Anatomic and Radiologic Classification of Posterior Communicating Artery Aneurysms

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Abstract: One-quarter of all cerebral aneurysms affect the posterior communicating artery. The clinical course typically involves subarachnoid hemorrhage and oculomotor nerve palsy. The objective of this study was to apply the de Aguiar and colleagues' anatomicosurgical classification of posterior communicating artery aneurysms to a series of ruptured and incidental aneurysms treated at a single center and ascertain whether correlations exist between this classification and surgical outcomes (successful or failed occlusion). A single-center, retrospective cohort study based on imaging data was carried out between 2005 and 2010. Patients were allocated into 2 groups depending on aneurysm presentation (acutely ruptured or incidental). In this series, posterior communicating artery aneurysms were 4 to 5 times more common in women than in men, and type II (temporal) aneurysms were those most frequently found. The worst prognosis in the acute bleeding group was seen in cases with fetal variant circulation. The overall prognosis was poorer for temporal aneurysms, particularly those with a higher Hunt and Hess scale grade. Unruptured aneurysms were associated with better outcomes after surgical treatment.

Key Words: posterior communicating artery, cerebral aneurysm, subarachnoid hemorrhage, classification

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For many years, research on the classification of aneurysms advanced by means of answers, sometimes tentative or conjectural, to a series of increasingly subtle questions which continuously promoted in-depth studies of the science of neurology and, particularly, its surgical techniques.[1]

In the study of aneurysms, the term "classification" designates the manner in which different types of aneurysms are grouped and categorized, whereas "typology"—a term from the field of taxonomy, the science of classifications—designates scales that group aneurysms according to their morphology, location, and dimensions, alongside other characteristics. Any attempt at classification must meet certain formal criteria, as the classification is an organizational system defined by a set of unifying signs, symptoms, and criteria meant to be universal.

The de Aguiar et al[2] classification provides a process whereby neurosurgeons may infer the relevant characteristics of aneurysms by analyzing their topographic location on the posterior communicating artery (PcomA). This new classification takes into account the most severe forms of subarachnoid hemorrhage (SAH) (grades IV and V on the Hunt and Hess scale), enabling adequate case review and improving accuracy when added to existing classification scales. Development of the de Aguiar et al[2] classification took into account such variables as morbidity, mortality, rupture risk, and the course and progression of each case.

It is widely known that aneurysms may be characterized according to their location in relation to their vascular segment of origin. Early classifications were based solely on etiology (spontaneous vs. traumatic) and anatomicopathologic aspects of aneurysms (sac shape and arterial wall structure).

Any surgical classification of posterior communicating artery aneurysms should presuppose the definition of 4 types of aneurysms: (a) aneurysms located at the junction of the internal carotid artery and PcomA; (b) fusiform aneurysms of the PcomA; (c) saccular aneurysms of the PcomA; and (d) internal carotid artery aneurysms.[3] The de Aguiar et al[2] classification, in turn, takes into account temporal or tentorial location, presence or absence of fetal variant circulation, and aneurysm size and shape (saccular, infundibular, or giant).

Within this context, the objective of the present study was to apply the de Aguiar et al[2] anatomicosurgical classification of PcomA aneurysms to a series of such aneurysms, diagnosed in the acute phase (ruptured) or found incidentally (unruptured), and ascertain whether correlations exist between aneurysm classification and surgical outcomes (successful or failed occlusion).

MATERIALS AND METHODS

This study sought to assess the technical and surgical implications of an anatomic and radiologic classification of incidental and ruptured aneurysms of the PcomA.

The study project was approved by the local Research Ethics Committee.

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Study Design

This was a retrospective cohort study conducted at a single hospital between 2005 and 2010. Data were collected from imaging tests, which were in turn obtained mostly from patient records.

The retrospective cohort design was used for allocation of patients with PcomA aneurysms into 2 groups, ruptured or incidental. The main characteristic of this study design is its longitudinal (follow-up) nature, which, in this case, was used for comparison of experiences over the 5-year study period.

