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The Outcome of Right Pterional Approach in Ruptured Anterior Communicating Artery Aneurysm in Patients with Left Dominant A1 Segment

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Abstract

Background: Assessment of safety and curative effect of microsurgical clipping anterior communicating artery (ACoAA) aneurysms through the right side Pterional approach in patients with dominant left A1 segment.

Aim of Study: This study is to assess safety and curative effect of microsurgical clipping anterior communicating artery (ACoAA) aneurysms through the right side pterional approach in patients with dominant left A1 segment.

Patients and Methods: The present study retrospectively was done on 25 cases with ruptured anterior communicating artery aneurysms with dominant left A1 circulation admitted to the emergency unit of the Neurosurgery department, Cairo University, Kasr Al-Ainy Hospital, between January 2019 and December 2020. The patients were assessed regarding their clinical outcome after surgical clipping.

Results: This study was performed on twenty-five cases presenting with ruptured aneurysms and diagnosed with left A1 dominance. The study focused on assessment of safety and effectiveness of microsurgical clipping anterior communicating artery (ACoAA) aneurysms through the Right Pterional approach in these cases. Regarding Intra-operative assessment, the right Pterional approach is a relatively short operation (average 2.92 hours) that provides accessibility and convenience to the neurosurgeons, especially the right-handed. It's a secure and reliable approach that allows successful clipping of the aneurysm. Admitting to the fact that 68% of operations had intra-operative complications showed serious clinical deficits in the post-operative period. Post-operative assessment reported 48% of post-operative complications however, 48% had good recovery with minimal disability, while 20% and 12% had moderate and severe disability respectively.

Conclusion: In view of the results of this study, it could be concluded that the right Pterional approach is the best surgical modality used for microsurgical clipping of ruptured ACOM aneurysms in patients with left A1 dominance. It's convenient, safe, reliable, and efficient with the least operative complications.

Key Words: *Right pterional approach – Acom aneurysm – Left dominant A1 segment.*

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Introduction

THE anterior communicating artery complex, which is composed of anterior cerebral artery, anterior communicating artery, and recurrent artery of Heubner, accounts for the anterior half of the circle of Willis and is a favorite site of aneurysm formation; Anterior communicating artery aneurysms accounts for most of intracranial aneurysms **[1].**

Anterior communicating artery (ACOM) aneurysms are the most complex aneurysms of the anterior circulation due to the angio-architecture and flow dynamics of the anterior communicating artery region, frequent anatomical variations, deep inter-hemispheric location, and danger of severing the perforators with ensuing neurologic deficits **[2].**

The peculiar anatomy of the anterior communicating artery complex, its anatomic variations, and its multiple perforators, along with the deep location of these aneurysms and our difficulty accessing them, pose challenging anatomic problems in their surgical treatment **[3].**

Anterior communicating artery aneurysms present frequently with SAH at small size. Furthermore, associated unruptured ACOM aneurysms may have increased risk of rupture regardless of size and require treatment **[4].**

The aim in management of an anterior communicating artery complex aneurysm is total occlusion of the aneurysm sac with preservation of flow in all branching and perforating arteries either by microsurgical clipping or therapeutic angiographic coiling **[4]**.

This demanding task necessitates perfect surgical strategy based on review of the 3D angio-architecture and abnormalities of the patient's anterior communicating artery complex with its anterior communicating artery aneurysm and to orientate accordingly during the microsurgical dissection or micro catheterizing, guide wiring and coiling during therapeutic angiography. The surgical trajectory should provide optimal visualization of the anterior communicating artery complex without massive brain retraction. Precise dissection in the 3D anatomy of the anterior communicating artery complex and perforators requires not only experience and skill but patience to work the dome and base under repeated protection of temporary clips and pilot clips **[3]**.

Management of each patient must be tailored because no one technique is suitable for all situations. Therefore, the surgeon's microsurgical clipping technique is an important facet of managing these aneurysms. The right-sided approaches allow right-handed surgeons to perform clipping with the right hand, which is the optimal configuration, although left-sided approaches are not significantly more difficult for right-handed surgeons when there is good reason to choose this side **[5]**.

