

Angiographic Morphological Characteristics of Middle Cerebral Artery aneurysms: Classification and effects on the risk of rupture

Características morfológicas angiográficas de aneurismas de artéria cerebral media: classificação e efeitos sobre os riscos de ruptura

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ABSTRACT

Background: The treatment of Middle Cerebral Artery Aneurysms (MCAA) and the relation of their morphology to the chance of rupture are an important topic in vascular neurosurgery. **Objective:** To assess the correlation between MCAA morphology and 1) the chance of aneurysm rupture and 2) its morbimortality. **Methods:** Twenty-nine patients with MCAA at the M1 segment (4 patients had multiple aneurysms), were followed/ treated by our crew at a single institution over the last 5 years; 14 aneurysms were ruptured at the time of admission and 15 were diagnosed incidentally. Aneurysms were classified by shape and their geometries were correlated with rupture rate and their morbimortality. **Results:** Aneurysms measured between 7 and 10 mm in diameter (90% of the aneurysms), and there was no difference in size between the ruptured and unruptured aneurysms. Patients whose MCAs were ruptured at admission were 3 times as likely than patients with unruptured aneurysms to have a transverse elliptic or inverted-pear-shaped aneurysm (21% vs 9%, $p < 0.05$). On the other hand, patients with unruptured MCAs were 6 times more likely than patients with ruptured MCAs to have a pear-shaped aneurysm (36.3% vs 5.2%, $p < 0.001$). Round-shaped aneurysms were more frequent overall, but they were not significantly more prone to rupture. **Conclusion:** Although this was a small group of patients, we conclude that transverse elliptic and inverted-pear-shaped aneurysms were more associated with rupture than round/ pear-shaped aneurysms.

Key words: Vascular neurosurgery; Intracranial aneurysm; Middle cerebral artery aneurysm; Aneurysm morphology.

RESUMO

O tratamento de aneurismas de artéria cerebral media (AACM) e a relação de sua morfologia com a probabilidade de ruptura são tópicos importantes na neurocirurgia vascular. **Objetivo:** Avaliar a correlação entre a morfologia desses aneurismas e 1) probabilidade de ruptura do aneurisma e 2) sua morbimortalidade. **Métodos:** Vinte e nove pacientes portadores de AACM no segmento M1 (4 pacientes com aneurismas múltiplos) foram acompanhados / tratados por nossa equipe em uma única instituição pelos últimos 5 anos. Catorze aneurismas sofreram ruptura no momento da admissão e 15 foram diagnosticados acidentalmente. Através do formato e geometria, os aneurismas foram classificados e correlacionados com a taxa de ruptura e morbimortalidade. **Resultados:** Os aneurismas apresentaram medidas entre 7 e 10 mm de diâmetro (90%), sem diferença no tamanho entre os rotos e não-rotos. Pacientes cujos AACMs se romperam na admissão eram o triplo daqueles não-rotos com formato elíptico transverso e de pera invertida (21% vs 9%, $p < 0,05$). Por outro lado, pacientes com AACMs não-rotos possuem aneurisma em formato de pera (36,3% vs 5,2%, $p < 0,001$). Aneurismas com formato arredondado eram os mais frequentes, embora não fosse significativamente propensos à ruptura. **Conclusão:** Embora a amostra seja pequena, concluímos que aneurismas com formato elíptico transverso e de pera invertida estavam mais associados a a ruptura que aqueles redondos ou em forma de pera.

Palavras-chave: Neurocirurgia vascular; Aneurisma intracraniano; Aneurisma de artéria cerebral media; Morfologia.

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INTRODUCTION

The prevalence of cerebral aneurysm in the general population is estimated to be between 1 and 2%^{7,8}. The management of an incidentally discovered intracranial aneurysm remains one of the most controversial topics in neurosurgery⁴. Therapeutic options include anywhere from microsurgical clipping or endovascular coiling to prevent subarachnoid hemorrhage, to a “wait-and-see” approach. The first option is associated with a high rate of morbidity and mortality, while the second option requires close follow-up.