Study Sample

Inclusion Criteria

From January 2005 to December 2010, 75 patients with intracranial aneurysms (77 aneurysms overall) underwent surgical treatment at the Neurosurgery Service of the hospital where the study was conducted. Only patients with posterior communicating artery aneurysms were included in the study sample. Computed tomography of the head, cerebral angiography, magnetic resonance imaging, documentation, and anatomic studies were used for patient selection. Patients with ruptured aneurysms presented to the emergency department and underwent head computed tomography (Toshiba X-Vision/EX, Otawara-Shi, Japan) for detection of SAH. If SAH was confirmed, patients underwent angiography (Philips Allura FD10, Best, the Netherlands) of the carotid (right and left) and vertebral arteries (left and right) to locate the aneurysm.

Exclusion Criteria

Patients with concomitant neurological conditions, such as brain tumors or demyelinating disorders, were excluded from the sample, as were those with a history of previous neurosurgical intervention, aneurysms located at sites other than the PcomA, and those operated by other surgical teams. The same exclusion criteria were used for both study groups.

Landmarks

Standard anteroposterior, oblique, and lateral views were used for aneurysm classification. Pterional (frontotemporal) craniotomy was the approach of choice, as it provides access to the skull base and, particularly, to the vessels of the circle of Willis. The head was elevated above the level of the heart, with the zygomatic bone highest, slightly rotated (15 degrees away from the affected side) and extended (15 degrees), and stabilized with a Mayfield skull clamp. In this position, the lesser wing of the sphenoid remains perpendicular to the floor to better expose the emergence of the PcomA.

The Sylvian fissure was entered at the level of the opercular part by microdissection, which proceeded medially and inferiorly until the internal carotid artery was reached at its supraclinoid segment, enabling proximal control. The Sylvian cistern was opened widely to expose the internal carotid artery bifurcation, optic nerve and chiasm, proximal portion of the anterior cerebral artery (segment A1), and main trunk and bifurcation of the middle cerebral artery at the level of the limen insulae. This was followed by drainage of cerebrospinal fluid, dissection of the aneurysm neck, identification of afferent and efferent branches, dissection and isolation of major perforating branches, and clip deployment.

Methods

Study Variables

The study variables were: (a) demographic data (sex, age); (b) surgical complications; (c) aneurysm presentation (ruptured or incidental); (d) neurological examination findings; (e) past medical history; (f) neuroimaging findings; and (g) patient outcomes (sequelae and mortality).

The sample comprised 75 patients for a total of 77 aneurysms. Patients were allocated into 2 groups: group A consisted of 42 patients (43 aneurysms overall) who presented with SAH and were treated acutely by aneurysm clipping; group B comprised 33 patients (34 aneurysms overall) with an incidental finding of PComA aneurysm.

Statistical Analysis

As this was a simple case series study, results are essentially descriptive and expressed as relative frequencies (percentages). However, we were able to conduct a statistical analysis of the variables of interest.

Continuous variables were expressed as means and SDs, and categorical variables, as absolute and relative frequencies. Student t test was used for comparison of means and Pearson χ^2 test or Fisher exact test as appropriate for comparison of proportions. These tests were supplemented by calculation of adjusted residuals. The significance level was set at 5% and all analyses were carried out in SPSS 17.0 and PEPI 4.0.

RESULTS

One subject in each of the study groups (ruptured or incidental aneurysm) had 2 aneurysms. Both of these patients had mirror aneurysms. All patients received a score on the Hunt and Hess scale[4] and were classified according to the de Aguiar et al scheme.[2]

As shown in Table 1, mean patient age was 54 years in group A and 52.4 years in group B. In both groups, the majority of patients were women (88.4% in group A and 82.4% in group B).

Of the 75 patients in the overall sample, 6 (8%) had a Hunt and Hess score of IV or V on admission. Although there are differences between grades IV and V, in our sample, the grades (which represent the most severe end of the scale) were pooled for the sake of clarity. All aneurysms were located in the PcomA, and nearly all originated superiorly and laterally to the PcomA and projected outward in the direction of the tentorial surface or temporal lobe.[5] Only 1 patient had an artery following a superolateral course toward the oculomotor nerve, due to the presence of fetal variant circulation.[6]

TABLE 1. Sample Profile

Variables	Group A (Ruptured) (n = 43)	Group B (Incidental) (n = 34)	*P*
Age (y), mean ± SD	54.0 ± 9.5	52.4 ± 6.7	0.663*
Female, n (%)	38 (88.4)	28 (82.4)	0.673†
Hunt and Hess IV/V	4 (9.3)	—	—

*Student *t* test
†Pearson χ^2 test.