However, a right-sided approach is more comfortable for the surgeon and provides less opportunity to damage the dominant hemisphere. Nevertheless, to achieve secure and precise clipping, additional factors should be considered before deciding on the approach side, such as A1 dominancy and the relationships between the aneurysm neck, A1 and A2 segments, ACoAA, perforators, and the presence of vascular anomalies **[5]**.

Material and Methods

The study was conducted on 25 cases with ruptured anterior communicating artery aneurysms with dominant left A1 circulation admitted to the emergency unit of the Neurosurgery department, Cairo University, Kasr Al-Ainy Hospital. All patients were reviewed for detailed history, clinical examination, and investigations. All the patients were admitted to the Neurosurgical ICU. Neurological status and GCS were assessed preoperatively according to the World Federation grading from **[1-5]**.

Table (1): World Federation Scale (WFS) **[6]**.

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

Inclusion criteria: Age >18 years, Patients with GCS ≥4, Patients with at least one documented, intradural, intracranial ruptured anterior communicating artery aneurysm, Patients with left dominant A1circulation, Patients with positive 4 vessels angiography. Also, the patient and aneurysm are considered appropriate for microsurgical clipping by the treating team. Exclusion criteria: Were Age <18 years, Patients with GCS <4, Patients with unruptured aneurysms, Patients with right dominant A1 circulation and Patients unfit for microsurgical clipping. All patients were subjected to thorough history taking and clinical examination with special attention to age, gender, neurological deficits and conscious level assessment.

Clinical findings include assessment of general condition of the patient, assessment of surgical fitness and neurological examination: Conscious level and motor power.

Radiological investigations include CT brain, CT angiography and 4 vessels angiography.

MRI Brain usually indicates areas of cerebral infarctions.

Micro-vascular clipping technique was performed in all the patients. The pterional (frontotemporal) approach with skull fixation using the Mayfield-Keys three-point device and extending and rotating the head 30 to 45 degrees was used. The skin incision was done beginning at the level of the zygoma, 1cm anterior to the tragus, and extended superiorly immediately behind the hairline and gently curves anteriorly to the midline. Then

the scalp was reflected as a myocutaneous flap. Bur holes were placed at the level of the key bur hole, one at the floor of the middle fossa, and one just inferior to the superior temporal line posteriorly. Then the bone flap was elevated after its separation from the dura through the bur holes with a Penfield 2 or 3. The anterior temporal bone was extracted with rongeurs. The dura was opened around the sylvian fissure in a semilunar fashion. The surrounding arachnoid membranes, including the medial sylvian fissure, were opened sharply till visualization of the subarachnoid course of the carotid artery, including the bifurcation into the middle and anterior cerebral arteries. Dissection of the aneurysm from the surrounding perforators after securing a proximal control and then the clip was applied. Hemostasis was done and closure in layers.

Intra-operative assessment:

During the operation the technicality of the Right Pterional approach was assessed, including the operative time (time from anesthetic induction to completion of skin closure) of the procedure itself, and the immediate intraoperative events or complications such as rupture of the aneurysm, direct trauma to the brain or bleeding due to compromise of a parent vessel or perforator. The duration of temporary clipping, the number of clips and times of application were assessed.

Post-operative care:

After the operation, the patients returned to the ICU. They were all assessed for the conscious level and any neurological deficits. The Glasgow Outcome scale was used to assess patients' recovery.

Postoperative imaging was ordered as well. Patients were followed-up for a period of two weeks to evaluate the outcome of the modality of treatment used clinically through conscious level, neurological deficits if the patient developed any and by neuroimaging studies to detect failed or incomplete occlusion of aneurysm, development of a related infarction or intracerebral hematoma, Glasgow Outcome Scale (GOS) was used for general assessment of the outcome. Finally, we compared the results of each modality and tried to figure out the better line of management for such cases of ruptured ACoAAs aneurysms.

Table (2): Glasgow Outcome Scale **[7]**.

