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Pericallosal Artery Aneurysms: Twenty-Six Years of Microneurosurgical Endeavor in Three Major Neurosurgical Centers in Abidjan

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Abstract

We present our experience of microsurgical treatment of pericallosal artery aneurysms (PCAA) in three neurosurgical centers in Abidjan (Ivory Coast) from 1990 to 2016. This present study aimed to evaluate characteristics of 6 patients with PCAA treated during a 26-year period and to establish the rate, clinical nuances, anatomical variations and respective microsurgical approaches of PCAA in Abidjan. We analyzed medical files of all 93 patients admitted for an intracranial aneurysm between 1990 and 2016 and focused on the 6 patients who were treated for a PCCA. The mean age of patients was 37 years, half of whom were less than 30 years old. They were 3 men and 3 women. The time from first symptom to admission was more than 3 days, but less than 16 days. Five out of six patients had ruptured aneurysms and the clinical condition on admission was WFNS grade 0 one patient (16.67%) and WFNS I-III five patients (83.33%). Analysis of radiological data revealed Fischer grade IV three patients and Fischer grade I-II three patients. A total of 7 PCCA were recorded and they accounted for 6.19% of all intracranial aneurysms and 9.72% of all anterior circulation aneurysms. Six out of seven aneurysms (85.71%) were either smaller (2 - 6 mm) or middle sized (6 - 15 mm). There was only one (14.29%) giant PCA aneurysm (>25 mm). According to the location, two aneurysms (28.57%) were located on the A2 segment of the pericallosal artery (PCA) and five (71.43%) on the A3 segment of the artery. We found 4 cases of saccular aneurysms (57.14%) and 3 cases of fusiform aneurysms (42.86%), two of which were located on A2 segments of the 2 PCA on the same patient (16.67%). We didn't find any PCA anatomical variation associated with any of the 7 aneurysms. Two patients developed perioperative rebleeding and in 1 case a severe preoperative hydrocephalus was diagnosed. The median time from rupture to surgery was 59.5 days with a range of 14 to 180 days. Treatment techniques included 4 clipping (57.14%) and 3 wrapping

(42.86%). In 2 cases there was premature perioperative rupture of the aneurysm (33.33%). One patient (16.67%) had postoperative persistent anosmia and, we didn't record any fatal outcome in our series. PCAA remain rare anterior circulation aneurysms, located in the vast majority of cases, on the A3 segment of the PCA and, are mostly smaller in size even when ruptured. Microsurgical clipping remains a safe and effective treatment option despite their complex surgical approaches and the risk of premature rupture.

Keywords

Pericallosal Artery Aneurysm, Pericallosal Artery, Microsurgery, Treatment, Abidjan

1. Introduction

Pericallosal artery aneurysms (PCAA), also known as distal anterior cerebral artery aneurysms, are intracranial vascular localized bulging of arterial walls, located distally to the anterior communicating artery on the A2 - A5 segment of the anterior cerebral artery [1]. They are relatively rare, accounting for 2% to 9% of all intracranial aneurysms [1]-[11]. It is suggested that they carry a higher risk of rupture than aneurysms in other locations of the anterior cerebral circulation [3] [12]. Some authors have suggested a strong relationship between the anatomical variations of the anterior cerebral circulation and the development of intracranial aneurysm on the pericallosal artery (PCA), which need to be taken into account when accessing and treating these lesions [13] [14] [15] [16]. The PCA holds a strategic and complex anatomical position in the brain blood supply system [17]. As a result, aneurysms arising from this artery are embedded between the cerebral hemispheres and require different microsurgical approaches than the aneurysms on the A1 segment or on the anterior communicating artery complex of the anterior cerebral artery [1] [2] [16] [17]. The surgical morbidity rate is estimated at 15% in most series [16] [18]. We present our experience of microsurgical treatment of PCAA in three neurosurgical centers in Abidjan (Ivory Coast) from 1990 to 2016. We evaluated characteristics of 6 patients with PCAA treated during the study period and sought to establish the rate, clinical nuances of PCAA in Abidjan as well as their anatomical variations and respective microsurgical approaches.

