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Ahmed Mohamed Farid Alsayed
Neurosurgery Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt,
ahmedfarid201820@gmail.com

Ali Khodair Ali Khodair
Neurosurgery Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

Mohamed Abdalaziz Elbily
Neurosurgery Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

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ORIGINAL ARTICLE

Assessment of the Efficacy of Stent-assisted Techniques for Endovascular Management of Complex Anterior Circulation Cerebral Aneurysm

Ahmed Mohamed Farid Alsayed*, Ali Khodair Ali Khodair, Mohamed Abdalaziz Elbily

Neurosurgery Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

Abstract

Background: **Stent-assisted coiling is an established treatment option for intracranial aneurysms, particularly, wide neck aneurysms with complex anatomy.**

Aim of the work: **To assess the safety, efficacy, and outcome of stent-assisted endovascular management of complex anterior circulation cerebral aneurysm.**

Patient and methods: **In a prospective and retrospective study, 15 patients diagnosed clinically and radiologically to have unruptured complex anterior circulation cerebral aneurysm and underwent endovascular stent-assisted techniques at the Neurosurgical Intervention Unit at AL-Hussein University Hospital were recruited from the beginning of Feb 2022 to the end of Feb 2023. Efficacy was assessed immediately post-procedure using the Raymond−Roy Occlusion Classification (RROC), while safety was assessed immediately post-procedure using the modified Rankin scale (mRS). mRS was classified further as either favorable (grade 0 or 1) or unfavorable (grade ≥2).**

Results: **In our study, the mean age was 53.3 ± 7.5 years. Most cases (86.7%) manifested headache, 26.7% had third cranial nerve manifestations, and 6.7% had sixth cranial nerve manifestations. The posterior communicating artery was then the main site of aneurysms (33.3%). They were mostly saccular (66.7%), medium-sized (40%), and wide-necked (66.7%). Ten patients (66.7%) were RROC class 1, and 5 patients (33.3%) were class 2. Two patients with third cranial nerve manifestations were improved. One patient (6.7%) developed a carotid cavernous fistula. mRS was favorable in 14 patients (93.3%) and non-favorable in one patient (6.7%).**

Conclusion: **Endovascular stent-assisted management of complex anterior circulation cerebral aneurysm is feasible, effective, and relatively safe with low complication rates.**

Keywords: Complex anterior circulation cerebral aneurysm, Endovascular, Modified Rankin scale (mRS), Raymond−Roy occlusion classification (RROC), Stent-assisted techniques

1. Introduction

Intracranial aneurysm (IA) is the most common cause of hemorrhagic stroke in younger people. A size >5 mm and position in the posterior circulation are two of many factors increasing the risk of IA rupture.[1]

The advantages of primary preventive treatment for unruptured IAs have been reported in numerous trials.[2] However, a neck size ≥4 mm and an aspect ratio <1.5 are still two factors limiting the efficacy of endovascular treatment (EVT).[3,4] These factors, when present, define complex aneurysms (i.e., those with unfavorable anatomical configurations).[5]

Due to its giant size, broad neck, difficult location, wall structure, calcification, branches arising from the aneurysm, presence of intraluminal thrombus, or previous treatments, Complex aneurysms have been suggested to be treated with intracranial stents.[6]

The need for transient luminal occlusion with balloon remodeling is avoided in stent-assisted coiling. In addition, the mechanical scaffold created by

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* Corresponding author at: Neurosurgery Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt.
E-mail address: ahmedfarid201820@gmail.com (A.M.F. Alsayed).

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the stent stops coil protrusion into the parent artery and supports endothelialization at the aneurysm neck. Therefore, this procedure has a much lower rate of angiographic recurrence compared with coiling alone or coiling with balloon remodeling.[7]

The present study aimed to assess the safety, efficacy, and outcome of stent-assisted endovascular management of complex anterior circulation cerebral aneurysm.

2. Patients and methods

Ethical approval was obtained from the Ethics Committee of the Al-Azhar Faculty of Medicine. Before enrollment, written informed consent from parents/guardians was obtained.

