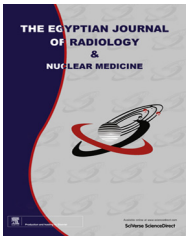
The Egyptian Journal of Radiology and Nuclear Medicine (2013) **44**, 523–530

Egyptian Society of Radiology and Nuclear Medicine

The Egyptian Journal of Radiology and Nuclear Medicine

www.elsevier.com/locate/ejrnm
www.sciencedirect.com



ORIGINAL ARTICLE

Endovascular coiling versus surgical clipping in the treatment of ruptured anterior communicating artery aneurysm in Cairo University Hospitals

Ayman Z. Ahmed [a,*], Ahmed M. Zohdi [b], Mohamed S. Zaghloul [b], Amr K. ElSamman [b]

[a] *Radiology Department, Faculty of Medicine, Cairo University, Cairo, Egypt*
[b] *Neurosurgery Department, Faculty of Medicine, Cairo University, Cairo, Egypt*

Received 27 April 2013; accepted 16 June 2013
Available online 5 July 2013

KEYWORDS

Subarachnoid hemorrhage (SAH);
Anterior communicating artery (Acom);
Endoscope assisted microsurgery (EAM)

Abstract *Introduction:* Aneurysmal Subarachnoid Hemorrhage (SAH) remains a devastating and often fatal form of stroke. The aneurysm is targeted for obliteration to prevent re-bleeding and to manage the possible complications from the event. Endovascular coiling has emerged as a less invasive alternative to conventional surgical clipping to treat aneurysms.

Patients and methods: This study was done prospectively in the Cairo University (Kasr El-Eini) hospitals to evaluate the outcome of both modalities used in the treatment of ruptured anterior communicating artery (Acom) aneurysm. 30 patients with Hunt and Hess grade I, II or III. were classified into two groups of microsurgical clipping (Endoscopic assistance used in five cases) and endovascular coiling.

Results: Mortality rate was higher in the clipping group (26.7%) compared to the coiling group while recurrence rate was high in the coiling group (26.7%). Complications including hydrocephalus, hemiparesis and failed procedures occurred in (6.7%).

Conclusion: We concluded that coiling is better for treating cases of ruptured Acom aneurysms being less invasive and achieving a favorable outcome compared to surgery. While Endoscope-Assisted Microsurgical Clipping (EAM) gives better control during clipping provided that a well-trained, competent and experienced neurosurgeon is available.

* Corresponding author. Tel.: +20 1001405857.
E-mail addresses: ayman28maha@gmail.com, ayman28maha@yahoo.com (A.Z. Ahmed).

Peer review under responsibility of Egyptian Society of Radiology and Nuclear Medicine.

ELSEVIER Production and hosting by Elsevier

1. Introduction

Aneurysmal subarachnoid hemorrhage (SAH) remains a devastating and often fatal condition. In patients who survive the initial ictus, the aneurysm is targeted for obliteration to prevent the occurrence and sequelae of re-hemorrhage events. In recent

0378-603X © 2013 Production and hosting by Elsevier B.V. on behalf of Egyptian Society of Radiology and Nuclear Medicine.
Open access under CC BY-NC-ND license. http://dx.doi.org/10.1016/j.ejrnm.2013.06.007

years, endovascular coiling has emerged as a less invasive alternative to conventional surgical clipping of the aneurysm (1).

The Anterior communicating (Acom) artery aneurysm is the most common location of cerebral aneurysms and accounts for as many as 36% of aneurysms (2). Among patients admitted to hospital in good clinical status for the treatment of ruptured Acom aneurysm, 80% have attained favorable results (3). Nevertheless, as many as 46% of survivors after SAH may experience cognitive dysfunction (2,4).

The International Subarachnoid Aneurysm Trial (ISAT) compared surgical clipping and endovascular coiling of ruptured intracranial aneurysms in a large randomized control trial. After 1 year, the results favored coiling and demonstrated a 7.4% absolute risk reduction in the proportion of patients who died or experienced ongoing dependence due to neurological disability (5,6). This trial had a dramatic impact on the management of aneurysmal SAH, resulting in an increase in the proportion of patients treated by endovascular coiling.

With the most sophisticated microsurgical techniques, the visualization of important structures is still not adequate in a certain number of cases. In those cases, retraction of brain parenchyma, vascular and neural structures, or the aneurysm itself may be necessary. Even the clip may have to be retracted to confirm its relative position to nearby structures (7).

There has been increasing use of neuro-endoscope as a complement to microsurgery. Endoscopic guidance during aneurysm surgery has the advantage of inspecting the blind corner of the surgical microscope also the magnification and illumination capabilities help in identifying deep tiny structures (8).

This paper will evaluate the outcome of microsurgical clipping with or without endoscopic assistance versus endovascular coiling in the treatment of 30 patients with ruptured Acom artery aneurysm done in the Cairo University (Kasr El Eini) Hospitals to provide the best protocol of management for this condition.