2. Materials and Methods

2.1. Description of the Study

This was a retrospective study in three major neurosurgical centers in Abidjan (Ivory Coast) from 1990 to 2016, which thoroughly analyzed medical files of patients admitted for intracranial aneurysms. During this period, 93 patients were selected with a total of 113 aneurysms being treated in either of the three centers (**Table 1**). We then excluded, for the purpose of our study, all patients

Table 1. Aneurysm distribution according to location.

Patients	Number of aneurysms per patient	Aneurysm size (mm)	Aneurysm shape	Aneurysm location	Preoperative complications	Perioperative complications	Surgical technique	Postoperative complications	GOS grading
1	1	3.9	Saccular	A3	Rebleeding	Premature perioperative Rupture	Clipping	Anosmia	2
2	1	8	Saccular	A3	None	None	Clipping	None	1
3	1	4	Saccular	A3	None	None	Clipping	None	1
4	1	6	Saccular	A3	Rebleeding	Premature perioperative Rupture	Cipping	None	1
5	1	50	Fusiform	A3	Hydrocephalus	None	Wrapping	None	1
6	2	4.9 et 7.1	Fusiform	A2 and A2	None	None	Wrapping	None	1

A2: Segment of anterior cerebral artery from the anterior communicating artery to the junction between the rostrum and genu of the corpus callosum. A3: Segment of pericallosal artery that winds around the genu of the corpus callosum and ends where the artery turns posteriorly above the genu.

with an intracranial aneurysm located outside the PCA or its branches; and narrowed our interest on the 6 patients who were diagnosed with an aneurysm of the PCA or its branches.

2.2. Study Variables

The time from first symptom to admission was deemed early admission, when the patient presented within 3 days of his or her first symptoms. Beyond this period it was referred to as late admission.

Age, gender and admission complaints were analyzed and duly included in the study. The clinical condition on admission was assessed using the WFNS grading scale in which grade 0 stands for patients with an unruptured aneurysm and grades I-V for those with ruptured aneurysms and varying status in the Glasgow coma scale with or without motor deficit [19].

Radiological data were analyzed against the standard Fischer CT scan grading system for evidence of blood on initial CT scan and Yasargil classification system for the size of aneurysm on CT or MRI angiography [19].

Complications before, during and after surgery were also assessed and recorded in the study.

Postoperative outcomes were assessed using the Glasgow outcome scale [19].

2.3. Classification of PCAA

The anatomy of the ACA is highly varying in its branches and branching sites [1]. Most authors use the genu of the corpus callosum as a stable anatomic landmark, together with the segmental division of the anterior cerebral artery by Fischer in classifying PCAA into seven groups when discussing their microsurgical treatment [20]. But given that our statistical analysis yielded a 100% location on the A2 or A3 segments of the PCA, we deliberately decided to simplify the above classification into only three groups: A2 aneurysms are locate on the

A2 segment below the genu of corpus callosum or on the branches of the A2 segment in the frontobasal region; A3 aneurysms are located on the A3 segment at the genu of corpus callosum, including aneurysms at the A2-A3 and A3-A4 junctions; and aneurysms on the A4 and A5 segments.

2.4. Statistical Analysis

Data were analyzed using a commercially available statistical software package (SPSS for Windows, version 13.0.1 2004).

3. Results

3.1. Demographic Distribution

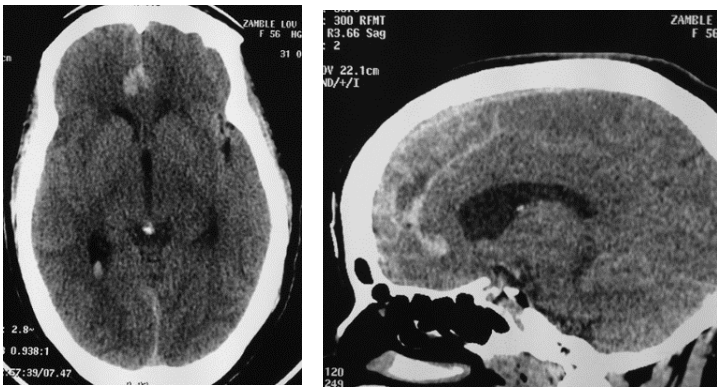
This series of PCA aneurysms is by far the largest published to date in Ivory Coast. During this period, 93 patients were selected with a total of 113 aneurysms being treated in any of the three centers. Six patients, 3 males and 3 females, out of 93 patients were recorded with a PCAA (Table 1). The mean age was 37 years with a range of 11 to 54 years. Half of our patients were less than 30 years old.