Results in Group A

In group A, mean aneurysm size was 6 mm (range, 5 to 25 mm). Clinical signs of vasospasm were observed in 6 patients. The operative technique of choice was pterional craniotomy with subfrontal exposure and dissection of the carotid cistern. External ventricular drains were required in 3 cases. Temporary clipping was employed in 4 cases of intraoperative rupture, all of which had a fatal outcome.

Table 2 shows the distribution of aneurysm types in group A and the morbidity and mortality rates observed in this group, stratified by aneurysm type.

Furthermore, 1 patient developed rebleeding before clipping, which led to a vegetative state, and 1 was left with severe impairment (aphasia and hemiparesis) due to a postoperative embolic ischemic stroke of the left-sided basal ganglia. Table 3 provides an overview of these results.

Figures 1–3 provide some illustrative examples of PComA aneurysms according to the de Aguiar et al classification: type 1a, infundibular aneurysm in the absence of fetal circulation (Fig. 1); type IIb, temporal aneurysms of the right carotid artery with fetal variant circulation (Fig. 2); and type IVa (Fig. 3).

Results in Group B

Mean aneurysm size in group B was 5.3 mm (range, 3 to 10 mm). There were no intraoperative ruptures, no postoperative deficits or sequelae, and temporary clipping was not required in any case.

TABLE 2. Morbidity, Mortality, and Hunt and Hess Scores in Group A (Ruptured Aneurysms)

de Aguiar et al[2] Classification	No. Aneurysms	Mortality	Morbidity	Hunt and Hess IV/V
Type Ia	1	0	0	0
Type 1b	0	0	0	0
Type IIa	18	2	1	1
Type IIb	3	0	0	1
Type IIIa	5	0	1	0
Type IIIb	0	0	0	0
Type IVa	2	0	0	0
Type IVb	3	1	0	1
Type Va	5	0	0	0
Type Vb	4	1	0	1
Type VIa	0	0	0	0
Type VIb	2	0	0	0
Overall	43	4	2	4

TABLE 3. Patient Characteristics in Group A (Ruptured Aneurysms)

No. patients	42
No. aneurysms	43
Mean size	6 mm (range, 5-25 mm)
Fisher grade III/IV SAH	21
Hunt and Hess score IV/V on admission	4
Surgical technique	Temporary clipping in all 4 cases with a fatal outcome
Mortality	4 patients (due to intraoperative rupture and severe ischemia after clipping)
Morbidity	2 patients: 1 with severe sequelae (aphasia and hemiparesis) due to embolic ischemic stroke of the left basal ganglia in the postoperative period; 1 with rebleeding
Surgical complications	
Clinically suspected vasospasm	6 cases
External ventricular drainage	3 cases

SAH indicates subarachnoid hemorrhage.

Table 4 shows the distribution of aneurysm types in group B and the morbidity and mortality rates observed in this group, again stratified by aneurysm type.

There were no deaths in group B. The sole instance of postoperative morbidity was a case of partial, temporary impairment due to oculomotor nerve paresis. Table 5 provides a summary of these results.

Comparison Between Outcomes in Groups A and B

Comparison between outcomes in the 2 study groups showed a higher incidence (42.0%) of de Aguiar type IIa aneurysms in group A, followed by types IIIa and Va (11.6%), Vb (9.3%), IIb and IVb (7.0%) IVa and VIb (4.6%), and, finally, type Ia (2.3%), as shown in Table 6. There were no type Ib, IIIb, or VIb aneurysms in group A.

In group B, de Aguiar types IIa (35.3%) and Ia (23.5%) accounted for the highest incidences, followed by types IIb (8.9%), IVa (8.8%), IIIa, IIIb, and IVb (5.9% each), and Ib and Vb (2.9% each). There were no type Va, VIa, or VIb aneurysms in this group (Fig. 4).