2. Patients and methods

This study was done prospectively in the neurosurgery department and the Neuro-intervention unit in the radiology department, Kasr Al Eini School of Medicine, Cairo University, from 6/2010 till 6/2011. 30 patients were admitted to the Emergency Unit of neurosurgery suffering from spontaneous subarachnoid hemorrhage (SAH) due to a ruptured anterior communicating artery (Acom) aneurysm. The age of the 30 patients ranged between 24 and 73 years with a mean age of 46.3 years. Incidence of SAH was slightly more prevalent in females 52.3% compared to males 46.7%.

Patients were divided equally into two groups according to the line of management:

1. Microsurgical clipping where the endoscope was introduced in some cases to visualize pre-clipping view. (15 patients)
2. Endovascular treatment by coiling (15 patients)

All patients included in the study fulfilled the following inclusion criteria:

1. Diagnosed ruptured Acom aneurysm by CTA demonstrating the SAH and the aneurysm.
2. World Federation of Neurosurgical Societies (WFNS) and Hunt-Hess classification grades I, II or III Table 1.
3. Aneurysmal sac size <2.5 cm.

Table 1 WFNS grade utilizes the combination of GCS score and motor deficit; the Hunt and Hess (H&H) grade utilizes only the clinical description Morbidity and mortality rates increase with a higher grade in each scale.

Grade	GCS score	Motor deficit	Clinical description
I	15	Absent	Asymptomatic, mild headache or slight nuchal rigidity
II	13–14	Absent	Moderate to severe headache, nuchal rigidity, and no other neurological deficit except cranial nerve palsy
III	13–14	Present	Drowsiness, confusion, or mild focal deficit
IV	7–12	Present or Absent	Stupor, moderate to severe hemiparesis, and possibly early decerebrate rigidity and vegetative disturbances
V	3–6	Present or Absent	Deep coma, decerebrate rigidity, and moribund appearance

Patients were distributed alternatively among clipping and coiling to minimize selection bias. Patients with Hunt Hess grade IV or V were excluded from the study due to the expected poor outcome irrelevant to the line of management. All patients had full neurological assessment and CT scan pre- and post-treatment.

All patients went for follow up for a period of at least 6 months to evaluate the clinical outcome by the conscious level, neurological deficits if any and performed neuro-imaging studies to follow the ventricular size, related infarctions or resolving intra-cerebral hematoma, Glasgow Outcome Scale (GOS) Table 2 was used for general assessment of the outcome. Four vessels angiography was the standard protocol of follow up in the coiled cases. It was planned at 6 months, 2 years and 4 year intervals from the treatment to insure the stability of the treatment and absence of recurrence. Finally, we compared the results of each modality and tried to figure out the better line of management for ruptured Acom aneurysms.

Table 2 Glasgow Outcome Scale (GOS) for patient follow up assessment.

Grade	Clinical description
1	Death
2	Vegetative state
3	Severely disabled (conscious but the patient requires others for daily support due to disability)
4	Moderately disabled (the patient is independent but disabled)
5	Good recovery (the patient has resumed most normal activities but may have minor residual problems)

3. Results

15 Patients were managed by endovascular coiling Fig. 1. And 15 patients underwent microsurgical clipping with endoscopic assistance used in 5 patients.

The incidence of multiple aneurysms was 10% (three cases). Complications were in the form of hemiparesis 10% (three cases; two of them were transient while one of them was permanent), hemiparesis is suggested to be due to vasospasm as a complication of SAH, no significant difference was detected while comparing the outcome of clipping versus coiling regarding the vasospasm which proves the fact that the vasospasm is a sequelae of SAH and not the method of treatment used. Hydrocephalus occurred in three cases (10%) as a sequelae of SAH for which a ventriculo-peritoneal (VP) shunt was applied, no significant difference in incidence of hydrocephalus following clipping or coiling was seen which proves the fact that the cause is the SAH.

Recurrence of aneurysm occurred in four cases of coiling out of 15 cases (26.7%) which were silent but detected during the follow up angiography done after 6 months of treatment. It required a second session for repacking and all were recoiled safely without recurrence detected in the next control angiography Fig. 2.

Failed procedure occurred in two cases (6.7%) where in one of them microsurgical clipping could not be achieved and the