In a prospective and retrospective study, 15 patients diagnosed clinically and radiologically to have unruptured complex anterior circulation cerebral aneurysm and underwent endovascular stent-assisted techniques at the Neurosurgical Intervention Unit at Al-Hussein University Hospital were recruited in from Feb 2022 to the end of Feb 2023.

We included patients aged above 18 years, diagnosed to have either unruptured complex aneurysms in the anterior cerebral circulation (saccular, non-saccular either fusiform or dissecting, wide neck, or recurrent after previous treatment) or ruptured anterior circulation cerebral aneurysm after the acute stage.

We excluded patients with acute ruptured anterior circulation aneurysms, posterior circulation aneurysms, impaired renal and hepatic functions, or coagulation disorders. In addition, pregnant women were excluded.

All patients involved in this study were subjected to complete medical history, general and neurological examination, brain imaging studies, endovascular intervention, and postoperative clinical and radiological assessment.

Table 1. Age, Sex, Predisposing factors, and clinical presentations in all studied cases.

	Studied patients (N=15)	
Age (years)		
Mean ± SD	53.3 ± 7.5	
Min–max	36–65	
Sex		
Male	8	53.3%
Female	7	46.7%
Predisposing factors		
DM	2	13.3%
HTN	10	66.7%
Clinical presentation		
Headache	13	86.7%
Third cranial nerve manifestations	4	26.7%
Sixth cranial nerve manifestations	1	6.7%

Table 2. Efficacy assessed by Raymond–Roy Occlusion Classification and cranial nerve improvement.

Efficacy	Studied patients (N = 15)	
Radiological assessment (Raymond–Roy Occlusion Classification)		
Class 1	10	66.7%
Class 2	5	33.3%
Third cranial nerve (N = 4)		
Improved	2	50%
Partially improved	1	25%
Not improved	1	25%
Sixth cranial nerve (N = 1)		
Improved	0	0%
Not improved	1	100%

The degree of aneurysmal occlusion assessed immediately post-procedure by the Raymond–Roy Occlusion Classification (RROC) was the primary efficacy outcome together with cranial nerve manifestation improvement. Immediate post-procedure morbidity and mortality were the primary safety outcome. The modified Rankin scale (mRS) was used to assess the degree of neurological disability. mRS was classified further as either favorable (grade 0 or 1) or unfavorable (grade ≥2).

2.1. Statistical analysis

SPSS (Statistical Package for the Social Sciences) program version 25.0 (IBM Inc., Chicago, USA) and Microsoft Office Excel 2016 software were used to calculate the statistical significance.

Descriptive statistics were done for all studied parameters. Frequency and percentage represented qualitative data. Mean ± SD (standard deviation) represented quantitative parametric data. The difference between qualitative variables was calculated

Table 3. Safety assessed by procedure-related complications and Modified Rankin scale.

Safety	Studied patients (N=15)	
Complications		
Rupture	0	0%
Carotid cavernous fistula	1	6.7%
Modified Rankin scale clinical assessment		
Favorable	14	93.3%
Non-favorable	1	6.7%
Modified Rankin scale grades		
Grade 0	8	53.3%
Grade 1	6	40%
Grade 2	0	0%
Grade 3	0	0%
Grade 4	0	0%
Grade 5	0	0%
Died	1	6.7%

Table 4. Correlation between modified Rankin scale and other studied data.