DISCUSSION

Cardentey-Pereda and Pérez-Falero[7] noted that cerebral aneurysms and SAH are most common between the ages of 40 and 60. According to the authors, these data support the theory that aneurysms are the consequence of an acquired degenerative process, their incidence rising gradually over time and peaking in the sixth decade of life. In a review of 5679 cases across 15 series, Cardentey-Pereda and Pérez-Falero[7] reported the following rates: < 1% in the first decade of life; 2% in the second; 6% in the third; 15% in the fourth; 26% in the fifth; 28% in the sixth; 16% in the seventh; and 6% in the eighth decade of life. Since the advent of new microsurgical techniques, greater knowledge of

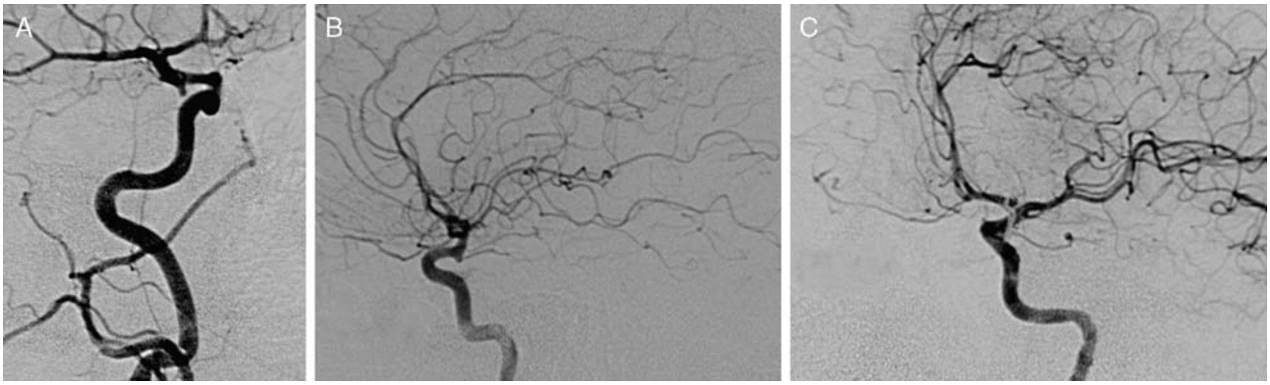

FIGURE 1. Type Ia aneurysms. A, Aneurysm, RICA. B and C, Left carotid.

microscopic vascular anatomy, and modern anesthetic agents, which provide a greater margin of safety during surgery, patient age is no longer a limiting factor for surgical intervention.[6,8,9]

The PcomA is a short vessel that connects the internal carotid and posterior cerebral arteries and gives off branches that irrigate the thalamus, tuberal region of the hypothalamus, posterior limb of the internal capsule, and the region of the subthalamic nucleus and basis pedunculi.[10]

In an anatomic study, VanderArk et al[11] reported that 35% of aneurysms project posteriorly, 24% are directed superiorly toward the tentorial incisure, 13% superiorly and medially, and only 2% inferiorly and medially.

These aneurysms are nearly always saccular and located on the posterior wall of the carotid artery, near the takeoff of the PComA. They may arise infratentorially and in the temporal lobe.[11] The most commonly reported types of aneurysms in the posterior circulation are fusiform aneurysms, microaneurysms, giant aneurysms, and saccular aneurysms, according to Sugita et al.[5]

Horikoshi et al[12] noted that the greater relative frequency of PComA aneurysms observed was due to patients

