unit for endovascular treatment.

All procedures performed at Nasser institute hospitals on a monoplane angiography system (Philips Allura FD imaging system).

All patients were treated by endovascular embolization between 2017 and 2020 with follow up angiography to the following management protocol.

Inclusion criteria: Patients treated by endovascular approach for intracranial aneurysm(s)**.,** Patients older than 18 years, Patients having aneurysms smaller than 15 mm. Patients accepting to participate in the study.

Exclusion criteria: Patients having a brain arterio-venous malformation, Patients having a fusiform, dissecting or mycotic aneurysm.

Six months at least follow up control conventional angiography was done to assess recanalization, aneurysm size, neck widening and shape of the aneurysm. Any changes in the morphology of the aneurysm or the coil mass will be evaluated, and the need for re-embolization was reported.

Preoperatively, all patients were examined according the following sheet:

History Taken from the patient himself or his/her relatives according to his conscious level)

Examination: Vital signs (pulse, blood pressure, respiration and temperature). Systematic review with stress on cardiac, respiratory, and ophthalmologic examination**.** Neurological examination including, conscious level: we used Glasgow Coma Scale (GCS), Cranial nerves examination, motor and sensory examination.

Radiological imaging:

CT scan: was done for all patients to look for Subarachnoid Hemorrhage (SAH) and/or lesions (susceptible Aneurysms), CTA, MRI & MRA (with and without contrast): done mainly in elective patients with suspicious lesions (non-ruptured aneurysms), Conventional 4-vessels angiography: giving full data about the aneurysm including site, size, shape, relation to the parent artery, relation to the perforators, relation to the bony landmarks, and the aneurysm dome/neck ratio, and 3D Rotational angiography with digital subtraction.

In each of the 89 patients, we used one (or more) of the following methods of treatment: Simple coiling alone: (63 patients), Balloon assisted coiling: (8 patients), Stent assisted coiling: (15 patients), and Flow diverters: (3 patients).

Each aneurysm's treatment method was tailored for that specific aneurysm according to many factors including the aneurysm size, shape, dome/neck ratio, volume, multiplicity and rupture status (ruptured or not?).

According to the rupture status, we prefer to use coils alone in ruptured aneurysms. Balloon remodeling of the vessel may increase the intra-aneurysmal pressure that lead to rerupture of the already ruptured aneurysm due to wall fragility. Stents and flow diverters are generally not preferred in ruptured aneurysms as the patient has to be preloaded with anti-platelet which may increase the rebleeding risk.

Material used:

Diagnostic cerebral angiography:

1) **Puncture system**: Standard Seldinger technique puncture system using an 18 gauge arterial needle.

2) Femoral sheath:6 French sheaths.

3) Diagnostic catheters: Bern and SIM II (*Mrerit*), (*Cordis*).

4) Guide wires: Two types of 0.035 inch were used Terumo guidewire (*Medi-tech*), Zipwire (*Boston scientific*).

Endovascular embolization:

1. **Simple coiling:**

The materials used in diagnostic cerebral angiography in addition to the following:

1) Guiding catheter: Different types of guiding catheters were used, Chaperon *(Microvention),* guider soft tip (Boston Scientific).

2) Microcatheter: Two types were used, Excelsior 10 (*Stryker*), Echelon 10 (*eV3*).

3) Micro guide wires: Three types were used like Transcend and Synchro I 14 *(Stryker),* and Traxscess *(Microvention).*

4) Coils: Platinum microcoils were the standard endovascular materials used for aneurysm occlusion. Many designs were used including 3D coils, 360° coils and helical coils, with different degrees of softness for framing, filling and finishing and from many manufacturers, Axium, Axium prime*(eV3)*, Target *(Stryker)* and Microplex*(Microvention)* and Optima *(Balt)*.

2. **Balloon assisted coiling:**

The same material used in simple coiling in addition to the following:

1) Remodeling balloon: Super compliant single lumen balloons, Hyperform (*eV3*), Transform (*Stryker*) and double lumen balloon like Sceptor XC (*Microvention*) and Eclipse (*Balt*).

3. **Stent assisted Coiling:**

The same material used in simple coiling in addition to the following:

1) Long sheath: in most of cases of stent assisted coiling a long sheath is used to add more support system during navigation and deployment of the stent. We used two types of long sheath either Brite tip 90 cm (*cordis*) or IVA 80 cm (*Balt*).

2) Intermediate catheter (Distal access catheter): Three types used. Catalyst (*Stryker*), SOFIA (*Microvention*) and Navien (*ev3*).