	Modified Rankin scale		Stat. test	*P* value
	Grade 0 ($N = 8$)	Grade 1 ($N = 6$)		
Aneurysm morphology				
Saccular	6 (75%)	3 (50%)	$\chi^2 = 0.93$	0.334 NS
Non-Saccular	2 (25%)	3 (50%)		
Aneurysm size				
Small	2 (25%)	1 (16.7%)	$\chi^2 = 1.75$	0.626 NS
Medium	4 (50%)	2 (33.3%)		
Large	2 (25%)	2 (33.3%)		
Giant	0 (0%)	1 (16.7%)		
Aneurysm neck				
Wide	7 (87.5%)	3 (50%)	$\chi^2 = 2.3$	0.124 NS
Narrow	1 (12.5%)	3 (50%)		
Previous intervention				
No	7 (87.5%)	4 (66.7%)	$\chi^2 = 0.88$	0.347 NS
Coiling	1 (12.5%)	2 (33.3%)		
Procedure				
Stent-assisted coiling	7 (87.5%)	6 (100%)	$\chi^2 = 0.8$	0.369 NS
Stent	1 (12.5%)	0 (0%)		
Stent type				
Surpass	0 (0%)	1 (16.7%)	$\chi^2 = 2.29$	0.807 NS
Pipeline	1 (12.5%)	0 (0%)		
Silk	1 (12.5%)	1 (16.7%)		
Neuroform	1 (12.5%)	1 (16.7%)		
LEO	3 (37.5%)	2 (33.3%)		
Soliter	2 (25%)	1 (16.7%)		
Complications				
Ruptured	0 (0%)	0 (0%)	–	–
Carotid cavernous fistula	1 (12.5%)	0 (0%)	$\chi^2 = 0.8$	0.369 NS

using the Chi-square test ($\chi 2$). The obtained findings were evaluated at a 5% significance level.

3. Results

In the current study, the mean age was 53.3 ± 7.5 years. Most cases were male (53.3%). Ten cases (66.7%) were hypertensive, while two (13.3%) were diabetic. Most cases (86.7%) manifested as headache; 26.7% had third cranial nerve manifestations, and 6.7% had sixth cranial nerve manifestations (Table 1).

The aneurysms were located mainly in the posterior communicating artery (33.3%) and the cavernous segment of ICA (26.7%). They were mostly saccular (66.7%), medium-sized (40%), and wide-necked (66.7%).

Three patients (20%) were subjected to previous coiling, while 12 patients (80%) had no previous interventions. Thirteen patients (86.7%) were subjected to stent-assisted coiling, while the remaining two patients (13.3%) were subjected to stent only. The following stents were used: LEO, Solitaire, Neuroform, Silk, Surpass, Pipeline, and FRED.

Regarding efficacy, 10 patients (66.7%) were RROC class 1, and 5 patients (33.3%) were class 2. Two patients out of 4 with third cranial nerve manifestations were improved. The patient with the sixth cranial nerve manifestations had not improved (Table 2).

Regarding safety, only one patient (6.7%) developed carotid cavernous fistula. Modified Rankin scale (mRS) was favorable in 14 patients (93.3%) and non-favorable in 1 patient (6.7%) (Table 3).

There was no statistically significant relation (P value > 0.05) between the modified Rankin scale and other studied data. There was a statistically significant difference (P value $= 0.007$) between class I and class II Raymond scale as regards aneurysm morphology. There was no statistically significant relation (P value > 0.05) between Raymond scale and other studied data (Tables 4 and 5).

Figs. 1 to 4.

4. Discussion

One effective method for treating complicated wide-neck aneurysms is stent-assisted coiling, which

Table 5. Correlation between modified Rankin scale and other studied data.

	Raymond scale		Stat. test	*P* value
	Class I ($N = 10$)	Class II ($N = 5$)		
Aneurysm morphology				
Saccular	9 (90%)	1 (20%)	$\chi^2 = 7.4$	0.007 S
Non-Saccular	1 (10%)	4 (80%)		
Aneurysm size				
Small	3 (30%)	0 (0%)	$\chi^2 = 5.8$	0.119 NS
Medium	5 (50%)	1 (20%)		
Large	2 (20%)	3 (60%)		
Giant	0 (0%)	1 (20%)		
Aneurysm neck				
Wide	6 (60%)	4 (80%)	$\chi^2 = 0.6$	0.439 NS
Narrow	4 (40%)	2 (20%)		
Previous intervention				
No	8 (80%)	4 (80%)	$\chi^2 = 0.0$	1.0 NS
Coiling	2 (20%)	1 (20%)		
Procedure				
Stent-assisted coiling	8 (80%)	5 (100%)	$\chi^2 = 1.1$	0.283 NS
Stent	2 (20%)	0 (0%)		
Stent type				
Surpass	0 (0%)	1 (20%)	$\chi^2 = 11.4$	0.077 NS
Pipeline	0 (0%)	1 (20%)		
Silk	0 (0%)	2 (40%)		
Fred	1 (10%)	0 (0%)		
Neuroform	2 (20%)	0 (0%)		
LEO	4 (40%)	1 (20%)		
Soliter	3 (30%)	0 (0%)		
Complications				
Ruptured	0 (0%)	0 (0%)	–	–
Carotid cavernous fistula	0 (0%)	1 (20%)	$\chi^2 = 2.1$	0.143 NS