3.2. Clinical Presentation and Radiological Data

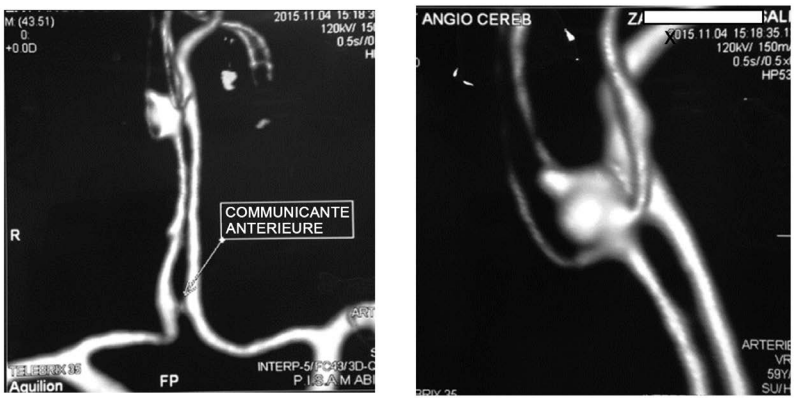
All 6 patients recorded a late admission, but were seen within 16 days from the time of the first symptom. There were 5 patients with primary subarachnoid hemorrhage from a ruptured PCAA and their clinical condition on admission was WFNS I-III (83.33%) (Figure 1(a)). One patient (16.67%) had an unruptured aneurysm and presented on admission with a chronic intracranial hypertension syndrome (Figure 2). The ruptured PCA aneurysms presented clearly more often with intracerebral hematoma or subarachnoid hemorrhage on the initial CT scan. Three of our patients had a Fischer grade IV and in 3 cases, the Fischer grading system was between grades I and II (Figure 3) (Table 2).

Table 2. Summary of patients' characteristics.

Patients	Gender	Age	Time from symptom to admission	Clinical presentation	WFNS grading	Fischer grading	Median time to surgery (day)
1	M	35	14	Subarachnoid hemorrhage	1	4	180
2	F	28	15	Subarachnoid hemorrhage	1	2	55
3	F	50	10	Subarachnoid hemorrhage	2	2	30
4	M	54	40	Subarachnoid hemorrhage	1	4	44
5	F	24	7	Chronic intracranial hypertension	0	1	14
6	M	11	11	Subarachnoid hemorrhage	3	4	34



(a)



(b)

Figure 1. (a) and (b) Subarachnoid hemorrhage and Aneurysm of the A3 segment of the pericallosal artery respectively.

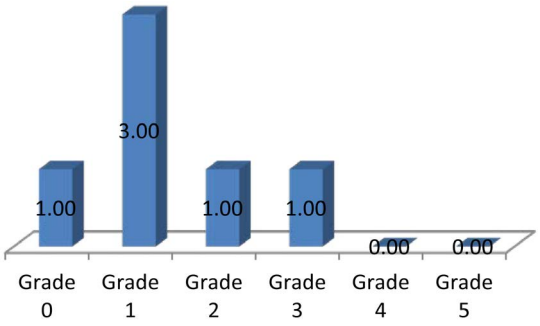


Figure 2. Patient distribution according to the WFNS grading scale.

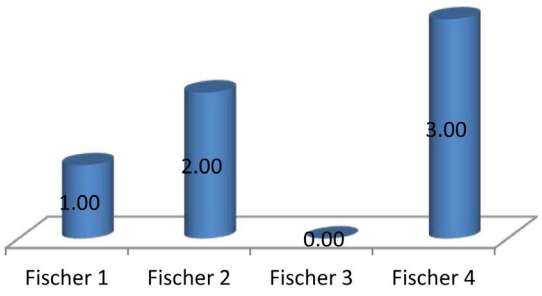


Figure 3. Patient distribution according to the Fischer grading scale.

