Online September 16, 2021
Journal of Neuroendovascular Therapy 2022; 16: 243–249 DOI: 10.5797/jnet.oa.2021-0078

Original Article

Endovascular Treatment for Posterior Communicating Artery Aneurysms with Oculomotor Nerve Palsy

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Objective: Coil embolization for the treatment of internal carotid artery–posterior communicating artery aneurysms (PComAAn) associated with oculomotor nerve palsy (ONP) remains controversial in terms of the therapeutic effect to improve ONP. Patients with PComAAn treated in our hospital were retrospectively analyzed to evaluate the effectiveness of coil embolization on ONP.

Methods: Twenty-three patients who had coil embolization for PComAAn with ONP were included in the analysis. In the evaluation of postoperative outcome of ONP, complete resolution of all symptoms was considered as a total recovery. ONP with a few residual symptoms that are stable and not disabling was considered as a subtotal recovery and that with only a slight improvement as a partial recovery.

Results: Preoperative ONP was complete palsy in 14 and partial palsy in nine cases. The mean maximum diameter of the aneurysms was 9.1 ± 3.5 mm (3–17 mm), and the mean time from the onset to treatment was 46.3 ± 98.4 days (0–300 days). The embolization state immediately after the procedure was complete occlusion in seven, neck remnant in eight, and body filling (BF) in eight cases. Total recovery was observed in nine, subtotal recovery in 11, and partial recovery in three cases. The mean time to any improvement in ONP was 6.0 ± 6.0 months (0.5–25 months). Comparing 20 cases with total plus subtotal recovery and three cases with partial recovery, five (25.0%) and three (100%) cases showed BF immediately after the procedure, respectively, which was statistically significant ($P = 0.015$).

Conclusion: The analysis indicated that coil embolization for the treatment of PComAAn with ONP resulted in satisfactory recovery of ONP in 87% of the cases and the outcome of aneurysm embolization was related to improvement in ONP.

Keywords coil embolization, posterior communicating artery aneurysm, oculomotor nerve palsy

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Received: May 26, 2021; Accepted: August 3, 2021
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*The abstract of this paper was presented at the 36th Annual Meeting of the Japanese Society for Neuroendovascular Therapy, November 2020, Kyoto.

Introduction

Internal carotid artery (ICA)–posterior communicating artery (PComA) aneurysms (PComAAn) often accompany oculomotor nerve palsy (ONP) mainly due to their direct compression on the nerve. More than one-third of cases of PComAAn have been reported to cause ONP.[1)] The occurrence of ONP is recognized as a warning sign of aneurysm rupture and early intervention is recommended. Surgical clipping is a well-established procedure to reverse ONP by releasing pressure from the aneurysm on the oculomotor nerve.[2–4)] Some reports have suggested that with the recent advances in the technique, coil embolization could improve ONP as effectively as clipping; however, the effects have

not been fully analyzed and the comparative efficacy remains unclear.[5,6] In the present study, we retrospectively analyzed cases of PComAAn with ONP treated with coil embolization to determine possible factors involved in the improvement of ONP.

Materials and Methods

Twenty-three patients who had coil embolization for PComAAn with ONP between December 2005 and March 2020 were included in the analysis. Preoperative ONP was assessed as complete palsy (CP) if all three signs of unequal pupils, oculomotor disorder, and ptosis were present and as partial palsy if any of the three signs were present. In the evaluation of postoperative outcome of ONP, complete resolution of all symptoms was considered as a total recovery. ONP with a few residual symptoms that are stable and not disabling was considered as a subtotal recovery and that with only a slight improvement as a partial recovery. The total and subtotal recovery groups were compared with the partial recovery group for selected parameters and to reveal possible factors influencing the improvement in ONP.

This study is approved by the medical ethics board of Kagawa university.