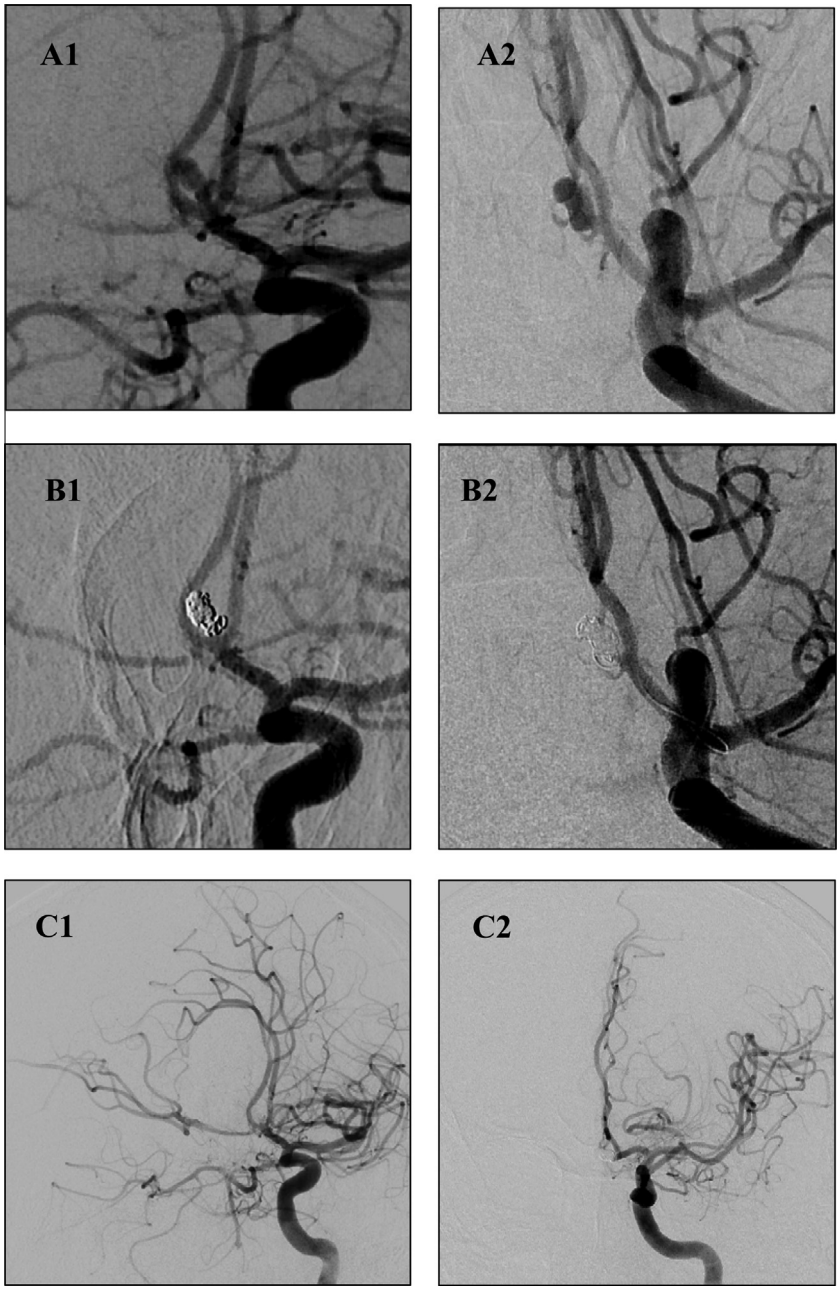


Fig. 1 (A1 and A2) two cases of ruptured anterior communicating (Acom) aneurysms with subarachnoid hemorrhage. (B1 and B2) Coiling of both Acom aneurysms. (C1 and C2) Follow up angiogram 6 months after treatment.

