Superior Hypophyseal Artery Aneurysms Have the Lowest Recurrence Rate with Endovascular Therapy


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SHA aneurysms are rare. They arise from the internal carotid artery between the origins of the ophthalmic and the posterior communicating arteries and project medially. Consequently, these aneurysms are intradural and may result in subarachnoid hemorrhage. SHA aneurysms have also been classified as paracoid aneurysms along with carotid cave, carotid ophthalmic, and posterior carotid wall aneurysms. Due to anatomic obstacles in this area, surgical clipping of SHA aneurysms is invariably challenging. Thus, endovascular therapy has been used frequently to treat these aneurysms in many centers, both here and abroad. It has been our observation that SHA aneurysms can be treated easily by endovascular means with remarkable short-term results. The rarity of these lesions has, however, precluded any quality studies assessing the effectiveness of endovascular therapy. We present the results of the largest series that assesses the safety and efficacy of endovascular therapy for SHA aneurysms.

**Materials and Methods**

We searched our data base for patients with SHA aneurysms who were treated with endovascular therapy at our institution between January 2006 and February 2011. Aneurysms arising from the internal carotid artery segment between the ophthalmic and posterior communicating arteries and projecting medially, as assessed by the senior author, were included in the study. Eighty-seven patients met our inclusion criteria. All patients had been offered endovascular therapy as a primary treatment option for their aneurysms. Thirty-five patients were treated with coil embolization; 45, with stent-assisted coiling; 4, with balloon-assisted coil embolization; and 3, with a flow-diversion technique. Minor complications occurred in 2 patients (2.2%). None of the patients had a major complication. The mortality and permanent morbidity rates related to the procedure were 0%. Imaging follow-up was available for 89.4% of patients (DSA in 65, MRA in 11 patients) at a mean time point of 10.4 months (range, 6–60 months). Of the 76 patients with available follow-up, 3 patients had a recurrence (3.9%) and only 1 required further intervention (1.3%). Stent-assisted coiling was associated with lower recurrence rates than simple coil embolization.

**Conclusions:** SHA aneurysms have the lowest recurrence rate with endovascular treatment compared with aneurysms in other locations by using historical data. Because of its safety and efficacy, endovascular therapy should be considered the procedure of choice for the treatment of SHA aneurysms.

**Abbreviation:** SHA = Superior Hypophyseal Artery Aneurysms

**Superior Hypophyseal Artery Aneurysms Have the Lowest Recurrence Rate with Endovascular Therapy**

**Background and Purpose:** Given the challenges posed by surgical clipping, endovascular techniques have been increasingly used to treat SHA aneurysms. The purpose of this study was to assess the safety and efficacy of endovascular techniques in the treatment of SHA aneurysms.

**Materials and Methods:** Medical charts and initial and follow-up angiograms were reviewed retrospectively for all patients treated with endovascular procedures at our institution between January 2006 and February 2011.

**Results:** We identified 87 patients with SHA aneurysms who were treated with endovascular techniques. Of these patients, 79 were women and only 8 were men (90.8% female predominance). Thirty-five patients were treated with coil embolization; 45, with stent-assisted coiling; 4, with balloon-assisted coil embolization; and 3, with a flow-diversion technique. Minor complications occurred in 2 patients (2.2%). None of the patients had a major complication. The mortality and permanent morbidity rates related to the procedure were 0%. Imaging follow-up was available for 89.4% of patients (DSA in 65, MRA in 11 patients) at a mean time point of 10.4 months (range, 6–60 months). Of the 76 patients with available follow-up, 3 patients had a recurrence (3.9%) and only 1 required further intervention (1.3%). Stent-assisted coiling was associated with lower recurrence rates than simple coil embolization.

**Conclusions:** SHA aneurysms have the lowest recurrence rate with endovascular treatment compared with aneurysms in other locations by using historical data. Because of its safety and efficacy, endovascular therapy should be considered the procedure of choice for the treatment of SHA aneurysms.
Results

Demographics and Aneurysm Characteristics

Of the 87 patients, 79 were women (90.8%) and 8 were men (9.2%). The mean age in the series was 51.1 years, with a range of 24–76 years and a median of 47 years. Mean aneurysm size was 6.0 mm, with a range of 2.5–15 mm and a median of 7 mm (Table 1). Of the 87 aneurysms, 12 were ruptured (13.8%) and 75 were unruptured (86.2%). Twenty-three patients had at least 1 aneurysm at another location (26.4%), 10 patients had ≥2 aneurysms at other locations (11.5%), and 14 patients had at least 1 associated paraclinoid aneurysm (16.1%). All associated aneurysms were located in the anterior circulation (100%), with paraclinoid aneurysms accounting for most of these (55.9%) (Table 2).