3) Remodeling stents: Two types of stents used either laser cut or braided stents. Neuroform atlas (laser cut stent) (*stryker*) Leo and Leo baby (braided stent) (*balt).*

4. **Flow diverter :**

The same material used in simple coiling in addition to the following:

1) Long sheath: in most of cases of stent assisted coiling a long sheath is used to add more support system during navigation and deployment of the stent. We used two types of long sheath either Brite tip 90 cm (*cordis*) or IVA 80 cm (*Balt*).

2) Intermediate catheter (Distal access catheter): Three types used. Catalyst (*Stryker*), SOFIA (*Microvention*) and Navien (*ev3*).

3) Flow diverter stents: two types of flow diverter stents were used, Pipeline Embolization Device (PED flex) (*ev3*) and Silk (*balt*).

Technique of Diagnostic Cerebral Angiography:

Under local anesthesia (general), right femoral puncture is performed using 6 French femoral sheath. Selective catheterization of both ICA and dominant vertebral arteries was done using either 5 French Bern, or Simone II catheter over 0.035 inch hydrophilic guide wire according to vessel tortousisty or anatomical variant. Bilateral vertebral angiography is performed in case of suspected PICA aneurysm. Diagnostic angiography is performed at AP and lateral views as slandered views. 3D rotation angiogram then is performed for better understanding of the aneurysm size, dome to neck ratio and relation between the aneurysm and parent artery. After finishing the 4-vessel angiography, we remove the femoral sheath and perform manual compression for 20-30 minutes.

Technique of Therapeutic Cerebral Angiography:

Steps are essentially the same as the diagnostic angiography with addition of a micro-catheter and a thinner guide microwire that are advanced to level of the aneurysm through the guiding catheter (6 French) which cannot be advanced distal to the skull base level. This microcatheter is smaller in diameter than the diagnostic catheter and more malleable to reach the distal cerebral circulation without injury of the soft blood vessels.

According to the method of treatment, we used these following more steps:

1-Embolization of aneurysms with simple coiling:

We selectively catheterize the aneurysm with the microcatheter, and start insertion and deployment of the coils through the microcatheter inside the aneurysm. Deployment of the coils through the microcatheter inside the aneurysm.

The coil has a radiopaque marker that confirms the position of the coil in the aneurysm under fluoroscopy. When the platinum part of the coils confirmed to be completely within the aneurysm cavity, it is separated from its metal pushing part by a special device. The coil pusher is then removed from the microcatheter and the same process is repeated until we have a good packing density and volume fill of the aneurysm.

Post embolization angiogram is then done to visualize the treatment result and to exclude complications such as distal embolism, dissection of the arterial wall, herniation of a coil loop into the parent artery, and aneurismal perforation. At the end, microcatheter is then removed and the remaining steps are continued.

2-Embolization of aneurysms with coils and balloon remodeling technique

Through a guiding catheter, we selectively catheterize the aneurysm with a microcatheter and a microwire.

The balloon catheter then advanced through the guiding catheter to the level of the aneurysm. After confirmation of the optimal position of the balloon, we start coiling of the aneurysm. We inflate the balloon with contrast during deployment of the initial coils to stabilize the coil mass within the aneurysm cavity and prevent its herniation into the parent artery through the aneurysm's wide neck.

After deployment of the initial coils, the balloon is deflated and we do an angiographic run to make sure the coil mass is stable within the aneurysm cavity. Balloon inflation and deflation can be repeated according the stability of the coil mass with the successive coils deployment within the aneurysm. When coiling is over, the balloon is inflated again and the microcatheter is slightly withdrawn. The balloon then deflated. Final control angiogram is performed and then the micro-balloon catheter is removed.

3-Stent-Assisted Coiling:

In stent assisted coiling it was preferred to use co axial system to add more support and stabilization and of the system during navigation and deployment of the stent.

A long sheath (either 90 or 80 cm was advanced and placed in the in the internal carotid artery or vertebral artery. After that an intermediate catheter is advanced through the long sheath as distal as possible. Through the intermediate catheter, the stent microcatheter is

advanced beyond the level of the aneurysm where the stent is deployed across the neck of the aneurysm.

After that, the coiling microcatheter was advanced over a microwire through the intermediate catheter to selectively catheterize the aneurysm. Then deployment of the stent was done. The diameter of the stent is selected based on the parent vessel diameter while its length is selected based on the length of the aneurysm's neck.

If the wide neck aneurysm arises at a vessel bifurcation, as in basilar tip aneurysms, then a Y-shaped stent configuration in used.

Post stent angiogram is then repeated. After stent deployment coiling of the aneurismal sac was started. When coiling is over, post embolization angiography was done and the microcatheter and guiding catheter are then removed.