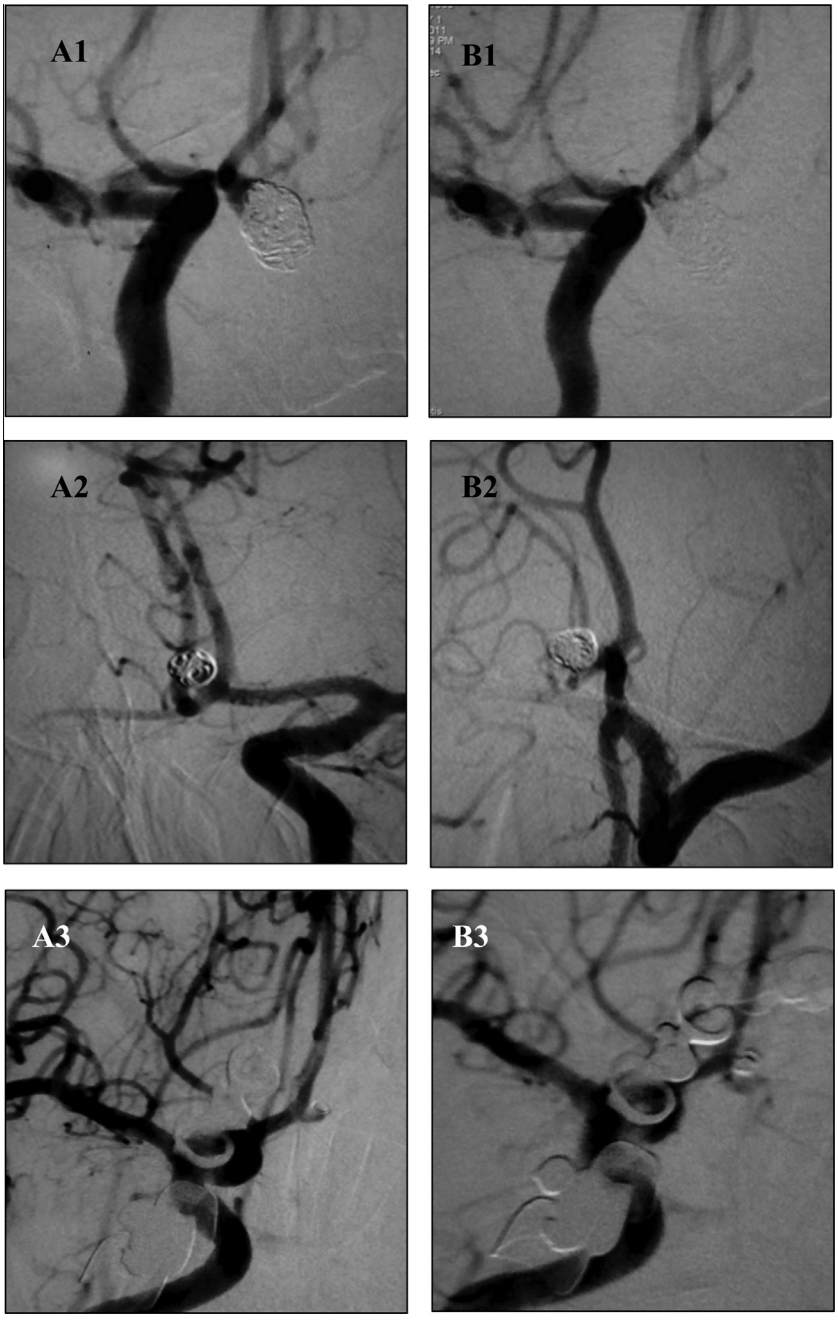


Fig. 2 (A1–A3) three cases of recanalization due to coil impaction discovered on the 6 month follow-up angiogram. (B1–B3) Final angiogram after recoiling showing total closure of the sac and neck.

Table 3 Complications in both groups in relation to total number of cases.

Complications	Clipping	Coiling	Total
Hydrocephalus	2/15 (13.3%)	1/15 (6.7%)	3/30 (10%)
Hemiparesis	1/15 (6.7%)	2/15 (13.3%)	3/30 (10%)
Failed procedure	1/15 (6.7%)	1/15 (6.7%)	2/30 (6.7%)
Recurrence	0%	4/15 (26.7%)	4/30 (13.3%)
Mortality	4/15 (26.7%)	1/15 (6.7%)	5/30 (16.7%)

Table 4 The Glasgow Outcome Scale (GOS) at 6 months follow up for both groups.

Glasgow Outcome Scale (GCS)	Clipping (no. of cases)	Coiling (no. of cases)
1	4	1
2	0	0
3	2	2
4	1	3
5	8	9

Acom was wrapped with the muscle. In one case of coiling after partial occlusion of the aneurysm sac progressive thrombosis of the Rt. A1 and both A2 segments (hypoplastic Lt. A1) were detected for which 40 mg Aggrastat (antiplatelets) and 4 mg Nimotop (Vasodilator) were injected intra-arterially. Complete patency was achieved in the Rt. A1 and both A2 segments and the procedure was aborted at that stage, the patient recovered with no sensory or motor deficits. Coiling was continued in another session with no recurrence noted on the 6 month follow up angiogram. The overall mortality was 16.7% (5 cases out of 30) which was significantly higher in the microsurgical clipping group 26.7% (4 out of 15 cases) compared to 6.7% (1 out of 15 cases) in the coiling group. Table 3 summarizes the incidence of complications related to each modality of treatment used. Glasgow Outcome Scale for both groups at the 6 month follow up is summarized in Table 4.

Endoscope-assistance was used in 5 out of 15 cases of the microsurgical clipping group. Visual confirmation was achieved pre and post-clipping in all of them and in one case the clip needed to be repositioned due to the inclusion of a small perforator branch. In the four mortality cases the surgeon did not use the endoscope and the suggested cause of mortality was hypothalamic insult, while in the mortality case

