Endovascular treatment of pericallosal aneurysms

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Object. Pericallosal artery aneurysms are uncommon. Their treatment strategy, surgical or endovascular, will present specific challenges. The objective of the study was to compare risks of coil therapy and the recurrence rate of pericallosal artery aneurysms with aneurysms in other intradural locations.

Methods. The authors examined data that were stored in a prospectively collected database for pericallosal artery aneurysms in patients who underwent coil placement between 1992 and 2005. Hemorrhagic and thromboembolic complications as well as clinical and angiographic outcomes were reviewed. Angiographically documented recurrences were classified as minor or major. These lesions were compared with a historical cohort of non–pericallosal artery aneurysms in patients who underwent coil therapy between 1992 and 2002. The known risk factors for recurrence and procedure-related hemorrhagic complications were evaluated in both groups to assess baseline imbalances.

Results. During a 13-year period, 25 pericallosal artery aneurysms were treated with coils in 25 patients. The non–pericallosal artery lesion group included 488 aneurysms of which 344 underwent follow-up imaging. Procedure-related perforations were more frequent for pericallosal artery aneurysms than those in other intradural locations (three of 25 compared with eight of 476, respectively; risk ratio 7.1, 95% confidence interval [CI] 2.1–22.5, p = 0.03). Follow-up imaging studies (obtained at a mean 28 months) were available for 19 patients with pericallosal artery aneurysms. The recurrence rate was not significantly higher in these patients (22.9/100 person–years of observation) than in those with non–pericallosal artery aneurysms (17.9/100 person–years of observation) (incidence rate ratio 1.3, 95% CI 0.6–2.4, p = 0.46).

Conclusions. Pericallosal artery aneurysms were associated with significantly higher periprocedural rupture than non–pericallosal artery lesions. No significant intergroup difference was found for aneurysm recurrence.

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KEY WORDS • aneurysm • perforation • pericallosal artery • recurrence

SURGICAL treatment of pericallosal artery aneurysms may be technically difficult. Compared with other supratentorial artery locations, pericallosal artery aneurysms are associated with a relatively higher operative morbidity rate up to 27%.3,6 Narrow exposure in the interhemispheric fissure, dense arachnoid adhesions between the cingulate gyri, adherence of the aneurysm dome to the parenchyma, vulnerability to rupture during operative exposure, and difficult control of the parent artery have been regarded as compounding difficulties a surgeon may encounter.4

In this regard, endovascular therapy in patients with pericallosal artery aneurysms is an alternative to surgery7 but has also been reported to be difficult.5,10 In one series, the authors noted 17% periprocedural ruptures (in three of 18 cases).3 The usual small size of pericallosal artery aneurysms and their distal location are anatomical characteristics that may render control of embolization more challenging11 and result in complications.

The topic of aneurysm recurrence after endovascular therapy has recently received increasing attention.11 Although the cumulative incidence of recurrence is estimated to range from 15 to 34%,1,11 no specific data exist for the pericallosal subgroup. This information may present future interest for the choice of therapeutic approaches or embolization material.

Two hypotheses were tested in the present study: pericallosal artery aneurysms are associated with 1) a higher procedure-related perforation rate and 2) a higher recurrence rate compared with other intradural aneurysm locations.

Clinical Material and Methods

Patient Population and Aneurysms

This was a retrospective cohort study in which we examined data for all coil-treated pericallosal artery aneurysms that were extracted from a prospectively collected database between 1992 and 2005 at a referral university hospital. The research protocol was approved by our institutional review board. We attempted treatment of 26 pericallosal artery aneurysms in 26 patients. In one case embolization

Abbreviations used in this paper: CI = confidence interval; mRS = modified Rankin Scale.
failed, and the patient was excluded from the study, leaving 25 pericallosal artery aneurysms and 25 patients. In the analysis on pericallosal artery aneurysm recurrence, we excluded aneurysms treated by occlusion of the parent vessel (one case) and patients with inhospital death (two cases) for a remainder of 22 aneurysms. The historical cohort used for comparative analysis had been previously extracted from the same database. There were 488 intradural non–pericallosal artery aneurysms treated in 453 patients between 1992 and 2002. Giant aneurysms (nine cases) and aneurysms treated by occlusion of the parent artery without coiling of the aneurysmal sac (three cases) were excluded, leaving 476 aneurysms for comparative analysis of procedural complications. Angiographic follow-up studies were not obtained in 120 patients and these cases were excluded from the comparative analysis of recurrence, leaving 344 non–pericallosal artery aneurysms. Characteristics known as risk factors for procedure-related perforation\(^2,12\) and/or recurrence\(^11\) were specifically assessed in both groups. The duration of angiographic follow-up, ruptured/unruptured state, aneurysm size defined by long-axis measurement, neck size, and initial occlusion results were recorded. Neck size and aneurysm long-axis were measured respectively on the projection that would result in the largest possible measurement.