4-Flow diverter device:

In flow diverter we used co axial system to add more support and stabilization and of the system during navigation and deployment of the flow diverter stent.

A long sheath (either 90 or 80 cm was advanced and placed in the in the internal carotid artery or vertebral artery. After that an intermediate catheter is advanced through the long sheath as distal as possible. Through the intermediate catheter, the stent microcatheter is advanced beyond the level of the aneurysm where the stent is deployed across the neck of the aneurysm.

After that, the coiling microcatheter was advanced over a microwire through the intermediate catheter to selectively catheterize the aneurysm. Then deployment of the stent was done. The diameter of the stent is selected based on the parent vessel diameter while its length is selected based on the length of the aneurysm's neck.

Post stent angiogram is then repeated. After stent deployment coiling of the aneurismal sac was started. When coiling is over, post embolization angiography was done and the microcatheter and guiding catheter are then removed.

Follow up protocol:

Six months at least follow up control conventional angiography was done to assess recanalization, aneurysm size, neck widening and shape of the aneurysm. Any change in the morphology of the aneurysm or the coil, in the form of coil compaction, coil migration through the aneurysm wall, and aneurysm growth was evaluated, and the need for re-embolization was reported.

Statistical methods:

Data were statistically described in terms of frequencies (number of cases) and percentages. Comparison between the study groups was done using Chi-square (χ^2) test. Yates's correction equation was used instead when the expected frequency is less than 5. Two-sided *p* values less than 0.05 was considered statistically significant. IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows was used for all statistical analyses.

Results

This study included 89 patients with intracranial aneurysms, their age ranged from 18 to 69 years (with mean of 43.93 ± 11.58 years). 56 (62.92%) of study participants were females while 33 (37.08%) were males. As regard risk factors: 32 patients (35%) were hypertensive,25 patients (28%) were smokers and 30 patient (33 %) were diabetic. Regarding the status of aneurysm, it was ruptured in 72 (80.9%) patients and non-ruptured in 17 (19.1%) patients (Table 1).

Table (1): Age, distribution, risk factors of population in the study

Age (years)	**Mean ± SD**	**43.93 ± 11.58**
	Range	18 – 69
Gender	**Female**	56 (62.92%)
	Male	33 (37.08%)
Smoking	**Smokers**	**25 (28.09%)**
	Non-smokers	64 (71.91%)
DM	**Diabetic**	30 (33.71%)
	Non-diabetic	59 (66.29%)
HTN	**Hypertensive**	32 (35.96%)
	Non-hypertensives	57 (64.04%)
Rupture Status of aneurysm	Ruptured	72 (80.9%)
	Non-ruptured	17 (19.1%)

Aneurysmal sac diameter, less than or equal to 10 mm was considered small, while more than 10 mm was considered large. Giant aneurysm was not included in our study. Aneurysm size ranged from 3 to 15 mm with a mean of 6.36 ± 2.94 mm. 81aneurysms (90.1%) were small and 8 aneurysms (8.9%) were large. giant aneurysm not included in our study. Sac neck ratio (SNR) was considered favorable if ≥ 1 and unfavorable if <1. Sac-neck ratio was favorable in 53 (59.55%) patients and unfavorable in 36 (40.45%) patients. Neck width <4 mm was considered narrow, while if ≥ was considered wide. In our study 76 (85.3%) were narrow neck aneurysms, and 13 (14.6 %) were wide neck. (Table 2).

Table (2): Aneurysm morphology.

Characteristics	
N. of aneurysm	89
Size of aneurysm	
Small≤10mm	81(90.1%)
Large>10mm	8(8.9%)
Neck diameter	
Narrow<4mm	76 (85.3%)
Wide≥4mm	13(14.6%)
SNR	
Favorable	53 (59.55%)
Unfavorable	36 (40.45%)

In our study among the 89 aneurysms 81 (91.01%) were located in the anterior circulation, while 8 (8.99%) were located in the posterior circulation (Table 3). The most common sites of intracranial aneurysm were A. com in 36 (40.45%) patients followed by MCA bifurcation in 15 (16.85%) patients. The least common sites were SCA, supraclinoid, azygos ACA and cavernous carotid each occurred in only 1 (1.12%) patient

