Endovascular Treatment Modalities for Basilar Artery Aneurysms

Modalidades de Tratamento Endovascular para Aneurismas da Artéria Basilar

Leandro José Haas1,2
Guilherme Wandall1,2
Wesley Severino3
Amanda Junges Derlam3
Camila Ceruti dos Santos3
Sheila Wayszceyk3
Rafael Destri Coelho3
Eduarda Alves3

ABSTRACT

Introduction: Basilar artery aneurysms are rare and account for 5% of all cranial aneurysms. Due to their location in the posterior fossa, their evolution associated with subarachnoid hemorrhage is generally reserved. Early diagnosis is key for the outcome and to reduce complications. Objective: To analyze the typical history of patients with basilar artery aneurysm treated with endovascular therapy. Methods: Observational, descriptive study of individuals with basilar artery aneurysm who underwent endovascular treatment in a Neurosurgery Department from 2005 to 2022. Results: A total of 95 aneurysms was analyzed. Cases were divided into two groups, ruptured and unruptured aneurysms. Unruptured group: prevalence of women (69.47%), age range 60-70, small aneurysms (52.63%), and saccular shape (85.26%). Aneurysms were treated with stents and coils. One-month morbimortality of 3% and one-year, 4%. Ruptured aneurysm group: Fisher 4, Hunt-Hess 2, and female patients stand out. Following SAH, one-month morbimortality of 14.73%, one-year, 25.55%. Conclusion: Choice of treatment: in the acute phase of Subarachnoid Hemorrhage, coils only, and on a late phase or for unruptured aneurysms, a combination of stent and coils.

Keywords: Intracranial aneurysm; Basilar artery; Subarachnoid hemorrhage; Endovascular procedure; Neurosurgery

RESUMO

Introdução: Os aneurismas da artéria basilar são raros e representam 5% de todos os aneurismas cranianos. Devido à sua localização na fossa posterior, a sua evolução associada à hemorragia subaracnoídea é geralmente reservada. O diagnóstico precoce é fundamental para o desfecho e para a redução de complicações. Objetivo: Analisar a história típica de pacientes com aneurisma da artéria basilar tratados com terapia endovascular. Métodos: Estudo observacional, descritivo, de indivíduos com aneurisma da artéria basilar submetidos a tratamento endovascular em um Serviço de Neurocirurgia no período de 2005 a 2022. Resultados: Foram analisados 95 aneurismas. Dois grupos: aneurismas roto e não roto. Grupo sem rutura: prevalência de mulheres (69,47%), faixa etária de 60 a 70 anos, pequenos aneurismas (52,63%) e forma sacular (85,26%). Os aneurismas foram tratados com stents e bobinas. Morbimortalidade de um mês de 3% e de um ano, de 4%. Grupo de aneurisma roto: destacam-se Fisher 4, Hunt-Hess 2 e pacientes do sexo feminino. Após HAS, morbimortalidade em um mês de 14,73%, em um ano, 25,55%. Conclusão: Escolha do tratamento: na fase aguda da HAS, apenas bobinas; em fase tardia ou para aneurismas não rompidos, uma combinação de stent e bobinas.

Palavras-chave: Aneurisma intracraniano; Artéria basilar; Hemorragia subaracnoíde; Procedimento endovascular; Neurocirurgia

1MD, Neurosurgeon, Interventional Neuroradiology specialist, Professor, Universidade Regional de Blumenau, Blumenau, SC, Brasil.
2Endovascular Neurosurgeon, Hospital Santa Isabel, Blumenau, SC, Brasil.
3MS, Medical student, Universidade Regional de Blumenau, Blumenau, SC, Brasil.
INTRODUCTION

A cerebral aneurysm is a ballooning of intracranial arterial capillarity whose etiology is an inflammation of the vessel, which entails degeneration of the tunica media; its mediation is influenced by macrophage activity. The arterial circulation in the encephalon is essentially linked to the polygon of Willis, a set of vascular bifurcations arranged to resemble a pentagon. This conformation is extremely important in the scenario of an aneurysmal rupture and is considered a factor of direct relevance in the case of patients with experience and rupture. In the skull base, the basilar artery plays an important role in the formation of the polygon of Willis, being part of one of the arterial systems - vertebrobasilar - which will converge onto the subsequent formation of this hemodynamic system.