**Endovascular Treatment**

Most patients underwent treatment after induction of general anesthesia with systemic heparinization during the procedure only. Procedures were performed on a monoplane C-arm angiographic system without 3D reconstruction between 1992 and 2004, and on a biplane angiographic system with 3D reconstruction after 2004. Systemic heparinization was administered after groin puncture in all cases, whether the aneurysm was ruptured or unruptured. Since 2003, aspirin-based antiplatelet therapy has been given 24 hours prior to the procedure in cases of unruptured aneurysms only. All aneurysms were treated using bare platinum coils. A procedure-related rupture was considered present if there was extravasation of contrast during coil embolization.

**Angiographic Results**

Initial and follow-up angiography studies were reviewed by two interventional neuroradiologists (F.G. and T.N.N.) to establish an immediate consensus. Initial angiographically documented obliteration was classified as complete, residual neck, or residual aneurysm, as defined previously.\(^11\) Angiographic follow-up was scheduled in all embolization-treated patients at 6 months, 18 months, 3 years, and 5 years. The follow-up intervals were defined as time between aneurysm treatment and the last angiographic study. If there was an aneurysm recurrence, month of follow-up was calculated as time between treatment and the time of first detection of recurrence. Multiple projections were used to detect any recurrent lesions. A residual neck was defined as the persistence of any portion of the original defect of the arterial wall as seen on any single projection but without opacification of the aneurysmal sac. Residual aneurysm was defined as any opacification of the sac. A recurrence was defined as any increase in the size of the remnant lesion. Incidence density was used to describe the recurrence rate to account for varying time periods of follow-up. Recurrence was considered major if the lesion was saccular and its size would permit retreatment with coils.

**Clinical Follow-Up**

Clinical follow-up status in patients with pericallosal artery aneurysms was assessed using the mRS. Good outcome was defined as an mRS score of 0 to 2.

**Statistical Analysis**

Homogeneity for different demographic and risk factors was assessed with t-test and Fisher exact test when appropriate. Hypothesis testing for differences in incidence density of recurrence (recurrence rate) and risk of perforation was performed using the Fisher exact test. The level of statistical significance was set at 0.05 and the Bonferroni method was used for multiple significance tests. Calculations were produced on StatsDirect statistical software (version 2.5,6).

**Results**

There were 25 pericallosal artery aneurysms treated with coils in 25 patients. One patient underwent occlusion of both the aneurysm sac and parent artery, and this case was excluded from the recurrence analysis. Of 12 patients with acutely ruptured pericallosal artery aneurysms, two died. One patient refused to undergo follow-up imaging, and two patients were lost to follow-up, leaving 19 cases in which data were used for recurrence analysis. The only relevant difference in risk factors reaching statistical significance after Bonferroni method for multiple significance tests were as follows: 1) higher proportion of small neck (≤ 4 mm), 74% (14 of 19) for the pericallosal artery aneurysm group compared with 42% (144 of 344) for the non–pericallosal artery aneurysm group (p = 0.01); and 2) more initial complete obliterations, 74% (14 of 19) for the pericallosal artery aneurysm group compared with 38% (130 of 344) for the non–pericallosal artery aneurysm group (p = 0.004) (Table 1). Table 2 provides a summary of perforation analysis results.

Procedure-related complications developed in four patients as follows: three with intraprocedural rupture due to coil perforation and one with transient hemiparesis. Of the three patients in whom coil perforation occurred intraoperatively, the aneurysm sizes were 6, 7, and 8 mm. One aneurysm was unruptured, and the two others were acutely ruptured. Compared with non–pericallosal artery aneurysms, there were more procedural ruptures in the pericallosal location (three of 25 compared with eight of 476, risk ratio 7.1, 95% CI 2.1–22.5, p = 0.03) (Table 3).