Following the ISUIA (International Study of Unruptured Intracranial Aneurysms), the treatment of choice for unruptured intracranial aneurysms is mainly based on the size and location of the aneurysm in the anterior or posterior circulation⁹.

Up to a few years ago, the morphological characteristics and vascular architecture of an aneurysm were not included in the treatment paradigm, but more recent studies have emphasized the role of morphology in the fate of ruptured and unruptured aneurysms^{1-3,5,6}.

Prior to these publications, the aspect ratio of an aneurysm, the undulation index, and the size ratio had not been identified as predictors of aneurysm rupture. However, these studies grouped together all aneurysm types, which may confound characteristics that are specific to the vascular anatomy associated with a specific location⁴.

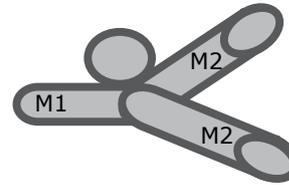
In this work, we used 3-dimensional CT angiography to assess the morphological variables of aneurysms in a group of patients recently treated for MCAA.

METHODS

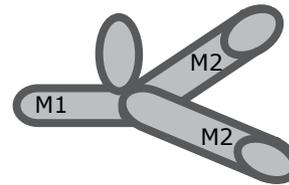
Patients who complained about headaches, or who developed focal neurological deficits/altered levels of consciousness, were admitted to the emergency room and submitted to brain CT and 3-dimensional CT-angiography (CTA) scans.

Patients whose CTA revealed an MCA aneurysm had their exam evaluated by our crew of neuroradiologists, who classified the aneurysms by shape, according to the following illustration:

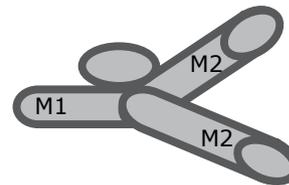
1. Round-shaped



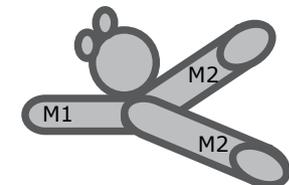
2. Transverse elliptic



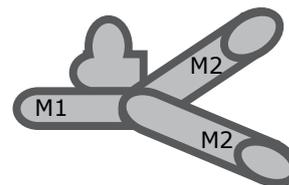
3. Longitudinal elliptic



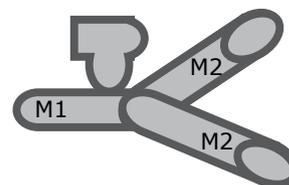
4. Multiloculated



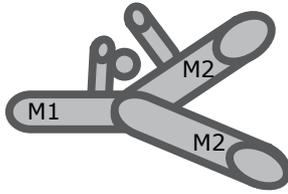
5. Pear-shaped



6. Inverted pear



7. Lenticulostriate



The goal of the present study was to estimate the predictive value of MCA aneurysm morphology with the chance of rupture and with its morbimortality.

We excluded patients harboring an aneurysm larger than 15mm or smaller than 4mm, patients harboring Ehlers-Danlos disease, Marfan, neurofibromatosis type 1, autosomal polycystic kidney disease or any other connective tissue disease.

RESULTS

Twenty-nine patients with MCAA at the M1 segment (4 patients had multiple aneurysms), were followed/ treated by our crew at a single institution over the last 5 years; 14 aneurysms were ruptured at the time of admission and 15 were diagnosed incidentally. Aneurysms measured between 7 and 10 mm in diameter (90% of the aneurysms), and there was no difference in size between the ruptured and unruptured aneurysms.

Patients were 17 females and 8 males who ranged in age between 51 and 82 years old. The morphology of their aneurysms was classified as follows: 8 round-shaped, 4 transverse elliptic, 2 longitudinal elliptic, 4 multiloculated, 5 pear-shaped, 4 inverted pear, and 2 lenticulostriate.