produces long-lasting and stable anatomical results. For this goal, numerous devices have been suggested, including first- and second-generation stents.[8]

First-generation laser-cut stents were vulnerable to coil prolapse due to their design, especially their cell size. In addition, they were technically difficult to deploy across complex anatomies with prominent curves and tortuous segments. Second-generation nitinol-braided stents were created to overcome these drawbacks.

Even in marked curves or tortuous vessels, these implants have better vascular conformability, and their small cell size minimizes coil prolapse and provides good support for the coil mass.[9]

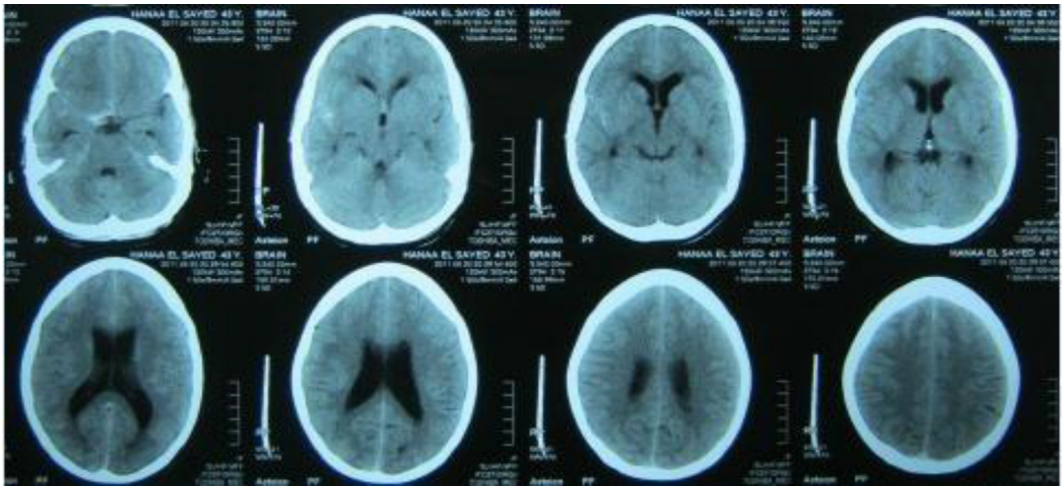

Figure 1. Plain CT brain shows SAH centered on the site of beginning Rt PCOM artery.

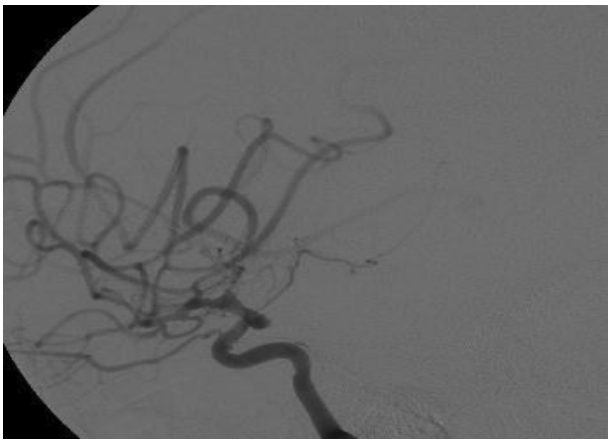

Figure 2. DSA lateral view shows PCOM small wide neck aneurysm.

The present study aimed to assess the safety, efficacy, and outcome of stent-assisted endovascular management of complex anterior circulation cerebral aneurysms.

In this series, 13 patients were subjected to stent-assisted coiling while the remaining two patients were subjected to stent only.