3.3. Size, Type and Distribution of PCAA on the Anterior Cerebral Artery

A total of 7 PCAA were recorded and they accounted for 6.19% of all intracranial aneurysms and 9.72% of all anterior circulation aneurysms. Five PCA aneurysms occurred most frequently (71.43%) on the A3 segment of the anterior cerebral artery (Figure 1(b)) versus two (28.57%) on the A2 segment. Six out of seven aneurysms (85.71%) were either smaller (2 - 6 mm) or middle sized (6 - 15 mm). There was only one (14.29%) giant PCA aneurysm. Four aneurysms were saccular (57.14%), and there were only three fusiform aneurysms (42.86%), two of which were located on A2 segments of the 2 PCA on the same patient (16.67%) (Table 3).

3.4. Multiple Aneurysms, Associated Aneurysms and Anatomical Variations

A part from the one patient who had multiple aneurysms, we didn't find any association with other aneurysms in our series, nor did we find any PCA anatomical variation associated with any of the 7 aneurysms.

3.5. Microsurgical Treatment

All 7 aneurysms were treated with microsurgery using the frontal interhemispheric route. Direct clipping was performed in 4 patients (57.14%) and wrapping in three patients (42.86%). The median time from rupture to surgery was 59.5 days with a range of 14 to 180 days. Two patients developed perioperative rebleeding and in 1 case, a severe preoperative hydrocephalus was diagnosed. In 2 cases there was premature perioperative rupture of the aneurysm (33.33%). One patient (16.67%) had postoperative persistent anosmia and, we didn't record any fatal outcome in our series (Table 3 and Figure 4).

Table 3. Summary of patients' characteristics.

Location	Number	Percentage
Intracranial carotid artery	31	27.43
Middle cerebral artery	26	23.01
Anterior communicating artery	23	20.35
Segment A1	04	3.54
Jonction A1-A2	12	10.62
Pericallosal artery	**07**	**6.19**
Posterior communicating artery	04	3.54
Basilar artery	03	2.65
Posterior cerebral artery	01	0.89
Anterior superior cerebellar artery	01	0.89
Carotid-ophthalmic junction	01	0.89
TOTAL	**113**	**100**

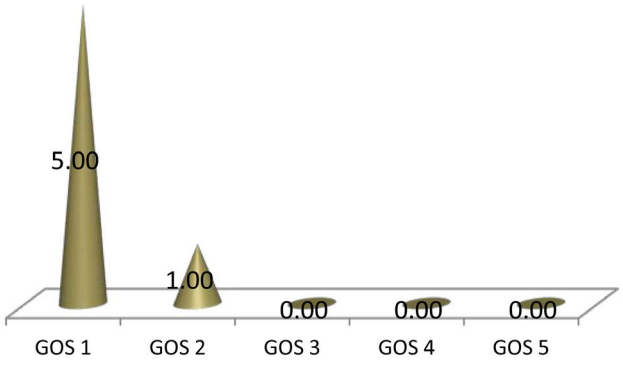


Figure 4. Postoperative outcome chart.

4. Discussion

This series of PCA aneurysms is by far the largest published to date in Ivory Coast, which included three major neurosurgical centers during a 26-year period and thoroughly analyzed medical files of an ethnically homogenous patient population with good medical records and complete follow-up of all patients admitted for an intracranial aneurysms. The sample size however modest compared to that of some European series, supports nonetheless most characteristics of PCAA.

4.1. Epidemiology

4.1.1. Frequency

The extent medical literature is crowded with series on the PCAA and they are relatively rare, accounting for 2% to 9% of all intracranial aneurysms [1]-[11]. In our series, they accounted for 6.19% of all intracranial aneurysms and 9.72% of all anterior circulation aneurysms, which supports Lauri *et al.* rate of 6.76% [21].

4.1.2. Gender

Most authors agree with Lehecka *et al.* who found a female predominance of 60% [1] [22] [23], given that he has the biggest series ever published on PCAA. Our modest sample size could not support multivariate analysis of gender, which explains the lack of sex predominance observed in our series.