Looking more specifically into the anatomy of the basilar artery itself, Elarjani et al. described that the basilar artery is an important vessel, because it irrigates extremely important areas of the encephalon, including the cerebellum, the brainstem, parts of the hemispheres and, as mentioned above, because the posterior circulation is largely represented by the indirect participation of the basilar artery through the posterior cerebral arteries.

One of the main consequences associated with cerebral aneurysm development would be the rupture of the aneurysm, a scenario that tends to considerably increase the likelihood of death or permanent neurological deficits in a wide range of patients. Treatment “customization” for each patient is not only one of the paradigms that have been implemented in neurosurgical endovascular practice, but a new way of ensuring better efficacy and safety for patients with surgical indications.

Thus, it is clear that many still consider endovascular therapy, which is the main focus of this study, a new option for medical practice. However, it is constantly changing after its recent implementation in surgical centers, especially due to the availability of stents and coils that are increasingly specific for each aneurysm.

METHODS

This is a concurrent descriptive observational study of a sample of individuals diagnosed with a basilar artery aneurysm, performed by the Endovascular Neurosurgery Department of Santa Isabel Hospital, 2005-2022.

The inclusion criterion was patients with a confirmed diagnosis of basilar artery aneurysm seen by the Neurosurgery Department. The exclusion criterion was patients without a confirmed diagnosis of basilar artery cerebral aneurysm.

Patient's data that were analyzed included aneurysm characteristics (morphology, size, ruptured or unruptured aneurysm), epidemiological profile (sex, age), and treatment of patients with a basilar artery aneurysm. In addition, the Fisher and Hunt-Hess scales for subarachnoid hemorrhage were used for evaluation purposes.

The project complied with current ethical standards and was approved by the local ethics committee under CAAE 36208720.7.0000.5370. The authors have no conflicts of interest and have received no funding.

RESULTS

Only 4.99% of the 1903 cases of intracranial aneurysms treated by the Endovascular Neurosurgery Department of the Santa Isabel Hospital between August 2005 and December 2022 were characterized as basilar artery aneurysms. Of these, 30.52% were on male patients, with an average age of 53.37, and 69.47% on female patients, with an average age of 58.48. The overall average age in the sample, 95 cases, was 56.71 (Figure 1).

All subjects of this sample of patients with basilar artery aneurysms had comorbidities. Diabetes Mellitus was found in 10.52%, hypertension in 70.52%, and dyslipidemia in 32.63% of them. Of these patients, 46.31% were smokers.

In this sample made up of 95 individuals, 85.26% of the cases were saccular aneurysms, 25.92% of which on male and 74.07% on female patients. Fusiform aneurysms accounted for 12.63% of the aneurysms, 66.66% of which on male and 33.33% on female patients. Mammillary aneurysms were 2.10%, 100% on female patients.
Most aneurysms were small, in 52.63% of cases, 22% of which on male and 78% on female patients. Large aneurysms were 24.21% of the cases, 26.08% of which on male and 73.91% on female patients. Giant aneurysms were 23.15% of the cases, 54.54% of which on male and 45.45% on female patients.

It was possible to identify 64 aneurysms in other locations associated with 33 basilar artery aneurysms, as shown in Figure 2.

We found that 61.05% of the cases were Fisher scale 1, 37.93% of which on male and 62.06% on female patients; 23.15% are Fisher scale 4; 9.47% are Fisher scale 2; and 6.31% are Fisher scale 3. (Table 1).