Endovascular Treatment

Of the 87 patients who underwent endovascular therapy, 35 were treated with coil embolization; 45, with stent-assisted coiling; 4, with balloon-assisted coil embolization; and 3 with flow diversion. One patient in the coil embolization group had an unsuccessful procedure due to coil prolapse into the parent vessel. She later underwent surgical clipping.

Minor complications occurred in 2 patients (2.2%). One
patient in the coil embolization group had a minor groin hematoma that resolved spontaneously. Another patient in the coil embolization group had angiographic evidence of extravasation into the cavernous sinus (with no extravasation in the subarachnoid space). This was easily controlled with coils, and the patient was asymptomatic and neurologically intact after the procedure. No major complications were observed in the series. There were no deaths or permanent morbidity related to the procedure.

Immediate Angiographic Results
Excluding the patient who had a failed procedure and the 3 patients who were treated with a flow-diversion technique, complete aneurysm occlusion (100%) was achieved in 50.6% of patients (42/83), near-complete occlusion (95%–100%) in 47.0% (39/83), and incomplete occlusion (<95%) in 2.4% (2/83). The initial angiographic results for the different endovascular modalities are summarized in Table 3.

Follow-Up Angiographic Results and Rate of Hemorrhage/Rehemorrhage
Of the 65 patients with DSA follow-up (75.5%), 62 (95.4%) showed stable or complete occlusion of their aneurysms at the last available follow-up. Three patients (4.6%) had evidence of a recurrence, and only 1 patient (1.5%) required further intervention (Tables 3–5). The first patient showed a 20% recurrence on the 6-month follow-up angiogram after initial treatment with coil embolization. She was successfully treated with additional coil embolization and maintained 100% occlusion at the 6-month angiographic assessment. The second patient had a 10% recurrence at 6-month follow-up angiography after initial obliteration with coils. This did not require further intervention, but the patient was lost to follow-up. The third patient showed only a slight decrease in the size of his aneurysm at the 6-month follow-up after treatment with a flow-diversion stent technique. No recurrences were noted in patients who underwent stent-assisted coil embolization or balloon-assisted coil embolization. Among the 41 patients in whom <100% aneurysm occlusion was initially achieved, 29 had an available DSA follow-up and 17 (58.6%) showed progression to complete aneurysm occlusion (Table 6).

None of the 11 patients who underwent MRA follow-up had evidence of a recurrence. Overall, among the 76 patients in whom follow-up imaging was available (MRA or DSA), 3 patients (3.9%) had a recurrence and only 1 had to be retreated (1.3%). No early or late hemorrhage was observed after initial treatment in the series.

Discussion
SHA aneurysms are a rare type of intracranial aneurysm. Data pertaining to the characteristics and management of these lesions are extremely scant. Their treatment has therefore been based mainly on comparison with the wider heterogeneous group of paraclinoid aneurysms and varies with the preferences and experience of different centers. Treatment options include open surgery or endovascular techniques. We have offered endovascular therapy as the primary treatment option for all patients with SHA aneurysms who presented to our institution because we believe that these lesions are effectively managed with endovascular means while being particularly challenging for open surgery. We have assessed the safety and efficacy of endovascular therapy in the largest series of SHA aneurysms to date.

An interesting finding of our study is the extreme female

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### Table 3: Immediate angiographic results for aneurysms treated with different endovascular techniques

<table>
<thead>
<tr>
<th>Aneurysm Treatment</th>
<th>Complete Occlusion (100%)</th>
<th>Near-Complete Occlusion (95%–100%)</th>
<th>Incomplete Occlusion (&lt;95%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil embolization</td>
<td>22 (64.7%)</td>
<td>12 (35.3%)</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>Stent-assisted coiling</td>
<td>16 (35.6%)</td>
<td>27 (60%)</td>
<td>2 (4.4%)</td>
<td>45</td>
</tr>
<tr>
<td>Balloon-assisted coil embolization</td>
<td>4 (100%)</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>39</td>
<td>2</td>
<td>83</td>
</tr>
</tbody>
</table>

*This table excludes the patient who had a failed procedure and the 3 patients who were treated with a flow-diversion technique.