Table (3): Location of intracranial aneurysm in the study participants

		Study participants (n =89)
Circulation	**Anterior**	81 (91.01%)
	Posterior	8 (8.99%)
Aneurysm site	**A com.**	36 (40.45%)
	MCA bifurcation	15 (16.85%)
	ICA bifurcation	8 (8.99%)
	P com	6 (6.74%)
	Para-ophthalmic	6 (6.74%)
	Basilar	5 (5.62%)
	A1 segment	4 (4.49%)
	Pericallosal	3 (3.37%)
	PICA	2 (2.25%)
	SCA	1 (1.12%)
	Supraclinoid	1 (1.12%)
	Azygos ACA	1 (1.12%)
	Cavernous	1 (1.12%)

A.com: Anterior communicating artery, ACA: Anterior cerebral artery, ICA: Internal carotid artery, MCA: Middle cerebral artery, P.com: Posterior communicating artery, PICA: Posterior inferior cerebellar artery, SCA: Superior cerebellar artery.

Technique of endovascular management:

In our study among the 89 aneurysms, the techniques used for management were simple coiling in 63 (70.79%) patients, balloon assisted coiling in 8 (8.99%) patients, stent assisted coiling in 15 (16.85%) patients, , and flow diverter in 3 (3.37%) patients (Table 4).

Table (4): Technique of endovascular embolization in the study

Technique used with aneurysm	**Simple coiling**	**63 (70.79%)**
	Stent assisted coiling	15 (16.85%)
	Balloon assisted coiling	8 (8.99%)
	Flow diverter	3 (3.37%)

Incidence of procedure related complications.

In our study 5 cases from 89 cases developed procedure related complication (5.6%) in the form of: 1 case developed intraprocedural rupture (1.1%). 4 cases developed thromboembolic complications. (4.5%).

Radiological follow up after endovascular embolization:

Six months at least follow up control conventional angiography was done to assess recanalization and the need for re-embolization was reported.

Follow up period ranged from 7 to 14 months with mean of 10.75 ± 1.89 months. During the follow up period 21 (24%) patients had recanalization after the endovascular management During the follow up period none of the recanalized aneurysms presented with rebleeding after treatment.

Among the 24 recanalized aneurysms 18 aneurysms required retreatment.

In our study major recanalization that require retreatment was defined as any increase of aneurysm contrast filling during follow-up, a 10% increase of aneurysm contrast filling, reopening of an initially completely occluded aneurysm, or deterioration in angiographic appearance of at least 2 mm (defined as a major recurrence).

Incidence of recanalization rate in relation to rupture status of the aneurysm:

Recanalization was observed in 25 % of ruptured aneurysms and 17 % of unruptured aneurysms (Table 5).

The results of the chi-squared test indicate that the association between recanalization and rupture status of the aneurysm is not statistically significant, where the p-value is 0.745.

Table (5): Incidence of recanalization rate in relation to rupture status

Rupture status		
	N. of aneurysms	N. of recanalized aneurysms. %
Ruptured	72	18 (25%)
Unruptured	17	3 (17%)

Incidence of recanalization rate in relation to size of the aneurysm:

Recanalization was observed in 22% of small aneurysms, and aneurysms and 37% of large aneurysms (Table 6). The results of the chi-squared test indicate that the association between recanalization and size of aneurysm is not statistically significant, where the p-value is 0.593.

Table (6): Size of aneurysm and recanalization rate.

Size of aneurysm		
	N. of aneurysms	N. of recanalized aneurysms. %
Small≤10	81	18 (22.2%)
Large>10	8	3 (37%)

Incidence of recanalization in relation to neck width of the aneurysm:

Recanalization was observed in 20.7% of narrow neck and 41.6 % of wide neck aneurysms (Table 7).

Table (7): Incidence of recanalization in relation to neck width of the aneurysm:

Neck diameter of aneurysm		
	N. of aneurysms	N. of recanalized aneurysms. %
Narrow<4mm	77	16 (20.7%)
Wide≥4mm	12	5 (41.6%)

The results of the chi-squared test indicate that the association between recanalization and neck width of aneurysm is not statistically significant, where the p-value is 0.223.

Incidence of recanalization in relation to Sac to neck ratio (SNR):

Recanalization was observed in 18% of aneurysms with favourable SNR, and in 30 % of aneurysms with unfavourable SNR (Table 8).