Score	Clinical description
1	Good Recovery
2	Moderate Disability
3	Severe Disability
4	Vegetative Stage
5	Death

Results

Twenty-five patients presenting with ruptured anterior communicating artery aneurysms (ACoAA) and diagnosed with left dominant A1 circulation were included in this descriptive study. All patients were managed with microsurgical clipping via right pterional approach.

In our study, the age ranged from 35 to 70 years with a mean age of 52.88±9.45.00 years. Incidence of SAH was slightly more prevalent in females 52% compared to 48% in males.

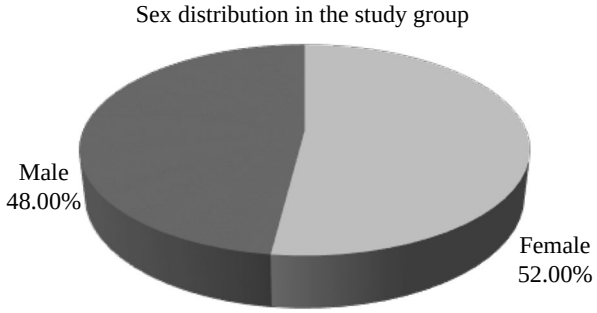

Fig. (1): Sex distribution in the study population.

Patients were assessed neurologically according to the World Federation Score (WFS). Most of the cases (48%) presented clinically with WFS grade I, while 36% and 12% presented with WFS grade II, and grade III respectively. One patient presented with WFS grade IV.

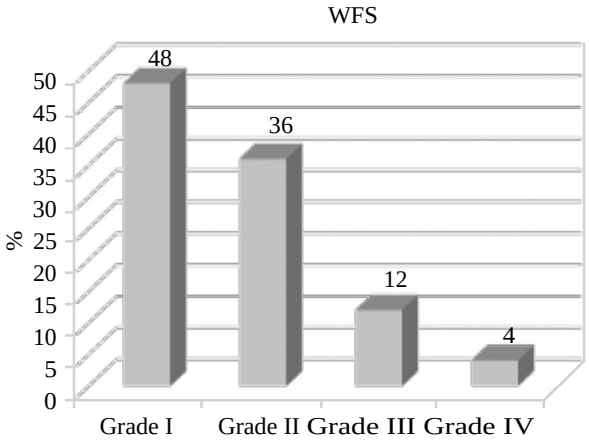

Fig. (2): Pre-operative WFS in the study group.

The direction of the aneurysm was assessed pre-operatively using 4-Vessel Catheter angiography. 10 aneurysms (40%) were directed antro-inferiorly, while 8 aneurysms (32%) were directed medially or laterally. Moreover, 4 aneurysms (16%) and 3 aneurysms (12%) were directed postero-superiorly and antero-superiorly respectively.

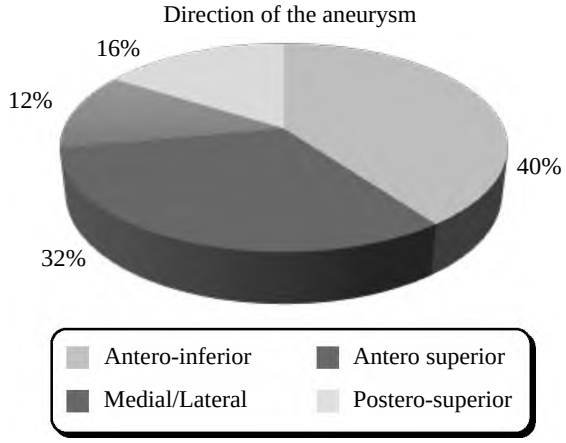

Fig. (3): Direction of the aneurysm in the study group.

The duration of microsurgical clipping via right pterional approach ranged between two hours and four hours with a mean 2.92±0.76 hours. Temporary clipping was required only once in 72% of the cases. However, it was needed twice in 26% of the patients, and thrice in only one patient. The duration of temporary clipping ranged between 2 minutes and 8 minutes (un-continued clipping) with mean 4.20±1.55.

Table (3): Mean operative duration, times of temporary clipping and its duration in the study group.