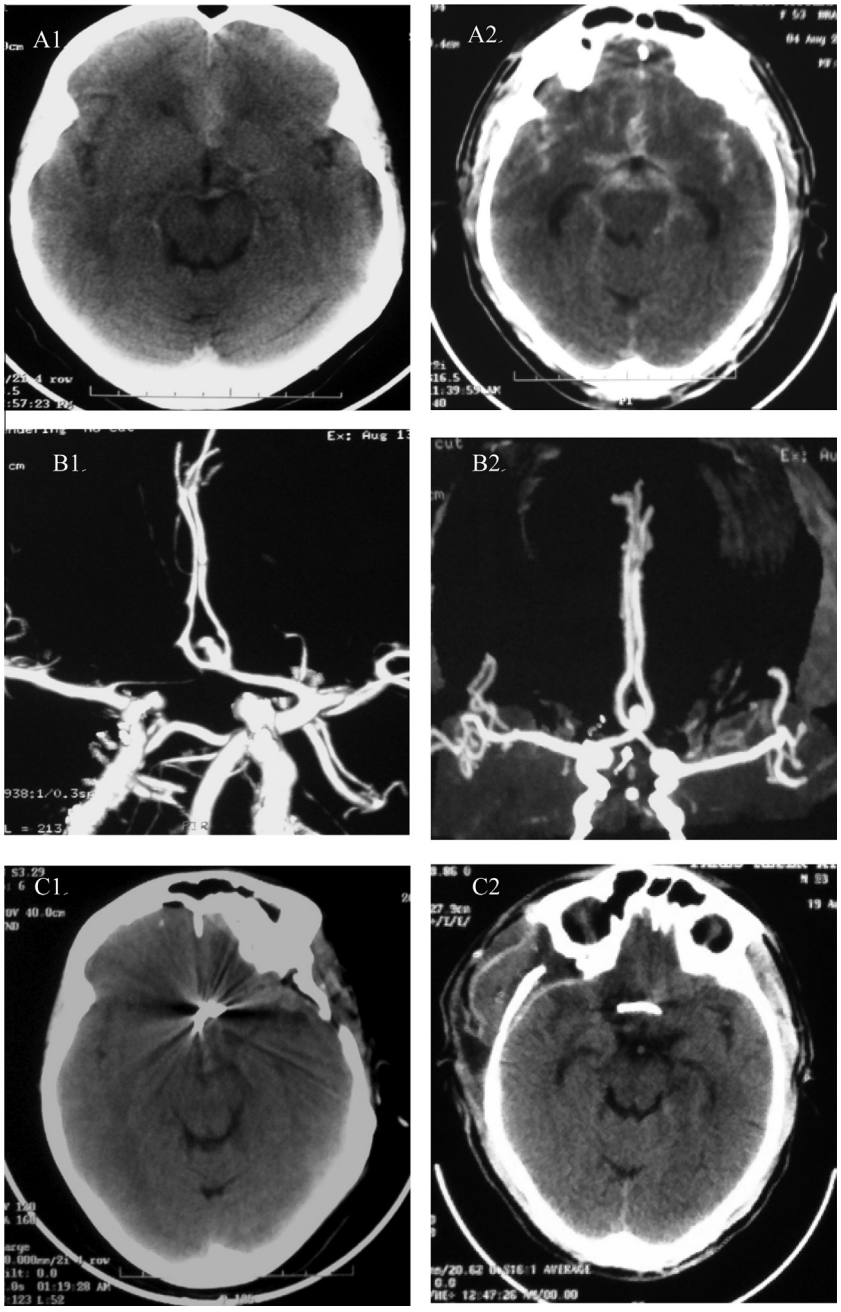


Fig. 3 (A1 and A2) CT of two cases of subarachnoid hemorrhage secondary to the rupture of Acom aneurysms. (B1 and B2) CTA of both cases showing the Acom aneurysms. (C1 and C2) CT follow up was done after clipping of both aneurysms.

of the coiling group the patient developed multiple strokes due to severe vasospasm which could not be managed by medical treatment Fig. 3.

4. Discussion

It is thought that approximately 6% of the international population harbor intracranial aneurysms with a higher prevalence in the Asian and Finnish populations (4–9%) (9). Risk factors associated with the presence and rupture of intracranial aneurysms have included high blood pressure, tobacco usage, genetic and ethnic related factors; however, the prevalence of lesions is still thought to be approximately 2% in those without any known risk factors (9).

The annual risk of rupture has been reported to be between 0.1% and 8%, depending on variable lesion characteristics (9). The International Study of Unruptured Intracranial Aneurysms (ISUIA) reported in two recent publications that the risk of aneurysm rupture was substantially lower than previously thought, that is, approximately 2% in anterior circulation aneurysms in those less than 7 mm (10,11).

The patients who experience (SAH) after aneurysmal rupture, approximately one third return to a functional life, one third have a morbidity, and one third do not survive.(9,11,12). The greatest risk after the initial aneurysmal rupture is re-rupture. Once the aneurysm is secured operatively or by endovascular treatment, the risks are of cerebral vasospasm leading to ischemic complications and of developing hydrocephalus from such an event, thereby underlying the importance of early intervention and close monitoring in the post-rupture period (13).

In 1996, Moret et al. published the results of endovascular treatment in 36 Acom aneurysms. In seven of these cases (20%) the treatment failed. This high rate of failure can be explained because the technical armamentarium in the mid-1990s was not as advanced and sophisticated as it is today. Of the 29 treated aneurysms, it was possible to achieve a complete occlusion in 23 cases (79%) and partial occlusion with neck remnant in the remaining 6 cases (21%). These investigators observed a post-procedural temporary neurological deficit in two cases, and the procedure-related permanent morbidity was 3.5% (1 case). No procedure-related death was reported (14).

