



Outcome, Prognostic Factors, and Follow-Up Results After Subarachnoid Hemorrhage from Pericallosal Artery Aneurysms

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■ **OBJECTIVE:** Pericallosal artery aneurysms (PAAs) are usually rare (2%–5%), and treatment is challenging for both surgical and endovascular modalities. We performed this analysis to determine the outcome and prognostic factors after subarachnoid hemorrhage (SAH) caused by ruptured PAAs.

■ **METHODS:** A total of 32 patients with ruptured PAA were admitted to our hospital between 1999 and 2014, added to our prospective database, and analyzed retrospectively. Outcome was measured based on the modified Rankin Scale (mRS) at 6 months after ictus (favorable mRS score, 0–2 vs. unfavorable mRS score, 3–6).

■ **RESULTS:** Only 16 (50%) patients had a good clinical status at admission (World Federation of Neurological Surgeons Grading System [WFNS] grades I–III), whereas 12 patients (37.5%) were comatose (WFNS grade V). In 18 patients (56%), intracerebral hemorrhage was confirmed, in 18 patients (56%) cerebrospinal fluid drainage was required immediately after admission, and in 5 cases (16%) decompressive craniectomy was performed. There were 17 patients (53.1%) who achieved a favorable outcome (mRS score 0–2) at follow-up. Unfavorable outcome was associated with smoking, cerebral infarction, and worse admission status after multiple logistic regression analysis.

■ **CONCLUSIONS:** Poor admission status, cerebral infarction, and smoking seem to be crucial factors for unfavorable outcome after SAH from PAA.

INTRODUCTION

Distal anterior cerebral artery (DACA) aneurysm (A2–A5), hence the term used is pericallosal artery aneurysm (PAA), represents a relatively infrequent cause of subarachnoid hemorrhage (SAH). They are rare (2%–5%) vascular malformations, and the course of ruptured pericallosal artery aneurysm (rPAA) harbors many difficulties.^{1,2}

In addition to the difficulty of microsurgery and endovascular treatment, treatment of rPAA is complex and challenging because of frontal intracerebral hemorrhage (ICH), vasospasm, and cerebral infarction (CI). ICH occurs more frequently in ruptured aneurysms of the DACA (46.2%) than in aneurysms elsewhere.³ Data on treatment and outcome for rPAA are rare.⁴ The aim of our study was to evaluate outcome and prognostic factors after SAH, with reference to rPAA.

METHODS

All patients with rPAA treated at our neurovascular center were recorded in our prospective database in the period from 1999 and 2014 and retrospectively analyzed.

Key words

- A. pericallosal aneurysm
- Cigarette use
- Clipping
- Endovascular treatment
- Prognostic factors
- Subarachnoid hemorrhage

Abbreviations and Acronyms

- CI: Cerebral infarction
- CVS: Cerebral vasospasm
- DACA: Distal anterior cerebral artery
- ICH: Intracerebral hemorrhage
- MCA: Middle cerebral artery
- mRS: modified Rankin Scale
- PAA: Pericallosal artery aneurysm

rPAA: Ruptured pericallosal artery aneurysm

SAH: Subarachnoid hemorrhage

WFNS: World Federation of Neurological Surgeons Grading System

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Ethical approval for the study was provided by the local ethics committee. Because the study design is retrospective, no written consent was performed and necessary by the patients prior to the study.

A total of 32 patients were registered. Inclusion criteria were older than 18 years of age and angiographically (computed tomography angiography or digital subtraction angiography) confirmed PAA related to SAH. Initial clinical presentation was classified based on World Federation of Neurological Surgeons Grading System (WFNS) grades.

Patients were assigned to the following groups: good admission state (WFNS grades I–III) and poor admission state (WFNS grades IV–V).

Patient characteristics, such as neurologic score at admission, SAH grade and associated ICH, aneurysm size, age, sex, cigarette use, course of SAH (vasospasm, infarctions, and hydrocephalus), and aneurysm treatment, were evaluated and investigated.

Outcome was measured based on the modified Rankin Scale (mRS) 6 months after ictus (favorable mRS score, 0–2 vs. unfavorable mRS score, 3–6). Outcome was assessed based on the clinical information from repetitive hospital stays and follow-up visits.