4.1.3. Age

The mean age of patients in our study was 37 years with a range of 11 to 54 years, half of whom were less than 30 years old. Many authors report a high incidence in young adults [1] [24]. But aneurysms can be found in age groups, as Lehecka in Finland and Aboukais in France found age ranges of 4 to 59 years and 37 to 75 years respectively [1] [2].

4.2. Clinical Details

4.2.1. Time from First Symptom to Admission

All 6 patients recorded a late admission, but were seen within 16 days from the time of the first symptom. Compounded factors specific to Ivory Coast including

but not limited to the lack of neurosurgical centers outside Abidjan, inadequate patient transport system and healthcare system as a whole, are all limiting factors for early patient admission.

4.2.2. Clinical Presentation and Radiological Data

There were 5 patients with primary subarachnoid hemorrhage from a ruptured PCAA and their clinical condition on admission was WFNS I-III (83.33%). This clinical presentation is reported in more than 90% of cases of ruptured intracranial aneurysms [25]. Pertuiset [26] summarized PCAA clinical presentations into three major scenarios: subarachnoid hemorrhage with or without motor deficit and chronic intracranial hypertension syndrome with clinical features mimicking a frontal tumor.

One patient (16.67%) had an unruptured aneurysm and presented on admission with a chronic high intracranial pressure syndrome mimicking a frontal tumor. We didn't record any patient with a WFNS grade IV-V. Aboukais reported a series of ruptured aneurysms where a third of the patients had a WFNS grade I, a third WFNS grades II-III and another third WFNS grades IV-V [2].

The ruptured PCA aneurysms presented clearly more often with intracerebral hematoma or subarachnoid hemorrhage on the initial CT scan. Three of our patients had a Fischer grade IV and in 3 cases, the Fischer grading system was between grades I and II. Two patients presented with an intracerebral hematoma and one patient had an intraventricular hemorrhage. Two patients had a Fischer grade II. Intracerebral hematoma was associated with subarachnoid hemorrhagein 40% in our study. Lehecka *et al.* reported a higher incidence of intracerebral hematoma in ruptured PCAA than in other intracranial aneurysms of 17% to 73% [1] [4] [8] [11] [27]. Lehecka further explained that the narrow pericallosal and adhesions of the embedded PCA to the adjacent brain could be the reason for this high incidence [1].

4.2.3. Size, Type and Distribution of PCAA on the Anterior Cerebral Artery

A total of 7 PCCA were recorded and they accounted for 6.19% of all intracranial aneurysms and 9.72% of all anterior circulation aneurysms.

Five PCA aneurysms occurred most frequently (71.43%) on the A3 segment of the anterior cerebral artery versus two (28.57%) on the A2 segment. Most series report rates of 69% to 82% of A3 segment aneurysms [3] [4] [5] [18]. The callosomarginal artery is believed to be where these vascular localized bulging of arterial walls occur [24]. We did not find any aneurysms on the A4 and A5 segments. In the literature, A2 and A4-A5 segment aneurysms account for 5% - 22% and 5% - 20% of all PCAA respectively [1] [3] [4] [5] [6] [8] [10] [27] [28] [29].

Six out of seven aneurysms (85.71%) were either smaller (2 - 6 mm) or middle sized (6 - 15 mm) according to Yasargil classification system for the size of aneurysm on CT or MRI angiography [19]. There was only one (14.29%) giant PCA aneurysm. These giant PCAA are rare [16] [18] [28]. There is however, a

cross-border agreement that most PCAA are smaller, as Carter *et al.* argued about an anatomical explanation of the size of distal arteries compared to proximal cerebral arteries [3] [4] [7] [27] [30] [31].

Four aneurysms were saccular (57.14%), and there were only three fusiform aneurysms (42.86%). This is consistent with most studies [16] [18] [28]. Kenichiro and Mitsunori in Japan reported a series of 10 PCAA where 8 aneurysms were saccular and 2 were fusiform [24]. Many factors have been associated with the genesis of PCAA, and they are not different from those found in the genesis of other intracranial aneurysms. Lehecka and Senegor reported cases of fusiform and saccular aneurysms of the PCA caused by head trauma [28] [32]. Sypert *et al.* reported case of PCAA caused by *Neisseria meningitidis* in the United States [33]. We did not have any case of traumatic or infectious aneurysm in our series.