	Mean	Standard Deviation	Median	Minimum	Maximum
- Duration (hrs.) Intra-operative	2.92	0.76	3.00	2.00	4.00
- Times of temporary clipping Intra-operative	1.32	0.56	1.00	1.00	3.00
- Duration of temporary clipping Intra-operative	4.20	1.55	4.00	2.00	8.00

Intra-operative events or complications reported were in 17 operations (68%), while 8 operations (32%) were performed successfully without any intra-operative complications or events.

Intraoperative rupture was the most common intra-operative event, which occurred in 11 cases (44%). Retraction injury including frontal lobe edema occurred in 4 cases (16%). Bleeding due to parent vessel injury occurred in only one (4%) case, and perforator vessel injury in 3 cases (12%).

Similarly, ventriculo-peritoneal shunt was inserted intra-operatively in 3 cases (12%).

Application of the clip was successful from the first time in 16 operations (64%), in contrast to 9 operations (36%) in which reapplication of the clip was needed.

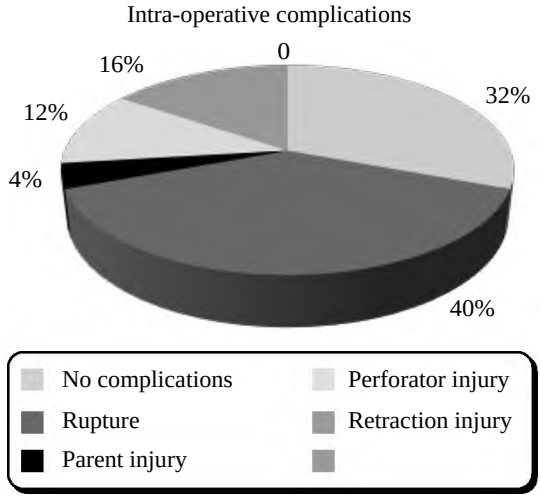

Fig. (4): Percentage of intra-operative events or complications in the study population.

Table (4): Percentage of Intra-Operative events or complications in the study group.

Intra-operative Complications or events	Count	%
Rupture:		
Yes	11	44.0
No	14	56.0
Injury to Parent:		
Yes	1	4.0
No	24	96.0
Injury to Perforator:		
Yes	3	12.0
No	22	88.0
Retraction Injury (including frontal lobe edema):		
Yes	4	16.0
No	21	84.0
Reapplication:		
Yes	9	36.0
No	16	64.0
VPS Insertion:		
Yes	3	12.0
No	22	88.0

Patients were assessed for 2 weeks post-operatively. Neurological outcome was assessed via GOS scale. Despite post-operative complications being reported in 12 cases (48%), the overall mortality was only 16% (4 cases out of 25). 12 cases (48%) had good recovery with minimal disability, while 5 cases (20%) and 3 cases (12%) had moderate and severe disability respectively. One case (4%) was vegetative.

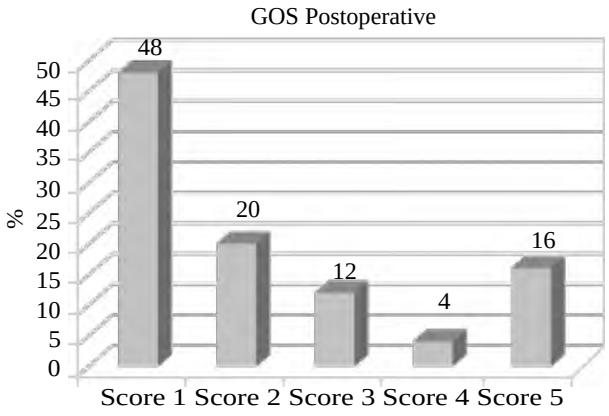

Fig. (5): Glassgow outcome score.

Table (5): Glassgow outcome score.

Post-operative assessment	Count	%
GOS Post-operative:		
Score 1	12	48.0
Score 2	5	20.0
Score 3	3	12.0
Score 4	1	4.0
Score 5	4	16.0

Post-operative infarction was the most common complication. It was reported in 7 cases (28%) while post-operative bleeding in only 2 cases (8%). Similarly, postoperative hydrocephalus and fits occurred in 8% only. A single case (4%) had post-operative CSF leakage.