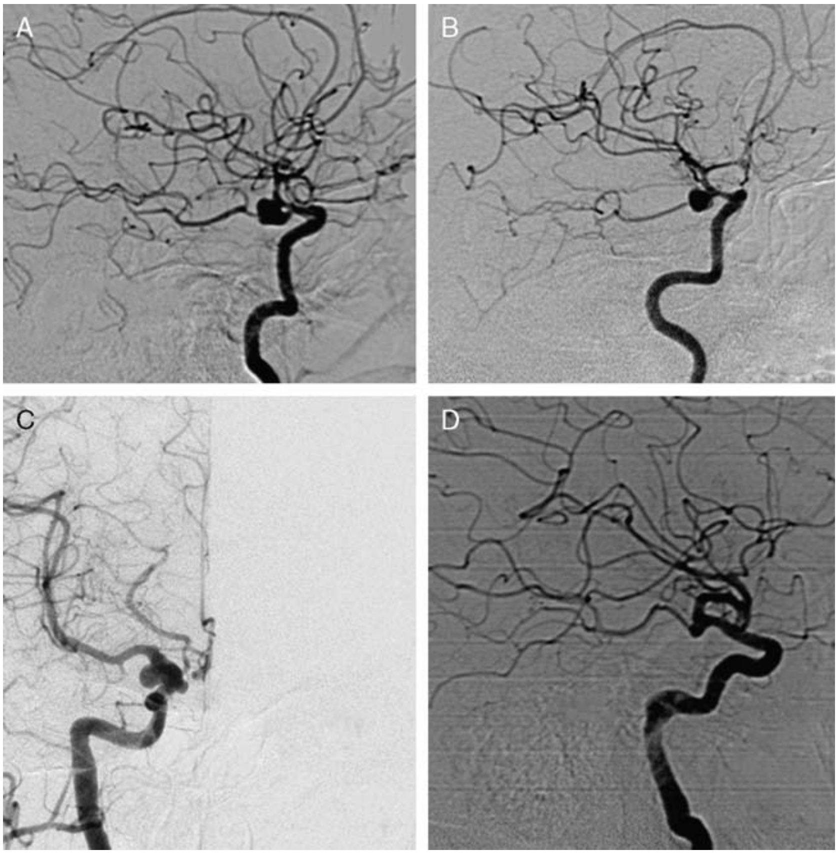

FIGURE 2. Type IIb aneurysms. A and B, Right carotid. C, Right internal carotid artery. D, PComA, right carotid.

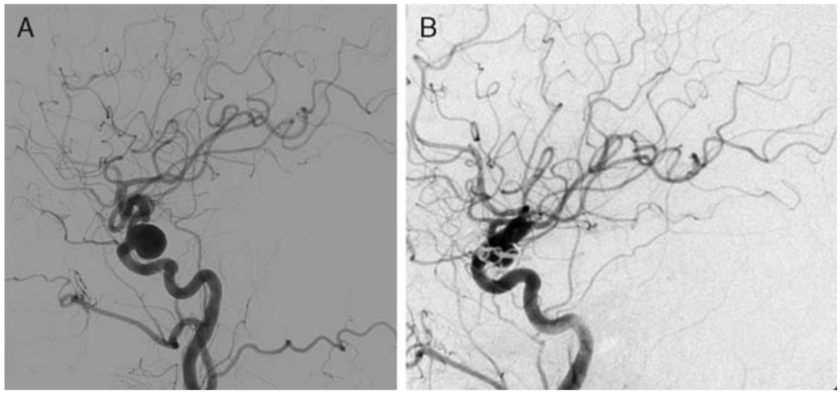

FIGURE 3. Type IVa aneurysms. A and B, Left internal carotid artery.

with fetal variant circulation.[13] Fetal variant vessels are significantly more common in women, who are at higher risk.[12]

The PcomA may follow a fetal pattern in 14.6% of healthy individuals and 33% of patients with aneurysms.[14] In the latter, clipping should preserve the fetal artery, or brainstem damage may occur.[3]

Fetal variant circulation was associated with the worst prognosis in cases of acute bleeding. Infratentorial aneurysms, particularly those with higher Hunt and Hess scores, are associated with poor prognosis. Infundibular aneurysms were associated with the best outcomes after surgical intervention, due to their small size and incidental nature, although controversy remains as to surgical treatment of these aneurysms. In these cases, aneurysm location is also a key prognostic factor.

The most important determinants of mortality and morbidity are the severity of initial bleeding, the incidence of rebleeding, and the development of vasospasm.