4.2.4. Multiple Aneurysms, Associated Aneurysms and Anatomical Variations

One patient (16.67%) had two fusiform aneurysms located on A2 segments of the 2 PCA. This is referred to as "mirror image aneurysms" [1]. In his 501 series, Lehecka found a 4% rate of mirror image aneurysms [5] [6]. Apart from the one patient who had multiple aneurysms, we didn't find any association with other aneurysms in our series, nor did we find any PCA anatomical variation associated with any of the 7 aneurysms. The literature report a frequent association between PCAA and other intracranial aneurysms in about 25% to 55% of cases [3] [4] [5] [7] [11] [27].

Anatomical variations should be thoroughly investigated in the planning of the surgery. Kakou *et al*., reported 4.34% of azygospericallosal artery in their microanatomy dissection of the azygospericallosal artery [17]. Baptista found only 0.26% of cases of a single PCA trunk and 12% of cases of a dominant PCA supplying the vast majority of the two hemispheres [15]. Cross branches of the PCA have been reported in about 26% to 64% of cases [16] [18] [28].

4.2.5. Microsurgical Treatment

It is widely admitted that microsurgical treatment of PCAA is more challenging than that of other intracranial aneurysms [1] [3] [4] [5] [7] [11]. The anatomical situation of the PCA along with morphological characteristics of the aneurysms are all contributing factors adding complexity to most microneurosurgical treatment of PCAA. Direct clipping remains nonetheless the modality of choice for total occlusion of PCAA, since it has the opportunity to provide both an immediate and a long-term viable outcome to the patient [1] [34]. The frontal interhemispheric route is the approach of choice for the microsurgical treatment of PCAA [1] [16] [18] [28]. Some authors suggest that neuronavigation should be used when accessing aneurysms on the A4 and A5 segments because of poor anatomical landmarks [1].

All of our 7 aneurysms were treated with microsurgery using the frontal interhemispheric route. Direct clipping was performed in 4 patients with saccular aneurysms (57.14%) and 3 wrapping (42.86%) in patients with fusiform aneu-

rysms. Lehecka clipped 98% of PCA aneurysms in his series [1].

The median time from rupture to surgery was 59.5 days with a range of 14 to 180 days. Patients in the Lehecka series were operated within 2 days [1]. All of our patients had a late admission due to reasons clearly stated above.

Two patients developed perioperative rebleeding and in 1 case, a severe preoperative hydrocephalus was diagnosed. In 2 cases there was premature perioperative rupture of the aneurysm (33.33%). In the literature the premature rupture rate is about 50% [3] [35] [36] [37]. Surgical morbidity and mortality are estimated at 15% to 20% and 0% to 15% respectively [3] [16] [18] [35] [36] [37].

One patient (16.67%) had postoperative persistent anosmia and, we didn't record any fatal outcome in our series. Apart from the one patient who had a grade II moderate handicap on the Glasgow outcome scale, a 9-month follow-up revealed that the 5 remaining patients recovered fully and has since been asymptomatic.

4.2.6. Endovascular Treatment

Some authors have advocated endovascular treatment as an attractive option for PCAA, even with pretty modest series, because it is less traumatic compared to microsurgery and has the advantage to reduce postoperative infection and epilepsy rates [38] [39]. But others have been very skeptical treating PCAA using endovascular techniques because of the anatomical nature of these lesions [40]. Lehecka embolised only 12 aneurysms out of 374 in his large aneurysm series making just 3.2%. Of all the 12, 7 were incompletely occluded and 4 had to be re-embolised and 3 clipped. Ivory Coast is currently and technically not yet ready for endovascular procedures.

5. Conclusion

PCAA are relatively rare, as our 6.19% rate is consistent with many series in the literature. They are located in the vast majority of cases, on the A3 segment of the PCA and, are mostly smaller in size even when ruptured. Their association with multiple aneurysms is more frequently than other intracranial aneurysms. Giant PCAA however rare, it might mimic clinical features of a frontal tumor. Microsurgical clipping remains a safe and effective treatment option with the same complication rates as for aneurysms at other locations.

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