![Figure 1. Age distribution of patients with basilar artery aneurysms, by sex from November 2005-November 2022 at Santa Isabel Hospital, Blumenau, 2022. Source: Santa Isabel Hospital, Neurosurgery Department, 2022.](image1)

![Figure 2. Aneurysmal site of aneurysm associations, by sex from November 2005-November 2022 at Santa Isabel Hospital, Blumenau, 2022. Source: Santa Isabel Hospital, Neurosurgery Department, 2022.](image2)

<p>| Table 1. Fisher scale scores for patients with basilar artery aneurysms by sex from November 2005-November 2022 at Santa Isabel Hospital, Blumenau, 2022. |</p>
<table>
<thead>
<tr>
<th>Fisher scale</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisher 1</td>
<td>22</td>
<td>36</td>
<td>58</td>
</tr>
<tr>
<td>Fisher 2</td>
<td>06</td>
<td>03</td>
<td>09</td>
</tr>
<tr>
<td>Fisher 3</td>
<td>0</td>
<td>06</td>
<td>06</td>
</tr>
<tr>
<td>Fisher 4</td>
<td>01</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>66</td>
<td>95</td>
</tr>
</tbody>
</table>

Source: Santa Isabel Hospital, Neurosurgery Department (2022).
After assessing patient’s clinical status based on the Hunt and Hess scale, we found that 61.05% of them were grade 0, 37.93% male and 62.06% female patients; 20% were Hunt and Hess scale grade 2; 14.73% were grade 3; 3.15%, grade 4; 1.05%, grade 5. No patients were Hunt and Hess grade 1 (Table 2).

Thus, in the study sample, 61.05% were unruptured aneurysms, Fisher scale 1 and Hunt and Hess scale Grade 0, 37.93% on the male population and 62.06% on the female population. The other 38.94% of aneurysms were ruptured, Fisher scale 2 or higher and Hunt and Hess scale grade 1 or higher, 18.91% of which on male and 81.08% on female patients (Table 3).

With regard to the treatment of basilar artery aneurysms, 100% of the sample underwent endovascular procedures. In 64.21% of the 95 individuals, the treatment used involved coils alone, with 26.22% of male and 73.77% of female patients. In 20% of the cases, the treatment of choice was a combination of coils and stent, 21.05% on male and 78.94% on female patients. A stent-only approach was used in 12.63% of patients, of which 75% were male and 25% female. In 1.05% of the cases, only flow-diverting stents were used. The procedures failed in 2.10% of the cases due to unfavorable anatomy and the unavailability of suitable materials for the early cases (Table 4).

Table 2. Hunt and Hess scale for patients with basilar artery aneurysms by sex from November 2005-November 2022 at Santa Isabel Hospital, Blumenau, 2022.

<table>
<thead>
<tr>
<th>Hunt and Hess scale</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunt and Hess 0</td>
<td>22</td>
<td>36</td>
<td>58</td>
</tr>
<tr>
<td>Hunt and Hess 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hunt and Hess 2</td>
<td>06</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>Hunt and Hess 3</td>
<td>01</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Hunt and Hess 4</td>
<td>0</td>
<td>03</td>
<td>03</td>
</tr>
<tr>
<td>Hunt and Hess 5</td>
<td>0</td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>66</td>
<td>95</td>
</tr>
</tbody>
</table>

Source: Santa Isabel Hospital, Neurosurgery Department (2022).

Table 3. Aneurism integrity according to sex, from November 2005-November 2022 at Santa Isabel Hospital, Blumenau, 2022.

<table>
<thead>
<tr>
<th>Aneurism integrity</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unruptured aneurysms (Fisher scale = 1 and Hunt and Hess scale = 0)</td>
<td>22</td>
<td>36</td>
<td>58</td>
</tr>
<tr>
<td>Ruptured aneurysms (Fisher scale ≥ 2 and Hunt and Hess scale ≥ 1)</td>
<td>07</td>
<td>30</td>
<td>37</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>66</td>
<td>95</td>
</tr>
</tbody>
</table>

Source: Santa Isabel Hospital, Neurosurgery Department (2022).

Table 4. Endovascular treatments in patients with basilar artery aneurysms, by sex, from November 2005-December 2022 at Santa Isabel Hospital, Blumenau, 2022.