Intraoperative aneurysm rupture is a major cause of morbidity and mortality that occurs in approximately 19% of surgically treated cases, with high rates ranging from 15% to 38%.[15,16]

Rupture may occur at 3 specific points in time: before dissection (before or during craniotomy, during dural entry, or during initial brain retraction), in 7% of cases; during dissection of the aneurysm in 48%; and during clip deployment in 45% of cases.[13,16]

Other factors associated with surgical complications were fetal PComA and a high Hunt and Hess grade on admission.[17,18] A widely recognized complication of surgical or endovascular obliteration of PComA aneurysms is inadvertent injury of the PComA itself or its perforating branches, which can lead to ischemic injury of dependent areas.[2]

In this regard, Gonzáles-Darder et al[19] state that PComA aneurysms carry a good prognosis and are not particularly challenging from a surgical standpoint. Nevertheless, the authors stress that PComA aneurysms have important anatomic relationships that may hinder exclusion by microsurgical clipping methods or endanger the patient's neurological integrity as a result of this treatment modality.[19]

Injury or occlusion of a fetal variant PComA may lead to an occipital infarct and later complications thereof (homonymous hemianopsia, alexia, aphasia, and hemiachromatopsia).[20] Perforating branches of the PComA may also receive secondary damage due to inadvertent

TABLE 4. Morbidity, Mortality, and Hunt and Hess Scores in Group B (Incidental Aneurysms)

de Aguiar et al[2] Classification	No. Aneurysms	Mortality	Morbidity	Hunt and Hess IV/V
Type Ia	8	0	0	0
Type 1b	1	0	0	0
Type IIa	12	0	0	0
Type IIb	3	0	0	0
Type IIIa	2	0	0	0
Type IIIb	2	0	0	0
Type IVa	3	0	0	0
Type IVb	2	0	1	0
Type Va	0	0	0	0
Type Vb	1	0	0	0
Type VIa	0	0	0	0
Type VIb	0	0	0	0
Overall	34	0	1	0

TABLE 5. Patient Characteristics in Group B (Incidental Aneurysms)

No. patients	33
No. aneurysms	34
Mean size	5.3 mm (range, 3-10 mm)
Fisher grade III/IV SAH	—
Hunt and Hess score IV/V on admission	—
Surgical technique	Usually pterional craniotomy followed by subfrontal approach to the aneurysm neck and basal cistern dissection. Temporary clipping was not required
Mortality	None
Morbidity	1 patient (temporary disability due to transient oculomotor nerve palsy)
Surgical complications	No intraoperative rupture or postoperative vasospasm

SAH indicates subarachnoid hemorrhage.

TABLE 6. Breakdown of Outcomes by Study Group

Variables, n (%)	Group A (Ruptured) (n = 43)	Group B (Incidental) (n = 34)	*P*
Type Ia	1 (2.3)	8 (23.5)*	0.045†
Type Ib	0 (0.0)	1 (2.9)	—
Type IIa	18 (42.0)	12 (35.3)	—
Type IIb	3 (7.0)	3 (8.9)	—
Type IIIa	5 (11.6)	2 (5.9)	—
Type IIIb	0 (0.0)	2 (5.9)	—
Type IVa	2 (4.6)	3 (8.8)	—
Type IVb	3 (7.0)	2 (5.9)	—
Type Va	5 (11.6)	0 (0.0)	—
Type Vb	4 (9.3)	1 (2.9)	—
Type VIa	0 (0.0)	0 (0.0)	—
Type VIb	2 (4.6)	0 (0.0)	—
Morbidity	3 (7.0)	1 (2.9)	1.000‡
Mortality	5 (11.6)	0 (0.0)	0.126‡

*Statistically significant, adjusted residuals (significance level 5%).
†Pearson χ^2 test.
‡Fisher exact test.

clipping, leading to midbrain lesions or thalamic injury, as reported by Zada et al.[21]

Some intracranial aneurysms are symptomatic due to mass effect. The most common symptom of this effect is headache, and its most common sign is oculomotor nerve (CN III) palsy. Aneurysms originating at the PcomA are the leading cause of aneurysmal oculomotor nerve injury.[22]

In this study, the worst outcomes were observed in the ruptured aneurysm group (group A). The mortality rate was 9.3%, and entirely attributable to intraoperative ruptures, despite temporary clipping. Hence, the mortality rate in the incidental aneurysms group (group B) was nil.