Results

The results are shown in **Table 1**. Subjects included two men and 21 women with a mean age of 72.7 ± 15.0 years (39–98 years). Fourteen had unruptured cerebral aneurysms and nine had ruptured cerebral aneurysms, all of which were Hunt & Kosnik (H&K) grade I subarachnoid hemorrhage. These aneurysms were located on the right side in 11 cases and on the left side in 12 cases. The mean maximum diameter was 9.1 ± 3.5 mm (3–17 mm) and the mean neck size was 4.2 ± 1.3 mm (2–6.4 mm). A simple technique was used to treat four cases, and as adjunctive techniques, double-catheter embolization was performed in two, balloon-assisted embolization in 16, and stent-assisted embolization in one case. The embolization state immediately after the procedure was complete occlusion (CO) in seven (30.4%), neck remnant (NR) in eight (34.8%), and body filling (BF) in eight cases (34.8%). The mean time from the onset of ONP to treatment was 46.3 ± 98.4 days (0–300 days), and 18 cases (78.3%) were treated within three weeks of diagnosis. After the procedure, ONP showed total recovery in nine (39.1%), subtotal recovery in 11 (47.8%), and partial recovery in three cases (13.0%), resulting in an ONP improvement rate of 87.0% with total and subtotal recovery combined. In all three cases of partial recovery, preoperative ONP was assessed as CP and the embolization state immediately after the procedure was BF. The mean time to improvement in ONP was 6.0 ± 6.0 months (0.5–25 months). One patient (Case 19) developed subarachnoid hemorrhage secondary to a recurrent aneurysm six years after the initial procedure and underwent coil embolization, which was not followed by ONP.

Comparing 20 cases with total plus subtotal recovery of ONP after coil embolization and three cases with partial recovery, five (25.0%) and three (100%) cases showed BF immediately after the procedure, respectively, which was statistically significant (P = 0.015). Preoperative ONP of these two groups was CP in 11 (55.0%) and three (100%) cases, respectively, showing a tendency of higher percentage of CP in the partial recovery group (P = 0.161) (**Table 2**).

Case Presentation

Case 3

An 81-year-old woman experienced a sudden headache and drooping of the left eyelid. The patient was diagnosed as having subarachnoid hemorrhage (H&K grade I) by a nearby doctor who examined her two days after the event, and she was referred to our hospital. Cerebral angiography revealed a cerebral aneurysm of 8.5 mm in maximum diameter at the junction of the left ICA and PComA (**Fig. 1A** and **1C**). Left ONP involved ptosis, dilated pupil, and oculomotor disorder (CP). On Day 2, balloon-assisted aneurysm coil embolization was performed and completed with minimal NR (**Fig. 1B** and **1D**). The patient was discharged home with a favorable postoperative course and ONP resolving. At the outpatient visit after 11 months, ONP had completely disappeared (total recovery).

Case 21

A 69-year-old woman presented to a local clinic with a sudden headache and repeated vomiting the day after first developing the symptoms. Dilation of the left pupil, ptosis, and oculomotor disorder were observed (CP) with a finding of subarachnoid hemorrhage in a head CT (H&K grade I). A cerebral aneurysm of 6 mm in maximum diameter was noted in cerebral angiography at the left ICA–PComA junction (**Fig. 2A** and **2B**). Balloon-assisted aneurysm coil embolization was performed on the same day and completed with BF (**Fig. 2C**). Her general condition was good after the procedure, but ONP improvement was poor and still severe at 11 months postoperatively (partial recovery).