The results of the chi-squared test indicate that the association between recanalization and SNR of aneurysm is not statistically significant, where the p-value is 0.308

Table (8): Incidence of recanalization in relation to SNR

SNR		
	N. of aneurysms	N. of recanalized aneurysms. %
Unfavorable	36	11 (30%)
Favorable	53	10(18%)

Incidence of recanalization in relation to the techniques used for embolization:

Among 63 aneurysms treated by simple coiling 18 (28.5%) aneurysms were recanalized, and among 15 aneurysms treated by stent-assisted coiling 1(6.6%) aneurysms was recanalized . and among 8 aneurysms treated by balloon remodeling 2(25%) aneurysms were recanalized and no recanalization was observed in the 3 aneurysms treated by flow diverter (Table 9) The results of the chi-squared test indicate that the association between recanalization and technique used for management of the aneurysm is not statistically significant, where the p-value is 0.237

Table (9): Incidence of recanalization in relation to technique of embolization

Technique used		
	N. of aneurysms	N. of recanalized aneurysms. %
Simple Coiling	63	18 (28.5%)
Stent-assisted coiling	15	1 (6.6%)
Balloon assisted coiling	8	2(25%)
Flow diverter	3	0(0%)

A 39 year old male patient presented with headache and neck stiffness with slight confusion. GCS was 14/15.CT brain showed diffuse SAH (Figure 1A). DSA revealed a small pericallosal aneurysm measuring 3 mm with narrow neck, sac/neck ratio of 2 (Figure 1B). And so, decision was made to do simple coiling, with complete occlusion of the aneurysm without immediate post coiling complications (Figure 1C). 12 months follow up shows no evidence of recanalization (Figure 1D).