Based on interdisciplinary consensus, aneurysms were treated by endovascular or microsurgical occlusion.⁴ All patients were treated equally for the treatment of cerebral vasospasm (CVS), blood pressure management, and hydrocephalus at our neurosurgical intensive care unit. Considering our treatment protocol, oral application of nimodipine was given to all patients with SAH started from the day of admission for 21 days. Patients with clipped aneurysm were investigated with additional digital subtraction angiography to verify aneurysm occlusion. Patients were monitored daily with transcranial Doppler. In case of increase in velocity (transcranial Doppler mean >150 cm/s or >50 cm/s in 24 hours) or delayed neurologic deterioration, computed tomography scan or magnetic resonance imaging was initiated to confirm CVS. On day 7 ± 2 after ictus, patients who could not be sufficiently evaluated clinically received a regularly scheduled computed tomography angiography or magnetic resonance angiography to detect CVS. A mean arterial pressure >90 mm Hg was kept at all times to sustain adequate cerebral perfusion. In patients with CVS, hypertension was induced, with the goal of a mean arterial pressure >110 mm Hg.⁵

Nimodipine was infused intra-arterially as rescue therapy in 7 cases (22%) for treatment of severe symptomatic vasospasm based on angiographic findings.

Statistical Analysis

Statistical analysis was performed using the statistical software package SPSS (IBM SPSS Statistics for Windows, Version 22 [IBM Corp., Armonk, New York, USA]). Categorical variables were analyzed in contingency tables using the Fisher exact test, and an unpaired t test was used for parametric statistics. For univariate analysis, statistical significance was set at $P < 0.05$. A backward stepwise method was used to construct a multivariate logistic regression model in relation to unfavorable outcome with an inclusion criterion of $P < 0.1$. The Mann-Whitney U test was used to compare the 2 treatment methods (clipping vs. coiling).

RESULTS

Patient Demographics and Neurologic Grading at Admission

Of 1423 patients with aneurysmal SAH in our database, 32 (2.2%) patients suffered from a rPAA. Most patients were women ($n = 24$; 75%). The median age was 50.3 ± 13 years.

Sixteen (50%) patients showed good clinical status at admission (WFNS grades I–III), and 16 (50%) patients suffered from severe SAH with WFNS grades of IV and V. Current smokers were compared with those not smoking at the time of the SAH. Among the evaluation, 59.4% of patients were current smokers. **Table 1** describes demographic data for the entire study cohort.

SAH and Aneurysm Characteristics

Our series included 21 (65.6%) small aneurysms (<7 mm), 8 (25%) medium aneurysms (7–10 mm), and 3 (9.4%) large aneurysms (10–25 mm). Nineteen (59.4%) aneurysms were located around the genu, 8 (25%) were at the rostrum, and 5 (15.6%) were supracallosal. In this regard, there was no difference in the distribution between the clipping ($n = 13$) and coiling ($n = 17$) groups. Ten of the small-size aneurysms were coiled, and 10 of the small-size aneurysms were clipped. One patient with a small-size aneurysm died before treatment. In addition, 1 large aneurysm was coiled and 2 were clipped. Six patients with medium-size aneurysms were treated endovascularly; this was the case in 1 patient in the clipping group. Most patients ($n = 25$; 78%) had a Fisher grade 3 or 4 bleeding pattern. In 56.3% of cases ($n = 18$), an ICH was detected. Hematoma volume was larger (mean: 8.6 vs. 6.3 cm³, respectively) in the clipping group than in the coiling group. Four (12.5%) patients required removal of ICH, and in 4 (12.5%) patients with ICH a bifrontal craniectomy was necessary. In 1 patient bifrontal craniectomy was necessary because of infarctions, so that a bifrontal craniectomy was performed in 5 (16%) patients. Early hydrocephalus was detected in 18 patients (56.3%); however, only 4 (12.5%) patients developed a shunt-dependent hydrocephalus. In univariate analysis, severe vasospasm was observed in 50% of patients and deemed to be a significant cause for CI (82.4% vs. 15.4% [severe CVS in patients without CI]; $P < 0.001$). Seventeen (53.1%) patients showed CI over the course of treatment.

Management

One patient died before treatment at day 1 after ictus, and another patient could not be treated because of severe vasospasm.

Because of a large ICH spreading branches from the aneurysm and/or a large size of aneurysm neck, 13 (43.3%) patients were clipped. Despite the cases with bifrontal craniectomy for hematoma evacuation, regularly a standard frontal interhemispheric approach was used, either by frontal paramedian or bifrontal craniotomy.

Endovascular treatment was performed in 17 (56.7%) patients.

There was no difference in age between the 2 groups (clipping vs. coiling). The rate of aneurysm complete occlusion and incomplete aneurysm occlusion, as measured by the Raymond-Roy criteria,⁶ was similar in both groups (**Table 2**). More than half of the patients in both groups (clipping vs. coiling) reached a favorable outcome, and our data could not reflect a statistical significant superiority of either treatment modality (61.5% vs.

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