<table>
<thead>
<tr>
<th>Endovascular treatments</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stents only</td>
<td>09</td>
<td>03</td>
<td>12</td>
</tr>
<tr>
<td>Coils only</td>
<td>16</td>
<td>45</td>
<td>61</td>
</tr>
<tr>
<td>Stents associated with coils</td>
<td>04</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Flow-diverting stent only</td>
<td>0</td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>Failure</td>
<td>0</td>
<td>02</td>
<td>02</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>66</td>
<td>95</td>
</tr>
</tbody>
</table>

Source: Santa Isabel Hospital, Neurosurgery Department (2022).

DISCUSSION

As later observed by Adigun et al., when aneurysmal disease is analyzed on a global scale and its incidence is compared with that of other possible sites of arterial ballooning, the specific capillarity of the basilar artery tends to account for 5% of all recorded cranial aneurysms. The result we found tends to be in line with this statistic, with 5.01% of the aneurysms observed in the study universe falling within the diagnosis of basilar aneurysm.

When we look at the profiles of patients diagnosed with basilar artery aneurysms, we can see their similarity with those in histories of patients with different aneurysm incidences recorded in the literature. As described by Ajiboye et al., cerebral aneurysms, in general, are mainly found in female patients; specifically, there is a 3:1 ratio of female to male patients among those diagnosed with cerebral aneurysms. Again, the data found in the study universe are consistent with the abovementioned scenario: almost 70% of the analyzed cases of basilar artery aneurysms were from female patients, showing that the latter are more likely to be affected by basilar artery aneurysms than males.
Again, the literature recognizes that there is a prevalence of females among aneurysm patients, as above mentioned by Ajiboye et al.\textsuperscript{7}. However, there seems to be no consensus on a specific cause for this discrepancy. Among the hypotheses raised thus far, there are studies, such as Stefani et al.\textsuperscript{8}, showing that the hemodynamic architecture of the polygon of Willis is related to the higher incidence of aneurysms in female patients. In particular, the caliber of the arteries appears to be the main cause of females being more often affected by cerebral aneurysms. The explanation for this is that smaller-caliber, and consequently higher-flow velocity, vessels are more commonly found in female patients, which leads to the conclusion that female vascular topography seems to favor greater tension in the wall of the vessels in the polygon of Willis, especially at their bifurcations.

Our analysis will now focus on the epidemiology of the condition in question. Among observed cases, patients fall into a clear age group. The incidence of basilar artery aneurysms proved to be more prevalent at approximately 57 years of age, leading us to believe that this would be the most likely age to develop arterial ballooning. When compared with Brisman et al.\textsuperscript{9} observations, basilar artery aneurysms fall within the typical age group for aneurysm development, 60-70 years.

As reported by Brown and Broderick\textsuperscript{10}, the most common conformation found in the general population is a small, saccular aneurysm. Clearly, the use of data to draw up a history of patients who are likely to develop a ruptured aneurysm is a great tool for medical professionals. In this context, the prerogatives made by the above mentioned authors, Brown and Broderick\textsuperscript{10}, seem to be in line with what we saw in our study of the basilar artery, where these vascular conformations, i.e. a small, saccular aneurysm, would be the most likely ones.

The history of patient’s evolution is inherently linked to their conditions prior to treatment. Among the possible complications associated with basilar artery aneurysms, vasospasms tend to be the most critical ones, highly related to mortality, especially in cases of subarachnoid hemorrhage\textsuperscript{11}.

The history of cerebral aneurysm treatment began in 1937, with records by Dandy\textsuperscript{12} on his surgery involving the rudimentary use of a clip to obliterate the aneurysm in the internal carotid artery of a human being. Over subsequent decades, microclipping remained the "gold standard" for treating this type of condition until the advent of the endovascular technique in the 1990s. Endovascular therapy changed the scenario of neurosurgery by promising greater post-operative patient safety, among other long-lasting benefits, such as its use in diagnostic tests. Much of the excellent outcomes of this type of minimally invasive therapy is due to technological advances, most notably in the field of coils and stents, with their increasingly specific properties for each type of vascular event physicians might encounter\textsuperscript{13}, thus making the treatment of cerebral aneurysms a much more deliberate and targeted process for each patient.