Table (6): Percentage of Post-Operative complications in the study group.

Post-Operative Complications	Count	%
Infarction Postoperative:		
Yes	7	28.0
No	18	72.0
Bleeding Postoperative:		
Yes	2	8.0
No	23	92.0
Fits Postoperative:		
Yes	2	8.0
No	23	92.0
Hydrocephalus Postoperative:		
Yes	2	8.0
No	23	92.0
CSF Leak Postoperative:		
Yes	1	4.0
No	24	96.0

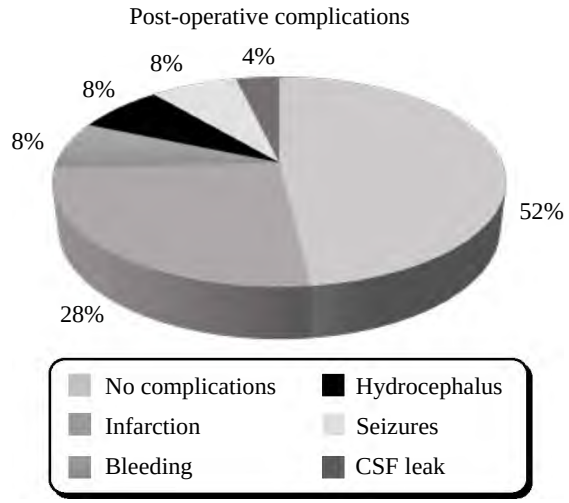

Fig. (6): Percentage of post-operative complications in the study population.

Discussion

Our study included twenty-five cases presenting with ruptured anterior communicating artery aneurysms (ACoAA) with left dominant A1 circulation. All patients were managed with microsurgical clipping via right pterional approach.

Our sample size is approximate to many studies such as those done by Hyun et al., (19 cases) and Chalouhi et al., (40 cases) *[5,8]*. However, Kim et al., and Suzuki et al., had a much larger sample size *[9,10]*.

Regarding the demographics, our cases aged between 35 to 70 years, with a mean of 52.8 years. Similarly, the mean age was 50.3 years and 51 years in Hyun et al., and Chalouhi et al., respectively *[5,8]*. But the study population was older in Kim et al., (56.3 years) and Suzuki et al. (57 years) *[9,10]*.

Our study population was composed of 13 females (52%) and 12 males (48%) denoting a slightly increased incidence of SAH in females.

Comparably, Chalouhi et al., included 22 female (55.0%) and 18 males (45%), while Kim et al., enrolled 55 males (48%) and 58 females (52%) *[8,9]*. However, Incidence of SAH was slightly more prevalent in males (52.6%) compared to females (47.4%) as per Hyun et al. *[5]*.

Like Chalouhi et al., the focus of this study was solely on ruptured aneurysms, unlike Kim et al., who focused mainly on unruptured ACOM aneurysms *[8,9]*. Hyun et al considered both un-ruptured (7/19 cases) and ruptured (12/19 cases) aneurysms *[5]*.

In the present study, only cases with left A1 dominance were considered, and the right pterional approach was the only protocol followed to manage the aneurysms.

Different to our study, in Kim et al., 62.8% cases had left A1 dominancy whereas right A1 dominancy was found 17.7% of cases. Moreover, both right pterional craniotomies (81.4%) and left pterional (18.6%) craniotomies were performed [9].

Chalouhi et al., did not focus solely on the right pterional approach as well. But they compared the clinical outcome of supraorbital keyhole and standard pterional approaches for ruptured anterior circulation aneurysms. Anterior communicating artery aneurysms were the most common type of aneurysms in both groups [8].

Some authors have suggested that side selection for the pterional approach needs to be based on multiple factors other than functional hemispheric dominancy.