### Table 4: Angiographic outcome in 76 patients treated with endovascular techniques

<table>
<thead>
<tr>
<th>No. of Patients at Last Follow-Up</th>
<th>Angiography</th>
<th>6 Months</th>
<th>1 Year</th>
<th>2 Years</th>
<th>5 Years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil embolization</td>
<td>23 (2 recurrences)</td>
<td>4 (no recurrences)</td>
<td>4 (no recurrences)</td>
<td>1 (no recurrences)</td>
<td>32 (2 recurrences)</td>
<td></td>
</tr>
<tr>
<td>Stent-assisted coiling</td>
<td>27 (no recurrences)</td>
<td>5 (no recurrences)</td>
<td>4 (no recurrences)</td>
<td>1 (no recurrences)</td>
<td>37 (no recurrences)</td>
<td></td>
</tr>
<tr>
<td>Balloon-assisted coil embolization</td>
<td>2 (no recurrences)</td>
<td>1 (no recurrences)</td>
<td>1 (no recurrences)</td>
<td>0 (no recurrences)</td>
<td>4 (no recurrences)</td>
<td></td>
</tr>
<tr>
<td>Flow diversion</td>
<td>2 (1 recurrence)</td>
<td>1 (no recurrences)</td>
<td>0 (no recurrences)</td>
<td>0 (no recurrences)</td>
<td>3 (1 recurrence)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>54 (3 recurrences)</td>
<td>11 (no recurrences)</td>
<td>9 (no recurrences)</td>
<td>2 (no recurrences)</td>
<td>76 (3 recurrences)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 5: Patients with recurrences after initial endovascular treatment

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age (yr)/Sex</th>
<th>Aneurysm Size/Status</th>
<th>Initial Treatment (% of Occlusion)</th>
<th>Complications</th>
<th>Recurrence</th>
<th>Further Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43/Female</td>
<td>4 mm/unruptured</td>
<td>Coils (100%)</td>
<td>Groin hematoma</td>
<td>20% recurrence at 6-month follow-up</td>
<td>Coils, showed 100% occlusion at 6-month follow-up</td>
</tr>
<tr>
<td>2</td>
<td>51/Male</td>
<td>12 mm/unruptured</td>
<td>Coils (95%)</td>
<td>None</td>
<td>10% recurrence at 6-month follow-up</td>
<td>None, then lost to follow-up</td>
</tr>
<tr>
<td>3</td>
<td>51/Male</td>
<td>3 mm/unruptured</td>
<td>Flow diversion</td>
<td>None</td>
<td>Small decrease in aneurysm size at 6-month follow-up</td>
<td>None</td>
</tr>
</tbody>
</table>