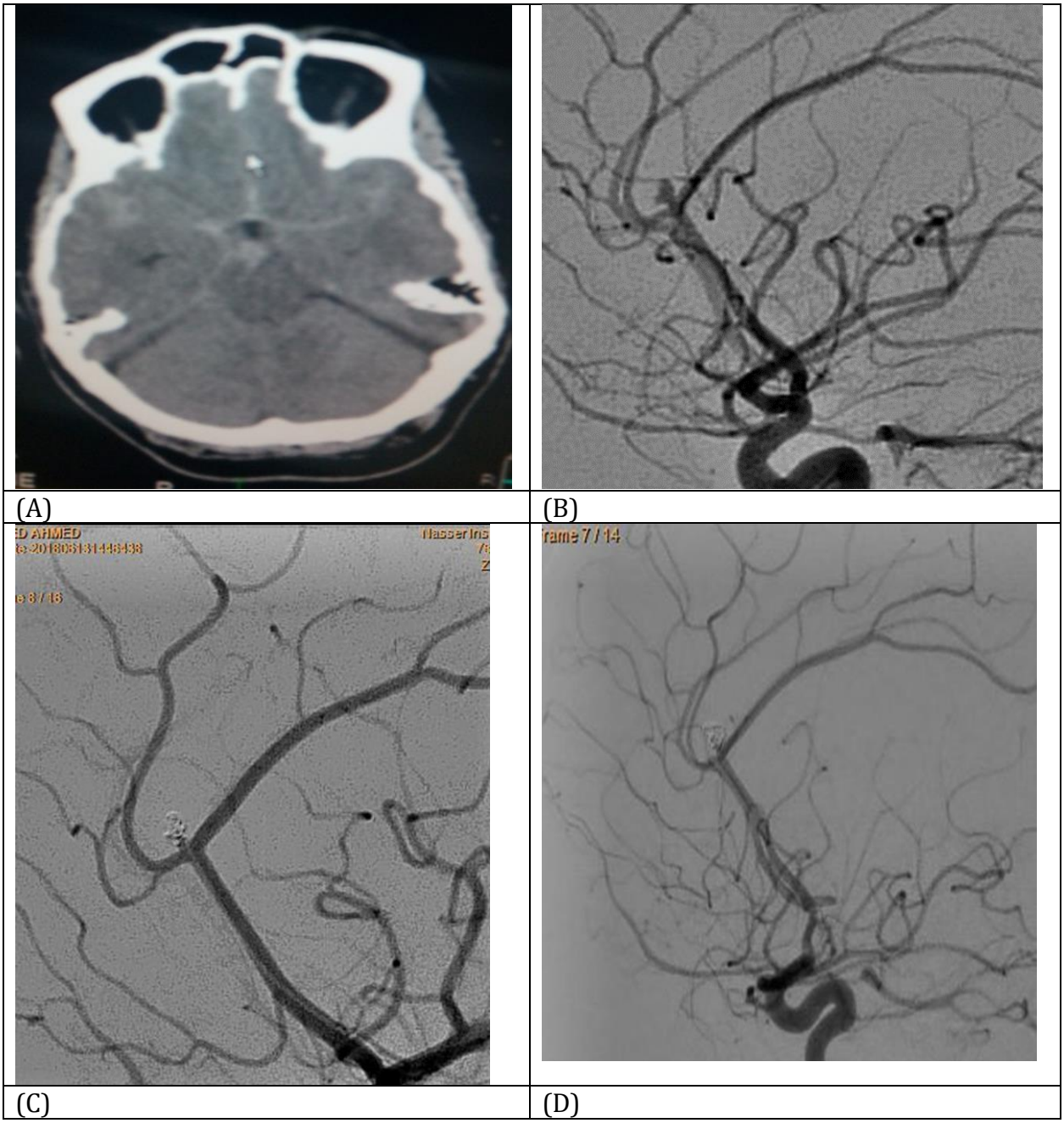

Figure 1: (A) brain shows diffuse SAH, (B): Diagnostic angiography showed pericallosal aneurysm. (Red arrow) ruptured pericalloal aneurysm). (C): Final control angiogrm showed complete occlusion of the aneurysm.(Red arrow) coil mass secure the aneurismal sac with no protrusion in the parent

artery. (D): 12 months follow up show no evidence of recanalization.(Red arrow) stable coil mass at follow up with no recanalization

Discussion

Aneurysm treatment is dedicated to prevention of rupture (for unruptured aneurysms) or rebleeding (for ruptured aneurysms). Endovascular embolization has become the first-line of treatment for intracranial aneurysms in the majority of cases in many institutions. This minimally invasive approach achieved lower morbidity and mortality rates when compared with surgical management **(3).**

However, although successful in improving patient care, its durability has been noted to be its Achilles' heel since the earliest application of this technology. Indeed, after endovascular treatment (EVT) around 20% of patients will experience aneurysm or neck reopening after endovascular embolization, necessitating retreatment **(8).**

Aneurysm recanalization has two primary risks: rebleeding/bleeding and retreatment. In previously ruptured aneurysms, recanalization exposes the patient to an aneurysm rebleed. The overall rate of target aneurysm rebleeding within the first year after coiling in the **ISAT** trial was 2.7% (26/959), with a mortality rate of 57.7% (15/26). **(3).**

The risks associated with retreatment of recanalized aneurysms are considerable. Evidence from a recent meta-analysis indicates a procedural mortality risk for retreatment of a previously coiled ruptured aneurysm of 0.8% for coiling after coiling, 2.2% for flow diverter after coiling, and 5.6% for surgery after coiling, with an overall combined retreatment morbidity/mortality risk of 6–11%. (**9).**

Here, we will discuss our results in comparison to results published in literature regarding follow up after endovascular embolization of intracranial aneurysms, and the incidence of recanalization and need for retreatment**.**

In our study we followed up 89 patients with intracranial aneurysms treated by endovascular embolization we had 56 (62.9 %) female and 33(37.08%) male with mean age 43.94 years. It is reported in literature that incidence of cerebral aneurysms is higher in females than males.

In Tian Z et al (10) a study performed to assess risk factors of recurrence after endovascular embolization with a total of 504 patients were included, 285(56.5%) of them were females and 219(43.5%) were males. The patient ages ranged from 39 to 59 years with a mean age of 48 years.

As regard risk factors: 32 patients (35%) were hypertensive.25 patients (28%) were smokers and 30 patients (33 %) were diabetics.

While smoking is clearly associated with the development and rupture of IA, its role in aneurysm recurrence remains unclear. No other modifiable factors (elevated blood pressure, diabetes mellitus, or dyslipidemia) have been clearly associated with aneurysm recurrence after coiling.**Pierot L et al (11)**

Regarding the rupture status of the aneurysm, in our study, it was ruptured in 72 (80.9%) patients and non-ruptured in 17 (19.1%) patients.

In Wiśniewski Ket al (12) a study done to assess the risk factors for recanalization after coil embolization a total of 184 aneurysms treated by endovascular embolization, the unruptured group was 118 (64%) and the ruptured group was 66 (35.8%).

As regard the aneurysm morphology in our study all 89 aneurysms were saccular, and the size ranged from 3 to 15 mm with a mean of 6.36 ± 2.94 mm, Sac-neck ratio was favorable in 53 (59.55%) patients and unfavorable in 36 (40.45%) patients. In our study 76 (85.3%) were narrow neck aneurysm, and 13 (14.6 %) were wide neck.

In our study among the 89 aneurysms 81 (91.01%) were located in the anterior circulation, while 8 (8.99%) were located in the posterior circulation.

The most common sites of intracranial aneurysm were A comm in 36 (40.45%) patients followed by MCA bifurcation in 15 (16.85%) patients. The least common sites were SCA, supraclinoid, azygos ACA and cavernous each occurred in only 1 (1.12%) patient.