In 2002 Kazekawa et al. presented the overall clinical and angiographic evaluation in 19 consecutive patients with Acom aneurysms who were treated with coils. Complete obliteration was obtained in 68% of cases, whereas a neck remnant was seen in 32% of cases. Regarding the overall clinical outcome, 3 patients (15%) who were originally categorized in Grades IV and V died, 1 (5%) was moderately disabled, and 15 (80%) had a good recovery (15).

With recent technical advancements, such as rotational angiography, new microcatheters and micro-guidewires, small and super-soft coils, and compliant balloons for the balloon assisted technique, the failure rate of coiling of Acom aneurysms is diminishing.

In 2009 Guglielmi et al. in their large endovascular series on 306 ruptured Acom aneurysms treated by coiling reported a complete occlusion achieved in 139 cases (45.5%). A neck remnant was detected in 145 aneurysms (47.5%), and in 22 cases (7%) a residual filling of the aneurysm was observed. Regarding the clinical neurological outcome, 280 patients (91.5%) remained neurologically intact, improved, or unchanged from their initial clinical status. Two large, wide-necked, subtotally occluded aneurysms ruptured 3–7 months after the procedure, with subsequent death of the patients. The procedure-related morbidity and mortality rates were 3.5% (11 cases) and 1% (3 cases), respectively (16).

In our study, 15 cases underwent endovascular coiling with Hunt and Hess grade I–III, 40% grade III, 33.3% grade II and 26.7% grade I, total occlusion was achieved in 13 cases (86.6%) with neck remnant left in 1 case (6.7%) and one case of failure (6.7%) due to a thrombotic event which was overcome by antiplatelets. The patient was coiled in a second session. The outcome measured on GOS was 5 in 9 cases (60%), 4 in 3 cases (20%), 3 in 2 cases (13.3%) and 1 in 1 case(6.7%). In our small series, we used the rotational digital angiography in all cases of endovascular coiling with the use of tridimensional 3D coils. We did not use balloons or stents as there was no indication to use them.

Guglielmi et al. observed a 16% rate of recanalization of the aneurysms on the follow-up angiograms. The most important factors related to aneurysm recanalization were the use of soft and smaller coils, large size of the aneurysm, large size of the neck of the aneurysm and packing density. Another factor that predisposes to recanalization is the spatial direction of the Acom aneurysm: lesions that point upward and posteriorly are more difficult to treat. In this type of aneurysm the difficulty of safe catheterization increases. It is important to steam-shape the microcatheter properly to improve its positioning and anchoring. A second session of embolization was performed in the majority of recanalized aneurysms, with a very low rate of iatrogenic complications (16).

In our study, 4 out of 15 cases (26.7%) had recanalization in the follow up angiogram done after 6 months. Recanalization occurred in one case due to a small neck remnant left post coiling and the other three cases likely had loose packing with low packing density. A second session was done for all recurrent cases with complete stable occlusion proved on the follow up angiogram done 6 months later.

The initial results of the International Subarachnoid Aneurysm Trial (ISAT): of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms were originally published in 2002, and were conducted to establish comparative outcomes in a prospective randomized fashion in patients equally suitable for either endovascular or surgical treatment (17). For such patients, the absolute reduction in death and morbidity was 6.9% and the relative risk reduction was 23% (18). A complete analysis at 1 year revealed that the absolute and relative risk reductions had increased to 7.4 and 24%, respectively (17).

The presence of symptomatic moderate or severe vasospasm is not a contraindication of the coiling of Acom aneurysms. It is possible to perform pharmacological manipulation of the spasm before coiling. The immediate occlusion of the aneurysm allows intense medical or endovascular therapy for the arterial vasospasm. A significant advantage over surgery is that there is no need for any kind of manipulation or resection of an ''angry swollen'' brain to reach the aneurysm (16).

In our study, all the patients received Triple H therapy (hypertension, hypervolaemia and hemodiluton) after securing the ruptured aneurysm either surgically or by coiling to counter vasospasm, despite this protocol, 80% of the total number

of cases included in the study suffered from vasospasm either clinically or radiologically, in two cases the vasospasm was severe enough to cause complete hemiplegia in one case of surgery and diffuse brain edema and mortality in another case of coiling. However, we could not relate the vasospasm to the line of management used either in surgery or endovascularly, but as a sequelae of SAH as reported in the literature.

Rupture alone or surgical repair of Acom aneurysm may result in cognitive deficits such as memory impairment and personality changes, which are referred to as ''Acom syndrome'' (19–22). Even patients with a postoperative Glasgow Outcome Scale score of 4 or 5 may still exhibit significant cognitive deficits (20).