Good outcome (mRS Score 0–2) was seen in the majority of patients (22 [88%] of 25). Moderate to severe disability was observed in one patient (mRS Score 4), who presented with Hunt and Hess Grade IV subarachnoid hemorrhage. In one patient with an unruptured aneurysm there was coil perforation and hemorrhage, resulting in right-sided hemiparesis, dyslexia, and acalculia. She fully recovered over the 1st year. Two other perforations occurred in patients with Hunt and Hess Grade IV subarachnoid hemorrhage. They both died after withdrawal of care.
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**TABLE 1**

Baseline comparison of pericallosal and non–pericallosal artery aneurysms for recurrence analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Artery Aneurysm Group (%)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pericallosal (19 cases)</td>
<td>Non–Pericallosal (344 cases)</td>
</tr>
<tr>
<td>aneurysm size ≥10 mm</td>
<td>6 (32)</td>
<td>145 (42)</td>
</tr>
<tr>
<td>aneurysm neck ≥4 mm</td>
<td>5 (26)</td>
<td>200 (58)</td>
</tr>
<tr>
<td>treatment during ruptured phase</td>
<td>12 (63)</td>
<td>177 (52)</td>
</tr>
<tr>
<td>incomplete initial occlusion</td>
<td>5 (26)</td>
<td>214 (62)</td>
</tr>
<tr>
<td>follow-up ≥17 mos</td>
<td>8 (42)</td>
<td>157 (46)</td>
</tr>
</tbody>
</table>

* Values represent the mean ± standard deviation.

**TABLE 2**

Baseline comparison of pericallosal and non–pericallosal artery aneurysms for perforation analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Artery Aneurysm Group (%)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pericallosal (25 cases)</td>
<td>Non–Pericallosal (476 cases)</td>
</tr>
<tr>
<td>treatment during ruptured phase</td>
<td>15 (60)</td>
<td>253 (53)</td>
</tr>
<tr>
<td>mean aneurysm size (mm)*</td>
<td>7.5 ± 4.9</td>
<td>9.2 ± 5.2</td>
</tr>
</tbody>
</table>

* Values represent the mean ± standard deviation.

due to their poor neurological state, which was perhaps aggravated by the perforation.

The cumulative rate of pericallosal aneurysm recurrence was 52.6% (10 of 19 lesions) compared with 34.3% (118 of 344 lesions) in other locations. When accounting for various follow-up intervals (mean 27.5 and 23.0 months for pericallosal artery aneurysms and non–pericallosal artery aneurysms, respectively), the incidence density of recurrence (recurrence rate) was not significantly higher for pericallosal artery aneurysms (22.9/100 person–years of observation) than for non–pericallosal artery aneurysms (17.9/100 person–years of observation) (incidence rate ratio 1.3, 95% CI 0.6–2.4, p = 0.46) (Table 3). Pericallosal artery aneurysm recurrence was major in four patients and minor in six. Major pericallosal aneurysm recurrence was detected at 8, 9, 15, and 36 months after treatment, respectively, and all four patients underwent retreatment.

Among the four (21%) of 19 patients in whom a major recurrence was demonstrated, the first retreatment involved surgical clip placement in two and coil therapy in the other two, with all four procedures producing complete obliteration. Of the two patients who underwent repeated coil treatment, each suffered a major recurrence—one at 6 months and the other at 2 years—after retreatment. One of these two patients underwent clip placement as his third treatment, and the other patient awaits a treatment decision.

Aneurysm rupture did not occur in any patient with pericallosal artery aneurysms, whereas it did occur in three patients in the historical cohort.