Six patients passed away, and all of them had suffered a subarachnoid hemorrhage. These patients' aneurysms were classified as follows: 1 transverse elliptic, 2 multiloculated, 1 pear-shaped and 2 inverted pear.

Patients whose aneurysms were ruptured at admission were 3 times as likely to have transverse elliptic or inverted-pear-shaped aneurysms than were patients with unruptured aneurysms (21% vs 9%, $p < 0.05$, Fisher's test). Moreover, half of the patients who passed away also had transverse elliptic or inverted pear-shaped aneurysms.

On the other hand, patients with unruptured MCAAs were

6 times more likely than patients with ruptured MCAAs to have pear-shaped aneurysms (36.3% vs 5.2%, $p < 0.001$, Fisher's test). Furthermore, patients with unruptured pear-shaped aneurysms evolved statistically better than patients with aneurysms with different shapes, and this was measured by means of the Karnofsky Performance Status Scale (KPS) (mode 90 vs. 60, $p < 0.05$, t -test).

Round-shaped aneurysms were more frequent overall; however, these were not statistically more prone to rupture, as we did not observe a difference in the number of ruptured versus unruptured round aneurysms ($p > 0.05$, Fisher's test).

In sum, our findings suggest that aneurysms with a transverse elliptic or inverted-pear shape are more prone to rupture than aneurysms with a round or pear-shaped morphology.

DISCUSSION

The risk of rupture of an intracranial aneurysm depends on a number of demographic and biological factors, in addition to the aneurysm's size and location⁴.

The relationship between an aneurysm's risk of rupture and its morphological parameters has only recently been studied systematically. Raghavan et al.⁵ evaluated 8 geometric factors in 27 MCA aneurysms (9 ruptured and 18 unruptured) and found that ruptured aneurysms were associated with significantly higher aspect ratios, undulation indexes and nonsphericity indexes.

Our study also suggests that the nonsphericity index is an important predictor of aneurysm rupture, since the round-shaped aneurysms revealed no predisposition to rupture, while the transverse elliptic/ inverted pear-shaped aneurysms showed a higher rate of rupture.

Two larger studies with aneurysm patients (one retrospective, $n = 45$, Dhar et al.² and one prospective, $n = 40$, Rahman et al.⁶), reported that size ratio was the most significant predictor of aneurysm rupture. In our study, 90% of the aneurysms were between 7-10 mm, which could explain why the size ratio between ruptured versus unruptured aneurysms was not statistically significant.

In a recent multivariate logistic analysis conducted by Lin et

al.⁴ with 79 MCA patients, the authors found that aspect ratio, flow angle, and parent-daughter angle were highly associated with the incidence of rupture. Aspect ratio is defined as the maximum perpendicular height divided by the neck, and characterizes the morphology of an aneurysm. The finding in our own study that the transverse elliptic shape is associated with a higher risk of rupture supports this last finding.

CONCLUSION

Although this study included a relatively small group of patients, we conclude that transverse elliptic and inverted-pear-shaped aneurysms were more associated with rupture than round/ pear-shaped aneurysms.

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COMMENTS

The findings of the study suggest that this sample of aneurysms with elliptical transverse or inverted pear shaped demonstrated a higher tendency to rupture of aneurysms than the other forms. As these sentences quoted: “In sum, our findings suggest that aneurysms with a transverse elliptic or inverted-pear shape are more prone to rupture than aneurysms with a round or pear-shaped morphology. (...) (...)since the round-shaped aneurysms revealed no predisposition to rupture, while the transverse elliptic/ inverted pear-shaped aneurysms showed a higher rate of rupture. (...)” These words affirm the certainty of outcomes. However, the word “may” could have been used suggesting the possibility of occurrence. In the “Conclusion”, instead of more associated, perhaps it would be wise to use the expression. “seemed to be more likely to rupture in our research”. Based on the results, we cannot conclude a major risk of rupture, but an association between aneurysms shape and diagnosis.

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