Pierot Let al (11), Analysis of Recanalization after Endovascular Treatment of Intracranial Aneurysm (ARETA) Study in a total of 1088 aneurysms it was anterior cerebral artery or anterior communicating artery 439 (40.3%) middle cerebral artery 221 (20.3%) intradural internal carotid artery 338 (31.1%) extradural internal carotid artery 13 (1.2%) vertebrobasilar 77 (7.1%).

In our study 5 cases from 89 cases developed procedure related complication (5.6%) in the form of, 1 case developed intraprocedural rupture (1.1%), 4 cases developed thromboembolic complications. (4.5%).

Pierot L et al (11), Technical adverse events with or without clinical modification were encountered in 15.4% of patients and included thromboembolic complications (7.1% per procedure), intra-operative rupture (2.6% per procedure), and device-related problems (2.9% per procedure).

In our study at least six months follow up control conventional angiography was done to assess the incidence of recanalization and the need for re-embolization was reported. Follow up period ranged from 7 to 14 months with mean of 10.75 ± 1.89 months. During the follow

up period 21 (24%) patients had recanalization after the endovascular management. Among the 24 recanalized aneurysms 18 aneurysms need for retreatment.

In our study major recanalization that require retreatment was defined as any increase of aneurysm contrast filling during follow-up, a 10% increase of aneurysm contrast filling, reopening of an initially completely occluded aneurysm, or deterioration in angiographic appearance of at least 2 mm (defined as a major recurrence).

Pierot Let al (11), in a study to asses patient and aneurysm factors associated with aneurysm recanalization after coiling the incidence of recanalization at mid-term follow-up was observed in 279/945 aneurysms (29.5%).

Jeon JP.et al (13) Risk Factor Analysis of Recanalization Timing in Coiled Aneurysms: Early versus Late Recanalization total of 870 coiled saccular aneurysms were monitored for extended periods (mean, 30.8 ± 8.3 months), 180 (20.6%)aneurysms showed recanalization. Retreatment was recommended for major recanalized aneurysms.

Tomalski Wet al (14), study to asses recanalization of cerebral artery aneurysms treated endovascularly — a midterm follow-up, 78 patients completed a 12-month follow-up period. In 11(14%) of those, a follow-up revealed recanalization 12 months after the intervention.

Renowden SA et al (15) retreatment of previously embolized cerebral aneurysms: the risk of further coil embolization does not negate the advantage of the initial embolization, revealed Of a total of 1834 aneurysms in 1631 patients, 100 aneurysms in 99 patients treated between January 1996 and December 2005 required additional coiling because of an enlarging remnant and subtotal occlusion. This comprised 6% of the patients treated.

As regard rebleeding after endovascular embolization .In our study none of our recanalized aneurysms was presented with rebleeding.

Aikawa H et al (16) Rebleeding after endovascular embolization of ruptured cerebral aneurysms**,** rebleeding after endovascular embolization was observed in six of the 227 patients (2.6%).

Chang SH et al (17) rebleeding of ruptured intracranial aneurysms in the immediate postoperative period after coil embolization, The incidence of rebleeding of ruptured aneurysms after coil embolization was 2.1% (7/330).

In our study recanalization was observed in 25 % of ruptured aneurysms and 17 % of unruptured aneurysms. The results of the chi-squared test indicate that the association between recanalization and rupture status of the aneurysm is not statistically significant,

where the p-value is 0.745. That may be due to lower number of cases of unruptured aneurysms in our study.

Zhang Q et al (18) Predisposing factors for recanalization of cerebral aneurysms after endovascular embolization, the study showed that there is no association between the rupture status of the aneurysm and recurrence. In that study, 10(25%) ruptured aneurysms were observed in the recanalization group (40 aneurysm), and 50 (20.6%) in the non-recanalization group (243 aneurysms), *P*=0.526.

Pierot Let al (11), in a study to assess Patient and aneurysm factors associated with aneurysm recanalization after coiling the incidence of recanalization was observed in 196/614 (31.9%), in ruptured aneurysms , while it was 83/331 (25.1%)in unruptured aneurysms. The study showed that there is strong association between the rupture status of the aneurysm and the recanalization. That may be due to that the condition of a ruptured aneurysm sac could disturb coil distribution and then we might insert less coils to avoid intra-operative rupture caused by coil perforation. In this condition, a lower packing density and disturbed coil distribution contribute to recanalization of the sac.

Tan IY et al (19) a study to asses recanalization rates after endovascular coil embolization in a cohort of matched ruptured and unruptured cerebral aneurysms, the unruptured aneurysm group has a lower rate of recanalization 10/49 (20.4%) compared to the ruptured aneurysm group 19/47 (40.4%). The study showed strong association between the incidence and the rupture status of the aneurysm.