In group A, morbidity was restricted to 2 cases: 1 patient with severe sequelae (aphasia and hemiparesis) due to a postoperative embolic ischemic stroke of the left-sided basal ganglia and 1 case of rebleeding.

Mean aneurysm size was 6 mm (range, 5 to 25 mm) in group A and 5.3 mm (range, 3 to 10 mm) in group B.

Although many surgical techniques are currently available for management of intraoperative complications, the optimal scenario for each of these techniques is dependent on precise anatomic and radiologic classification. In the ruptured aneurysm group of our study, the most prevalent aneurysm type according to the de Aguiar classification was type IIa (temporal aneurysm without fetal variant circulation, 42.0%), followed by types IIIa (tentorial aneurysm without fetal variant circulation) and Va (multilobular aneurysm without fetal variant circulation), which accounted for 11.6% of cases each. This was consistent with the de Aguiar et al study.[2] There were no de Aguiar type Ib, IIIb, or VIa aneurysms in the sample.

In group B (incidental aneurysms), the most prevalent types according to the de Aguiar and colleagues' classification were IIa—(temporal aneurysm in the absence of fetal circulation, 35.3% of cases) and Ia (infundibular aneurysm in the absence of fetal circulation, 23.5%). Types IIb (temporal aneurysm with fetal variant circulation) and IVa (giant aneurysm in the absence of fetal circulation) each accounted for 8.9% of cases. Types IIIa, IIIb, and IVb each accounted for 5.9% of the group, and types Ib and Vb, for 2.9% of cases, whereas types Va, VIa, and VIb were not represented in the sample (0.0%).

This is consistent with the original study by de Aguiar et al,[2] in which type IIa aneurysms (temporal aneurysm in the absence of fetal circulation) were the most common type.

In this series, use of the de Aguiar et al classification[2] provided advantages during the decision-making process for adequate surgical treatment of PComA aneurysms. These advantages are the result of a summarized analysis of the anatomic and surgical peculiarities of each aneurysm and of the implications of the fetal variant circulation pattern for the PComA. It also enabled more precise risk stratification in terms of aneurysm shape, size, and direction.

Furthermore, in future, once this classification has been described in greater detail and in a greater number of cases, it may be used to improve the precision of neurosurgical treatment planning and predict what aneurysm types may have a more or less favorable course with a low incidence of complications.

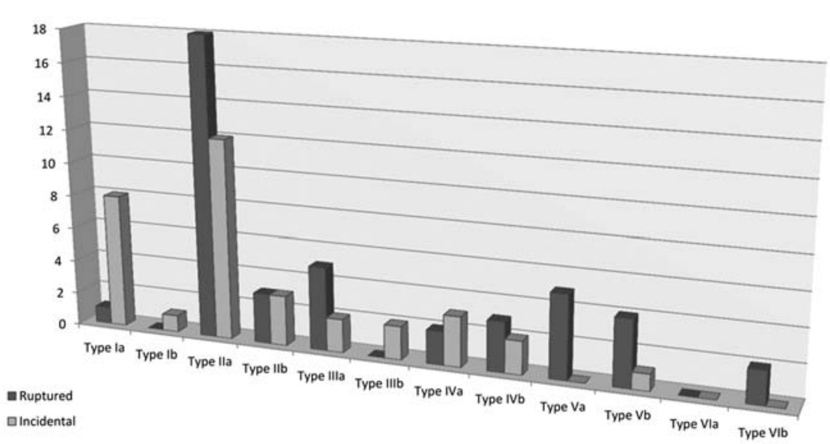

FIGURE 4. Distribution and assessment of outcomes by study group. Ruptured, incidental.

CONCLUSIONS

The de Aguiar et al[2] classification of PcomA aneurysms played an important role in surgical planning in these patients. Other studies with larger samples should be conducted in an attempt to reach statistical significance. We believe precise classifications for neurosurgical conditions can increase benefit to patients by improving the surgical planning stage.

The results of this study show that the de Aguiar et al classification[2] is yet another neurosurgical resource that can enable more precise localization of PcomA aneurysms.

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