In their study, Liu et al., concluded that, the pterional approach contralateral to supply of dominant blood is the best way to expose the anterior communicating artery complex for clipping the aneurysm. This allows good proximal control, which is more convenient, safe, and effective for the treatment of aneurysm [11].

Suzuki et al, however, differentiated Acom aneurysms into inferiorly projecting aneurysms and superiorly projecting aneurysms, and proposed several consideration factors such as aneurysm position (high or low), aneurysm projection (dorsal or anterior), and the plane containing both A2 vessels (open A2 plane or closed A2 plane) [10].

Chen et al., classified Acom aneurysms into 4 types according to the aneurysm projection and used the A2 for orientation, in other words, the relationship between both the A2 and the mid-sagittal planes [11].

Although we agree that the above can be useful factors to consider before surgery, our experience, similar to other authors, has shown that the right-pterional approach can provide many more surgical benefits.

Our study reported that the right pterional approach is the best modality in handling ruptured ACOM aneurysms with left A1 dominance. The procedure is very suitable especially for right-handed neurosurgeons providing easy and quick access to the aneurysm, good control of the bleeding and finally effective complete clipping of the aneurysm.

In 2015, Kim et al., investigated the effectiveness of a right pterional surgical approach in treating ACOM aneurysms. They reported many advantages to this approach. First, mistakes by right-handed surgeons will be minimized. Second, damage to the brain is minimal. Third, wide exposure of both the aneurysm neck and the bilateral A1 is possible since surgeons can freely dissect the cisterns and the H-complex without obstructing the operating field with their working hand [9].

Unlike our study they focused on unruptured ACOM aneurysms, yet their conclusion was similar to ours. Their study proved that complete clipping was much more successful for right-side approaches. It was achieved in 94.9% of cases (74 of 78) via right-side approach but in only 81.3% of cases (13 of 16) via left-side approach.

Additionally in our study, times of clip application were assessed to emphasize on the convenience of the approach. Clip application was successful from the first time in 64% of operations, in contrast to 36% in which reapplication was needed. Thus, emphasizing that the right pterional approach is very practical.

On the other hand, Hyun et al., argued that despite the belief that the right pterional approach matches with the dominant hand of most surgeons, and therefore, is expected to result in a better clinical outcome, there was no significant difference between right-sided and left-sided approaches [5].

In this study, we also measured the operative time as an indication for the convenience and simplicity of the right pterional approach. We reported that the operative time of the right pterional approach is relatively short (average of 2.92 hours). The maximum duration was 4 hours in only 4 cases.

In contrast, Chalouhi et al., argued that shorter operative time was the advantage of the supraorbital approach over the pterional approach. Nevertheless, the study concluded that the pterional approach is yet a simpler procedure [8].

Some studies, such as Kim et al., have suggested that the gyrus rectus was routinely aspirated for clear visualization of the aneurysm and to avoid excessive brain retraction [9].

However, we believe that gyrus rectus aspiration is only needed when the approach to the aneurysm is difficult, and thus gyrus rectus resection was not done in any of the performed operations. Our protocol was found to be beneficial, with excellent clinical and lesional outcomes after our surgical intervention.

In 2013, Chalouhi et al., concluded that the pterional approach was associated with a lower rate of intra-operative complications (most commonly intra-operative rupture). The study reported that the pterional approach is a reliable and efficient procedure [8].

In the present study, 32% of operations were performed successfully without any intra-operative complications. Similarly to Chalouhi et al., intraoperative rupture was the most common complication.

Moreover, Kim et al., debated that using the right pterional approach is much safer when approaching ACOM aneurysms because brain damage is usually minimal. Although there may be some retraction injuries or venous infarctions after the surgery, the chances for this to develop into clinical complications are quite low [9].

Retraction injury, including frontal lobe edema, occurred in only 16% of our cases, however all cases had excellent post-operative clinical outcome. None of the cases developed venous infarcts in the post-operative period.

Regarding post-operative complications, Kim et al., reported acute complications after surgery that occurred in 15.9% of cases. One case underwent surgery due to acute epidural hematoma. Cerebral contusion or venous infarction occurred in five cases. One case had seizures. Permanent surgical morbidity was detected in 8 cases. One case had temporary aphasia and permanent hemiparesis [9].