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mortality rates as high as 3%–6%.\textsuperscript{4,14-16} These rates are well
corresponding complication rates ranging from 15% to 35% with
intra-cranial aneurysms—is still significant. Recent series have re-
vised techniques, the rate of complications
ary gland, especially for large aneurysms. Despite recent ad-
for perforating branches supplying the optic chiasm and the pitu-
during clip placement to preserve the patency of the small
apparatus and other surrounding structures. It is also difficult
obtaining proximal control, drilling of the ante-
average), which is a common finding for paraclinoid aneu-
size of SHA aneurysms was quite large in our series (6 mm on
average), which is a common finding for paraclinoid aneu-
srums,\textsuperscript{11,13} Surgical clipping of SHA aneurysms can be technically
challenging. Obtaining proximal control, drilling of the ante-
rrior clinoic process to allow adequate exposure of the aneu-
srum, and opening the dural ring may add potential surgical morbidity. The procedure carries a risk of injury to the optic apparat
and other surrounding structures. It is also difficult
during clip placement to preserve the patency of the small
perforating branches supplying the optic chiasm and the pitu-
itary gland, especially for large aneurysms. Despite recent ad-
ances in microsurgical techniques, the rate of complications
related to surgical clipping of paraclinoid aneurysms—including
SHA aneurysms—is still significant. Recent series have re-
ported complication rates ranging from 15% to 35% with
mortality rates as high as 3%–6%.\textsuperscript{4,14-16} These rates are well
above those observed with endovascular therapy in this series.
We found a remarkable 0% and 2.2% risk of major and minor complications, respectively. In addition, there was no proce-
dure-related permanent morbidity or mortality.
We also found an exceptionally low recurrence rate of 3.9%
at follow-up. Furthermore, the rate of recurrence requiring
further intervention was as low as 1.3%. This is, to our knowl-
edge, the lowest recurrence rate reported for any type of aneu-
ysm with endovascular therapy. To put this into perspective,
the recurrence rate is 24%–35% for posterior circulation aneu-
srys,\textsuperscript{17,18} 18%–32% for middle cerebral artery aneu-
srys,\textsuperscript{19} 37% for posterior communicating artery aneu-
srys,\textsuperscript{20} 25% for anterior communicating artery aneurysms,\textsuperscript{20} 26% for carotid opthalmic artery aneurysms,\textsuperscript{20} 40% for cavernous aneurysms,\textsuperscript{21} and 12%–29% for all paraclinoid aneu-
srys.\textsuperscript{4,5,11,22} One plausible explanation for the observed low
recurrence rate after endovascular therapy is the fact that SHA aneurysms are sidewall aneurysms projecting medially, which
prevents the direct jet flow of blood from entering the aneu-
srum sac, hence, favoring stasis and thrombosis. This would
also explain why bifurcation or end-vessel aneurysms tend to
recur after endovascular treatment. In our series, no hemor-
rhages were observed after initial endovascular treatment,
which shows that SHA aneurysms can be reliably secured with
endovascular therapy.
We are aware of only 1 study that assessed the safety and
efficacy of endovascular therapy for SHA aneurysms specifically.
In this study, Gurian et al\textsuperscript{a} performed coil embolization
in 11 patients with SHA aneurysms that were considered to be
at high risk for surgery. They had no procedure-related com-
lications and reported aneurysm recanalization in 1 of 7 pa-
tients at follow-up angiography. The authors concluded that
coil embolization was an excellent alternative for treating SHA
aneurysms. Although the results of this study are in line with
our findings, the sample size was too small to draw any firm
conclusions. Moreover, no patients were treated with stent or
balloon-assisted coiling techniques. In other series, small sam-
ple s of SHA aneurysms were included along with other para-
clinoid aneurysms. The rate of recurrence at follow-up ranged
from 12% to 29%, and complications were seen in 3%–7% of
patients.\textsuperscript{5,11,22} However, no separate analysis was done for
SHA aneurysms specifically to identify this seemingly unique
category in the large heterogeneous group of paraclinoid an-
urysms. Furthermore, because of the nonavailability of stents
at the time these studies were conducted, none of the patients
were treated with stent-assisted coil embolization.
In fact, many SHA aneurysms are complex with wide necks
and, thereby, require stent-assisted techniques. Besides pre-
venting coil herniation into the parent vessel, stent deploy-
ment diverts blood flow away from the lumen and enhances
thrombosis in the aneurysm.\textsuperscript{23} In the present series, while 2
recurrences and 2 complications occurred in patients treated
with coil embolization, none were noted in the stent group. Al-
though the number of events is too small to allow any sta-
tistical analysis, stent techniques seem to have the highest oc-
cclusion rates and the lowest complication rates for SHA aneu-
rysms. Overall, regardless of the technique, endovascular
therapy has an unparalleled safety-efficacy profile and should
be considered the procedure of choice for the treatment of
SHA aneurysms. Surgery should be reserved for patients in
whom endovascular therapy is unsuccessful.
One limitation of our study is the lack of comparison with
a control group that was treated with surgery. Because most

\begin{table}
\centering
\begin{tabular}{|l|l|l|l|l|}
\hline
 & Complete Occlusion & Stable Occlusion & Recurrence & Total \\
\hline
Complete occlusion (100\%) & 32 (97.0\%) & same & 1 (3\%) & 33 \\
Near-complete occlusion (95\%–100\%) & 15 (55.6\%) & 11 (40.7\%) & 1 (3.7\%) & 27 \\
Incomplete occlusion (<95\%) & 2 (100\%) & 0 & 0 & 2 \\
Total & 49 & 11 & 2 & 62 \\
\hline
\end{tabular}
\caption{Initial and follow-up DSA results for patients treated with endovascular therapy}
\end{table}

\footnotesize
* This table excludes the 3 patients who were treated with a flow-diversion technique as well as the 11 patients who underwent MRA follow-up.
centers, including ours, prefer to manage SHA aneurysms with endovascular therapy, we believe that it is very difficult to design a study with a control surgical group. Other limitations of this study stem from its retrospective design and the lack of angiographic follow-up in 10.6% of patients. Given the relatively short-term nature of the angiographic follow-up in this series, longer follow-up periods are required to ascertain that endovascular therapy provides durable aneurysm closure.

Conclusions
In this study, we present the results of the largest series of SHA aneurysms to date. We found an extremely female sex predominance for these lesions and a high incidence of associated aneurysms in the anterior circulation (exclusively). We were therefore able to demonstrate that endovascular therapy has a remarkably low rate of complications for SHA aneurysms. The rate of recurrence after endovascular treatment is the lowest for SHA aneurysms compared with aneurysms in other locations by using historical data. Endovascular therapy should therefore be considered the procedure of choice for the treatment of SHA aneurysms. Stent-assisted coiling seems to be the preferred endovascular technique. Surgery should be considered as an alternative whenever endovascular treatment fails.


References