One study (23) evaluated the quality of life and the degree of cognitive dysfunction in 93 patients 4.5 years after surgery of a ruptured brain aneurysm and reported that patients with an Acom aneurysm were more likely to suffer cognitive dysfunctions than patients who had a ruptured aneurysm elsewhere in the intracranial vasculature. The only study that compares the cognitive outcome between surgically and endovascular treated patients was published by Chan et al. (24) on 18 patients with ruptured Acom aneurysm. Half of them had undergone surgical clipping and the other half had endovascular embolization. Endovascular treatment showed significantly fewer severe cognitive deficits than those with surgical clipping (16). In our study we could not assess the cognitive function of the treated patients due to lack of applicable tests.

In our hospital, endovascular coiling was introduced starting from the early 2000 with a very limited experience at the start, but then few radiologists got involved in this technique with a tedious learning curve using the up to date instruments and angio suites. Nowadays, we have an advanced specialized neuro-interventional unit with favorable outcomes in the management of various intracranial vascular pathologies.

Suzuki et al. reported on the post-surgical overall clinical outcome in 603 patients with Acom aneurysm. Of these patients, 367 (61%) had an excellent outcome, 107 (18%) had a good outcome, 99 (16%) had a fair/poor outcome, and 30 (5%) died. Of the 264 patients who presented in Hunt and Hess Grades I–III, 86% had an excellent or good outcome (25).

Fukushima et al. reported on the overall clinical outcome post-surgery in 138 patients with Acom aneurysm. In 119 cases (86%) the outcome was excellent or good, and 8 (6%) died. Of the 83 patients presenting in Hunt and Hess Grades I–III, 92% had an excellent or good outcome (26).

A review of surgical series of patients with Acom aneurysms revealed that the main cause of unfavorable outcome appears to be the initial SAH with its deleterious consequences, specifically, direct brain damage, hydrocephalus, or vasospasm-related ischemia (27). Other literature reported that the main surgical complication responsible for unfavorable outcome due to cerebral infarction or disabling stroke was vessel occlusion, which ranged between 1% and 13% of patients (28,3).

After microsurgical clip application, the incidence of aneurysm rest has been assessed as between 4% and 9%, reaching up to 19% for giant aneurysms (29). Repeated surgery for an aneurysm rest may result in a 7% rate of procedural complication with an 89% rate of complete occlusion (29).

In our study, 15 cases underwent microsurgical clipping with Hunt and Hess grades I–III, 40% grade III, 40% grade II and 20% grade I, the outcome measured on GOS was 5 in 8 cases (53.3%), 4 in 1 case (6.7%), 3 in 2 cases (13.3%) and 1 in 4 cases (26.7%). In our surgical limb we did not have any method for intra-operative assessment of residual aneurysm or a follow up angiogram schedule. However, a further study of a larger number of cases and introduction of intraoperative indocyanine green (ICG) angiography are mandatory to exclude residual aneurysm after microsurgical clipping.

5. Conclusion

Endovascular treatment by coiling is better than micro-surgical clipping in the management of ruptured anterior communicating artery (Acom) aneurysm being less invasive and of lower mortality. Recurrence is higher with coiling, however, it can be discovered in the early follow up angiograms and managed safely by re-coiling. Endoscopy assisted microsurgery gives better control during clipping provided that a well-trained, competent and experienced neurosurgeon is available.

6. Conflict of interest

Authors declare that there is no conflict of interest.

References

(1) O'Kelly CJ, Kulkarni AV, Austin PC, Wallace MC, Urbach D. The impact of therapeutic modality on outcomes following repair of ruptured intracranial aneurysms: an administrative data analysis. J Neurosurg 2010;113:795–801.
(2) Brisman JL, Song JK, Newell DW. Cerebral aneurysms. N Engl J Med 2006;355:928–39, 10.1056/NEJMra052760.
(3) Proust F, Debono B, Hannequin D, Gerardin E, Clavier E, Langlois O, et al. Treatment of anterior communicating artery aneurysms: complementary aspects of microsurgical and endovascular procedures. J Neurosurg 2003;99:3–14.
(4) Suarez JI, Tarr RW, Selman WR. Aneurysmal subarachnoid hemorrhage. N Engl J Med 2006;354:387–96, 10.1056/NEJMra052732.
(5) Molyneux AJ, Kerr RSC, Yu L-M, Clarke M, Sneade M, Yarnold JA, et al. International subarachnoid aneurysm trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised comparison of effects on survival, dependency, seizures, rebleeding, subgroups, and aneurysm occlusion. Lancet 2005;366:809–17, 10.1016/ S0140-6736(05)67214-5.
(6) Allen R, Raper DM. International subarachnoid trial in the long run* critical evaluation of the long term follow-up data from the ISAT trial of clipping versus coiling for ruptured intracranial aneurysms. Neurosurgery 2010;66(6):1166–9, Jun, discussion1169/10.1227/01.NEU.000369613.44834012.
(7) Fischer J, Mustafa H. Endoscopic-guided clipping of cerebral aneurysms. Br J Neurosurg 1994;8:559–65.
(8) Perneczky A, Fries G. Endoscope-assisted brain surgery: part 1–evolution, basic concept, and current technique. Neurosurgery 1998;42:219–24, discussion 224–225.
(9) Weir B. Unruptured intracranial aneurysms: a review. J Neurosurg 2002;96:3–42, 10.3171/jns.2002.96.1.0003.
(10) Unruptured intracranial aneurysms–risk of rupture and risks of surgical intervention, International Study of Unruptured Intracranial Aneurysms Investigators. N Engl J Med 339:1725–1733, 1998, 10.1056/NEJM199812103392401.
(11) Wiebers DO, Whisnant JP, Huston 3rd J, Meissner I, Brown Jr RD, Piepgras DG, et al. Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment. Lancet 2003;362:103–10.