Within each treatment option, certain nuances were observed in relation to patients’ sex. One example: the most commonly used treatment method, coils alone, was mostly chosen for female patients – in more than 70% of the cases. However, the exclusive use of stents was more prevalent on male patients, with 75%. Furthermore, the combined use of stents and coils was similar to that of coil therapy alone, with a majority of female patients (78.94%). In addition, both the two instances of failure and the single case in which a flow-diverting stent was used occurred in female patients.

Continuing to delve into the conformational modality of aneurysms in the case of patients undergoing endovascular treatment. Coils alone were predominately used in saccular aneurysms -which, as previously discussed, are the most common conformation in this capillarity:- 98.36% of these therapies concerned saccular aneurysms, with only one case of mammillary aneurysm contrasting with this statistic.

Looking at the general outcomes, it is somewhat rare to find situations that deviate from the norm as much as the size of aneurysms we find in the treatment records of patients with basilar artery aneurysms. The latest results showed a certain pattern associated with the typical patient, with saccular conformation and small size being the most prevalent in almost any comparison with other patients. However, the treatment for different sizes of aneurysms showed a noticeable contrast, with the small size being significantly more prevalent in only one type of treatment, coils alone, with 59.01%.

As for the Fisher Scale, the distribution of patients according to treatment choice shows that all therapeutic options were more prevalent among Fisher 1 individuals; the only exception concerns to Fisher 4 patients, who are substantially more likely.
to be treated with coils alone; even so, the dominant Fisher score was found in approximately 15% of the individuals.

Based on what has been seen, we can say that many patients tend to survive the basilar artery aneurysm. However, the impact this condition has on their lives could have irreversible consequences due to episodes of complications such as subarachnoid hemorrhage, plegia and aphasia\(^\text{14}\).

Complications following endovascular treatment can range from limitations in daily life activities to death. In relation to the most extreme of possible complications, the meta-analysis by Solenski et al.\(^\text{11}\) found that there is a minimum likelihood of 4.8% of dying within a month of the procedure. Furthermore, other texts discuss the difficulty in finding a more detailed catalogue of aneurysm deaths\(^\text{13}\), which means that there is a selection bias in many studies when disclosing deaths in the unit where the study was conducted.

When comparing the previous statistic of a 4.8% likelihood of dying in the first month post-procedure, the mortality rate we observed for basilar aneurysms in this period -0.73% - was lower than that in the literature. The most affected age group was 50-60; however, there was a great disproportion between male and female patients in this age range, the latter accounting for 92.85% (N=13) of all deaths.

---

**ILLUSTRATIVE CASE PRESENTATION**

Male, 31 years old, presenting sudden headache, loss of consciousness, and vomiting. Computerized tomography showed subarachnoid hemorrhage (SAH). Fisher grade IV. Hunt-Hess scale II. Arteriography showed aneurysm at the top of the basilar artery. Treatment option was embolization with Cerecyte coils (Figures 3-6).

---

Figure 3. A and B. Pre-embolization images. C and D. Immediate post-embolization images.
CONCLUSION

In general, the typical basilar artery aneurysm patient has the following characteristics: female over the age of 70, with a history of hypertension and smoking, presenting with a small saccular aneurysm. In the acute phase of subarachnoid hemorrhage, the chosen treatment was coils alone. In the late phase or for unruptured aneurysms, we used a combination of stent and coils, stent alone and/or flow-diverting stent.

REFERENCES


2. Stojanović NN, Kostić A, Mitić R, Berilažić L, Radisavljević M. Association between circle of willis configuration and rupture of


CORRESPONDING AUTHOR

Guilherme Wandall, MS
Medical student
Universidade Regional de Blumenau
Blumenau, Santa Catarina, Brasil
E-mail: wandallguilherme@gmail.com

Funding: nothing to disclose.
Conflicts of interest: nothing to disclose.
Ethics Committee Approval: CAAE 36208720.7.0000.5370.