Post-operatively, 7 of our cases suffered from infarctions either due to intraoperative vessel injury (3 cases of perforator injury and 1 case of parent vessel injury) or due to vasospasm, all 7 cases suffered from permanent hemiplegia. Two cases experienced seizures, and another two had intra-cerebral hemorrhage. Hydrocephalus occurred in one case only.

Post-operative cognitive impairment was also assessed by Kim et al. One case exhibited temporary memory disturbance after surgery; however, he showed no cognitive impairment at 1 month after discharge. Three cases had long term memory loss presumably from injuries of the hypothalamic perforators. The study strongly recommended a right-side approach when one operates on ACOM aneurysm to preserve hypothalamic branches and cognitive function [9].

Unfortunately, long term memory loss and cognitive impairment were not assessed in this study due to shorter period of follow-up and lack of proper neuropsychological assessment tools.

Regarding post-operative follow-up, Kim et al., reported that more than 90% of the cases who underwent right pterional approach had an excellent outcome at discharge (GOS 5). At 6-month follow-up 92.9% had an excellent outcome (GOS 5), 6.2% suffered some disability (GOS 4) and a single case was severely disabled (GOS 3) [9].

In the current study, we followed the cases for 2 weeks, however, longer follow-up durations were not possible in this study. Our results showed comparable results to previous studies where 68% had good recovery with minimal to moderate disability (GOS 5-GOS4), while 12% had severe disability (GOS3). One case (4%) was vegetative.

Our study also reported that the poor outcome encountered in the pos-operative follow-up were contributed mainly to pre-operative morbid conditions such as old age, impaired conscious level, and existing medical conditions.

The limitations of this study were primarily related to the small sample size, absence of randomization, and outcome assessment by the operating surgeon.

Finally, our results pertain to a single-center experience with specific surgical techniques and protocols, which limits generalizability. Our findings also cannot be extrapolated to unruptured or posterior circulation aneurysms.

Conclusion:

In view of the results of this study, it could be concluded that the right pterional approach is the best surgical modality used for microsurgical clipping of ruptured ACOM aneurysms in patients with left A1 dominance. It's convenient, safe, reliable, and efficient with the least operative complications.

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الناتج للنهج الجنيحى الأيمن للتمدد الشريانى المنفجر بالشريان الأمامى الموصل فى المرضى ذوى الامداد الدموى السائد من القطاع الأول للشريان المخى الأمامى الأيسر

إن حالات التمدد الشريانى لمركب الشريان الأمامى الموصل بالمخ تمثل نسبة كبيرة من حالات التمدد الشريانى المنفجر بالمخ. وتعتبر هذه الحالات من الأكثر تعقيداً بسبب الشكل التشريحى واختلافاته العديدة والمتكررة وديناميكية الحركة وتدفق الدم فى هذه المنطقة ووجود شرايين متعددة وكذلك مكانه العميق فى المخ.

ويكون الهدف الأساسى من التدخل الجراحى هو الإغلاق التام للكيس المتمدد مع الحفاظ على تدفق الدم فى الأوعية الدموية الرئيسية والمتفرعة والثاقبة فهذه المنطقة.

وقد أجريت هذه الدراسة على خمسة وعشرين مريضاً لدراسة فاعلية الجراحة عن طريق النهج الجنيحى الأيمن لحالات التمدد الشريانى المنفجر بالشريان الأمامى الموصل فى المرضى ذوى الامداد الدموى السائد من القطاع الأول للشريان المخى الأمامى الأيسر.

وقد أظهرت الدراسة أن استخدام الجراحة عن طريق النهج الجنيحى الأيمن لحالات التمدد الشريانى المنفجر بالشريان الأمامى الموصل في المرضى ذوى الامداد الدموى السائد من القطاع الأول للشريان المخى الأمامى الأيسر يحقق أفضل النتائج من ناحية أداء الجراحة ووقتها وأقل المضاعفات اثناء الجراحة أو بالمريض بعد ذلك.