**Discussion**

Consistent with a previous report, we found that pericallosal artery aneurysms were associated with a similar procedure-related perforation risk (three of 18 patients in the series described by Keseton et al. compared with three of 25 patients in ours). This risk rate stands in contrast to that in another series of 12 patients with ruptured pericallosal aneurysms, in which there were no procedure-related complications. Risk factors for a procedure-related perforation include an aneurysm in a previously ruptured state and the size of the aneurysms. In our crude analysis we found similar distribution for frequency of ruptured state (Table 2). The lesion size was smaller in the pericallosal artery aneurysm group than the non–pericallosal artery aneurysm group (mean 7.5 mm compared with 9.2 mm, respectively). This difference should be considered a possible explanation for a higher procedure-related aneurysm perforation rate. The small number of perforations, which did not allow data stratification to correct for this baseline imbalance, is an obvious limitation in our estimating the effect of this size difference. Moreover, the risk of procedure-induced perforation may also be related to anatomical peculiarities. The more distal location leads to catheter positioning via a longer segment in a small-caliber vessel, allowing a lesser degree of catheter deflection when the coil encounters resistance. Particular concern arises when the tip of the catheter is positioned against the fragile wall of the aneurysm. Surgical treatment has also been associated with a higher risk of intraoperative rupture, reported in up to 50% of these lesions. Pericallosal artery aneurysms, due to anatomical factors, are more prone to these complications regardless of the approach.

With regard to treatment durability, recurrences developed at a similar rate for pericallosal artery locations and other sites. Whereas the frequency of cumulative recurrence was higher for pericallosal artery aneurysms than others (52.6 and 34.3%, respectively), the follow-up period was also longer in the former (27.5 and 23.0 months, respectively). A longer follow-up period allows a higher rate of detection of aneurysm recurrence. To adjust for the confounding difference in follow-up periods, the relative incidence density of recurrence was calculated assuming a constant recurrence risk over time. This revealed an incidence rate ratio of 1.3 (p = 0.46) for pericallosal artery compared with other aneurysms, a relative difference of questionable clinical significance. Data analysis was significant for a higher proportion of small aneurysm neck size and better initial complete obliteration for pericallosal aneurysms. These two characteristics, known to be protective against recurrence, could act as confounders that partially explain similarities between our two groups. The small number of cases, which did not permit data stratifi-

**TABLE 3**

Aneurysm perforation and recurrence rates*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pericallosal Non–Pericallosal RR or IRR p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>perforation risk</td>
<td>0.12 (3/25) 0.017 (8/476) RR 7.1 (95% CI 2.1–22.5)</td>
</tr>
<tr>
<td>recurrence rate</td>
<td>22.9/100 17.9/100 IRR 1.3 (95% CI 0.6–2.4)</td>
</tr>
</tbody>
</table>

* IRR = incidence ratio rate; RR = risk rate.
cation to correct for these baseline imbalances, is a shortcoming, and this merits further investigation. Although these limitations do not allow for firm conclusions, our estimation of the incidence rate ratio of pericallosal aneurysm recurrence is probably conservative. From a surgical perspective in which recurrence is low after clip therapy, the cumulative 52.6% recurrence in our pericallosal artery aneurysm cohort could appear significant and raises the question of the long-term value of coil treatment of these aneurysms.

Other limitations were the retrospective, single-center nature of the study as well as the use of a historical cohort for comparison. The interventional neuroradiologists reviewing the follow-up pericallosal artery angiograms generated the hypothesis tested in the study, which may have heightened their sensitivity to detecting minor aneurysm recurrence.

The landmark study by the authors of the International Subarachnoid Aneurysm Trial showed improved outcome after endovascular treatment of ruptured aneurysms compared with clip placement. In that study, pericallosal artery aneurysms accounted for 95 (4.4%) of 2143 randomized aneurysms, a fraction that parallels its rare incidence (2–5.5% of all cerebral aneurysms). Because of the small number of aneurysms in this location and the weakness of subgroup post hoc analysis, no therapeutic approach was associated with superiority for managing pericallosal artery aneurysm. As a general rule, the most reliable estimate of treatment effects for a particular subgroup remains the overall effect of all subgroups combined, rather than the observed effect in that subgroup of a trial. Although the results of our study may be interpreted as a warning for perforation in the endovascular treatment of pericallosal aneurysms, caution is warranted to preclude an unsupported inference for a treatment decision toward surgery. In the face of such uncertainty, such decisions should be supported by the best available evidence, which is coil therapy compared with clip placement when a ruptured aneurysm is thought equally suitable for both treatments. In the setting of unruptured aneurysms, such data have not surfaced.

**Conclusions**

We found a significantly higher rate of procedure-related aneurysm perforation in cases of pericallosal artery aneurysms compared with aneurysms in other intradural locations. Recurrence rates were found to be similar in these two groups.

**References**


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