Lylyk et al.[10] reported an 8% technical failure rate caused by delivery issues with first-generation Neuroform stents. When using the Neuroform 2 delivery system, Fiorella et al.[11] found technical issues with the delivery and deployment of stents in only 2 of 53 patients.

In this series, endovascular stent therapy was attempted in 15 procedures; all procedures (100%) were completed with no technical failure observed.

According to Pasquale et al.,[12] 22.2% (4/18) was the rate of temporary procedure-related neurological impairments; all of them were attributable to periprocedural thromboembolism. However, there was no long-term morbidity or mortality related to the procedure.

Mortality rates in the literature range from 2.1 to 8.9%, and morbidity rates from 4.8 to 25%.[10,13] Thromboembolic problems were the most frequently reported adverse effects which confirm the thrombogenicity of stent administration.[12]

In this series, the procedure's safety was evaluated by the presence of any procedure-related complications, such as aneurysm or parent vessel rupture, a thromboembolic event, or a hemorrhagic event during the procedure. The modified Rankin scale (mRS) was used to assess the degree of neurological disability. Only one patient (6.7%) developed a carotid cavernous fistula. Modified Rankin scale (mRS) was favorable in 14 patients (93.3%) (mRS 0,1) and non-favorable in only one patient (6.7%) (mRS 5).

These good clinical results may indicate that the application of endovascular stents is a relatively safe and tolerable therapy for intracranial aneurysms difficult to treat.[11]

Postprocedural angiograms were obtained immediately after the technique. The degree of aneurysmal occlusion assessed immediately post-procedure by the Raymond–Roy Occlusion Classification (RROC) was the primary efficacy outcome together with cranial nerve manifestation improvement.

In this series, 10 patients (66.7%) were RROC class 1, and 5 patients (33.3%) were class 2. Two patients out of 4 with third cranial nerve manifestations were improved. The patient with the sixth cranial nerve manifestations had not improved.

Guidelines for antiplatelet therapy following stent-assisted embolization are primarily based on cardiology experience. Current cardiology guidelines recommended acetylsalicylic acid be taken

Figure 3. (Rt) DSA lateral view during neuroform stent deployment (Lt) final control angiogram shows complete occlusion.

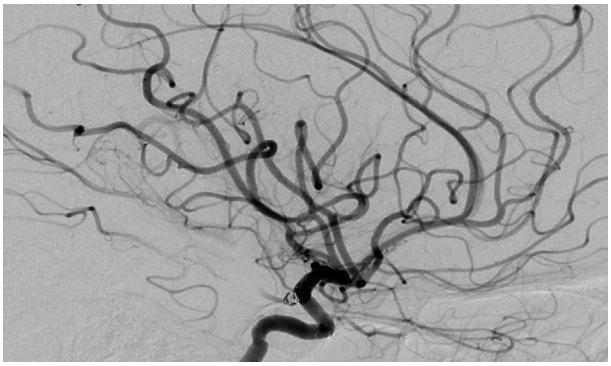

Figure 4. Follow-up DSA lateral view shows complete occlusion of the aneurysm.

indefinitely following coronary stenting, while clopidogrel bisulfate is typically taken for 3–12 months.[14]

However, while using intracranial stents, aneurysmal variables should be considered. Incomplete aneurysm occlusion may result in a dead space when combined with a stent, causing ongoing flow disturbance and turning into a long-term embolic source.[15]

Incomplete stent apposition to the parent vessel wall has been linked to both short- and long-term thromboembolic consequences, as well as vascular thrombosis and occlusion.[16]

In this series, all patients were taken double antiplatelet (clopidogrel for 3–6 months and ASA for invariably) with no symptomatic thromboembolic or in-stent thrombosis observed.

Although our results show an effective and safe procedure, we believe some limitations were present. First, the number of cases in this series was relatively few and second, a further follow-up period is required.

4.1. Conclusion

Broad neck and complex configuration cerebral aneurysms could be treated successfully and reasonably safely using endovascular stent-assisted coiling. A larger sample size could be used in further studies with a follow-up period.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article.

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Conflicts of interest

The authors declared that there were no conflicts of interest.

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