(12) Woo D, Khoury J, Haverbusch MM, Sekar P, Flaherty ML, Kleindorfer DO, et al. Smoking and family history and risk of aneurysmal subarachnoid hemorrhage. Neurology 2009;72:69–72, 10.1212/01.wnl.0000338567.90260.46.
(13) Diringer MN. Management of aneurysmal subarachnoid hemorrhage. Crit Care Med 2009;37:432–40, 10.1097/CCM.0b013e318195865a.
(14) Moret J, Pierot L, Boulin A, Castaings L, Rey A. Endovascular treatment of anterior communicating artery aneurysms using Guglielmi detachable coils. Neuroradiology 1996;38:800–5.
(15) Kazekawa K, Tsutsumi M, Aikawa H, Iko M, Tanaka A, Go Y, et al. Endovascular treatment of anterior cerebral artery aneurysms using Guglielmi detachable coils: mid-term clinical evaluation. Radiat Med 2002;20:291–7.
(16) Guglielmi G, Viñuela F, Duckwiler G, Jahan R, Cotroneo E, Gigli R. Endovascular treatment of 306 anterior communicating artery aneurysms: overall, perioperative results. J Neurosurg 2009;110:874–9.
(17) Molyneux A, Kerr R, Stratton I, Sandercock P, Clarke M, Shrimpton J, et al. International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised trial. Lancet 2002;360:1267–74.
(18) Raymond J, Guilbert F, Weill A, Georganos SA, Juravsky L, Lambert A, et al. Long-term angiographic recurrences after selective endovascular treatment of aneurysms with detachable coils. Stroke 2003;34:1398–403, 10.1161/01.STR.0000073841.88563.E9.
(19) Alexander MP, Freedman M. Amnesia after anterior communicating artery aneurysm rupture. Neurology 1984;34, 752–752.
(20) Mavaddat N, Sahakian BJ, Hutchinson PJ, Kirkpatrick PJ. Cognition following subarachnoid hemorrhage from anterior communicating artery aneurysm: relation to timing of surgery. J Neurosurg 1999;91:402–7, 10.3171/jns.1999.91.3.0402.
(21) Sekhar LN, Natarajan SK, Britz GW, Ghodke B. Microsurgical management of anterior communicating artery aneurysms. Neurosurgery 2007;61:273–90, discussion 290–292, 2007, 10.1227/01.neu.0000303980.96504.d9.
(22) Thornton J, Debrun GM, Aletich VA, Bashir Q, Charbel FT, Ausman J. Followup angiography of intracranial aneurysms treated with endovascular placement of Guglielmi detachable coils. Neurosurgery 2002;50:239–49, discussion 249–250.
(23) Sonesson B, Ljunggren B, Säveland H, Brandt L. Cognition and adjustment after late and early operation for ruptured aneurysm. Neurosurgery 1987;21:279–87.
(24) Chan A, Ho S, Poon WS. Neuropsychological sequelae of patients treated with microsurgical clipping or endovascular embolization for anterior communicating artery aneurysm. Eur Neurol 2002;47:37–44.
(25) Suzuki J, Mizoi K, Yoshimoto T. Bifrontal interhemispheric approach to aneurysms of the anterior communicating artery. J Neurosurg 1986;64:183–90, 10.3171/jns.1986.64.2.0183.
(26) Fukushima T, Miyazaki S, Takusagawa Y, Reichman M. Unilateral interhemispheric keyhole approach for anterior cerebral artery aneurysms. Acta Neurochir Suppl (Wien) 1991;53:42–7.
(27) Nathal E, Yasui N, Sampei T, Suzuki A. Intraoperative anatomical studies in patients with aneurysms of the anterior communicating artery complex. J Neurosurg 1992;76:629–34, 10.3171/jns.1992.76.4.0629.
(28) Gilsbach JM, Harders AG, Eggert HR, Hornyak ME. Early aneurysm surgery: a 7 year clinical practice report. Acta Neurochir (Wien) 1988;90:91–102.
(29) Lin T, Fox AJ, Drake CG. Regrowth of aneurysm sacs from residual neck following aneurysm clipping. J Neurosurg 1989;70:556–60, 10.3171/jns. 1989.70.4.0556.