In our study recanalization was observed in 22.2% of small aneurysms, and 37% of large aneurysms.

The results of the chi-squared test indicate that the association between recanalization and size of aneurysm is not statistically significant, where the p-value is 0.593. That may be due to small number of large aneurysms included in our study.

Zhang Q et al (18) Predisposing factors for recanalization of cerebral aneurysms after endovascular embolization: a multivariate study, showed that Aneurysm size was significantly associated with recanalization, as previously reported. What is more, it was also found a 4.5 folds increase in the risk of recanalization with an aneurysm size >10 mm.

Ogilvy CS et al (4) stratification of recanalization for patients with endovascular treatment of intracranial aneurysms, Recanalization was observed in 24.7% of small aneurysms, and 42.8 % of large aneurysms. The study showed Size (>10 mm), independently associated with retreatment.

In our study Recanalization was observed in 20.7% of narrow neck and 41.6% of wide neck aneurysms, also recanalization was observed in 18% of aneurysms with favourable SNR, and

in 30 % of aneurysms with unfavorable SNR. Our study showed that the association between recanalization and neck width of aneurysm is not statistically significant, where the p-value is 0.223.That was may be due to small number of case with wide neck aneurysms.

Zhang Q et al (18) a study to assess the predisposing factors for recanalization of cerebral aneurysms after endovascular embolization: a multivariate study, the incidence of recanalization was observed in 23/126 (18.2%) of wide neck aneurysms and it was 17/157 (10.8%) in narrow neck ones. The study showed that there was a non-significant trend towards recurrence of wide neck aneurysms, *P*=0.075

Pierot Let al (11), in a study to asses patient and aneurysm factors associated with aneurysm recanalization after coiling the incidence of recanalization was observed in 179/557 (32.1%) of wide neck aneurysms and it was 100/388 (25.8%) in narrow neck ones. The neck size was found to be significantly associated with recanalization.

This might be due to the difficulty in achieving dense filling in wide-necked aneurysms. Wide-necked aneurysms often have greater blood flow. Therefore, neck width was also found to be an independent risk factor for the recurrence of aneurysms.

Ogilvy CS et al (4), stratification of recanalization for patients with endovascular treatment of intracranial aneurysms. The study showed that Dome-to-neck ratio (≤1.5) (*P* = 0.454) were not significantly associated with recanalization.

In our study Among 63 aneurysms treated by simple coiling 18 (28.5%) aneurysms were recanalized, and among 15 aneurysms treated by stent-assisted coiling 1(6.6%) aneurysm was recanalized and among 8 aneurysms treated by balloon remodeling 2(25%) aneurysms were recanalized and no recanalization was observed in the 3 aneurysms treated by flow diverter.

The results of the chi-squared test indicate that the association between recanalization and technique used for management of the aneurysm is not statistically significant, where the p-value is 0.237.

Zhang Q et al (18), study to assess predisposing factors for recanalization of cerebral aneurysms after endovascular embolization, 283 patient was treated either by simple coiling (86 aneurysms) or stent assisted coiling (197 aneurysms), the rate of recanalization was higher in simple coiling group16/86 (18.6%) compared to the stent assisted coiling group24/197(12.2%). Aneurysms treated only by coiling showed a higher percentage in the recanalization group compared with the non-recanalization group (40% vs 28.8%, respectively), though it was demonstrated to be insignificant *P*=0.154.

Pierot Let al (11), in a study to asses Patient and aneurysm factors associated with aneurysm recanalization after coiling the incidence of recanalization was observed in

149/516 (29.8%) in patient treated with coiling alone, and 130/429 (30.3%) in patient treated with balloon remodeling. That was proved to statistically non significant *P* =0.63.

Ogilvy CS et al (4), Stratification of Recanalization for Patients With Endovascular Treatment of Intracranial Aneurysms, the incidence of recanalization after simple coiling 61/147(41.4%) and after stent assisted coiling was 17/107 (15.8%) , and after flow diverter was 1/14(7.1%).

Conclusion

In our study although there were a higher incidence of recurrence in ruptured aneurysms, , aneurysms more than 10 mm, and wide neck aneurysm, however it was not statistically significant. That may be attributed to small number of cases and the short period of the study. Our study also showed that there was no influence of using the remodeling techniques in on the recurrence of the endovascularly treated aneurysms this also may be due to small number of cases treated with remodeling technique in our study. In our study some risk factors affecting the recanalization such as the location of the aneurysm could not be assessed due to small number of cases in some locations/

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