Table 1 Patient characteristics

Case	Age	Sex	SAH	Side	Aneurysm maximum size (mm)	Aneurysm neck size (mm)	Adjunctive technique	Radiological outcome	Third nerve palsy	Timing of treatment (days)	Recovery status	Time to recovery (months)
1	44	F	No	Lt	8	3	Balloon	NR	PP	3	Total	3
2	86	F	No	Lt	15	5	Double cath.	BF	CP	21	Total	4
3	81	F	Yes	Lt	8.5	3.9	Balloon	NR	CP	2	Total	11
4	39	M	No	Lt	7	3	Balloon	NR	CP	3	Total	2
5	41	F	Yes	Lt	10	4	Balloon	BF	PP	3	Total	4
6	80	F	No	Rt	17	5	Simple	NR	PP	14	Total	2
7	70	F	No	Lt	13	5	Balloon	CO	PP	0	Total	0.5
8	78	F	Yes	Rt	3	2.5	Balloon	CO	PP	1	Total	0.5
9	79	F	No	Lt	10	5	Balloon	BF	CP	4	Total	6
10	82	F	Yes	Rt	8	5.2	Balloon	BF	PP	11	Subtotal	0.5
11	82	F	No	Lt	10	3.7	Stent	CO	CP	90	Subtotal	9
12	64	F	No	Rt	8	2	Simple	NR	CP	7	Subtotal	5
13	67	F	No	Lt	7	2.8	Simple	NR	PP	180	Subtotal	14
14	63	F	Yes	Rt	8	3.2	Balloon	CO	PP	0	Subtotal	25
15	81	F	No	Lt	10	4	Balloon	NR	CP	180	Subtotal	11
16	86	F	Yes	Rt	9	6.4	Balloon	BF	CP	1	Subtotal	12
17	83	F	Yes	Rt	7	5	Balloon	NR	CP	1	Subtotal	12
18	63	M	No	Rt	7	3	Simple	CO	CP	21	Subtotal	4
19	83	F	No	Rt	5	3	Balloon	CO	CP	11	Subtotal	6
20	80	F	No	Lt	6	6	Balloon	CO	PP	30	Subtotal	1
21	69	F	Yes	Lt	6	3.7	Balloon	BF	CP	1	Partial	-
22	98	F	Yes	Rt	10.5	6.4	Balloon	BF	CP	2	Partial	-
23	72	F	No	Rt	17	5	Double cath.	BF	CP	300	Partial	-

BF: body filling; CO: complete occlusion; CP: complete palsy; Double cath.: double catheter; F: female; Lt: left; M: male; NR: neck remnant; PP: partial palsy; Rt: right; SAH: subarachnoid hemorrhage

Table 2 Comparison of total or subtotal group with partial group of recovery status

	Recovery status		
	Total or subtotal (n = 20)	Partial (n = 3)	*P* value
Age	71.6 ± 15.0	79.7 ± 15.9	0.681
Sex (female)	18 (90.0%)	3 (100%)	0.64
SAH	7 (35.0%)	2 (66.7%)	0.332
Side (left)	11 (55.0%)	1 (33.3%)	0.527
Aneurysm maximum size (mm)	8.8 ± 3.2	11.1 ± 5.5	0.434
Aneurysm neck size (mm)	4.0 ± 1.2	5.0 ± 1.4	0.268
Radiological outcome (BF)	5 (25.0%)	3 (100%)	0.015
Third nerve palsy (CP)	11 (55.0%)	3 (100%)	0.161
Timing of treatment (days)	46.5 ± 92.2	101.0 ± 172.3	0.891

BF: body filling; CP: complete palsy; SAH: subarachnoid hemorrhage

Discussion

As described in this report, patients with PComAAn with ONP were treated with coil embolization and 87% of the cases had sufficient improvement in ONP without interfering with daily activities, indicating that coil embolization is an effective treatment for improving ONP. A retrospective literature review comparing clipping and coil embolization in the treatment of PComAAn associated with ONP showed a significant improvement of ONP by clipping compared with coil embolization, as clipping fully restored ONP in 55% (72 of 132 patients), whereas coil embolization restored ONP in only 32% (17 of 54 patients), according to a systematic review in 2011.[4] A systematic review of 297 cases from nine papers published in 2017 reported that there was no significant difference between the two surgical strategies in total recovery of ONP, but clipping was more likely to result in better ONP outcomes.[6] However, in 2019, Zhong et al. reported that the postoperative total recovery rate of ONP was 49% (19 of 39 patients) and 60% (38 of 63 patients) by clipping and coil embolization, respectively, with coil embolization improving ONP as much or more than clipping.[5] In 2020, Signorelli et al. also reported a total of 55 unruptured PComAAn cases of which 24 were treated with clipping and 31 with coil embolization, and permanent ONP improvement was achieved in more than 70% of cases in both procedures.[7] Overall, the treatment results of ONP with coil embolization have been showing progress over time, possibly due to technological advances in endovascular treatment and the development of devices. As the development of various types of coils such as surface modified coils, stents, balloons, and other devices in endovascular treatment has improved treatment outcomes with better therapeutic reliability and safety, it appears that endovascular treatment is more often indicated for simple cases that have otherwise been treated by clipping. In this study report, which followed up the subjects from 2005 to 2020, no significant difference was observed in the improvement of ONP by the timing of treatment between 12 patients treated in the first half (2005–2014; five total, six subtotal, and one partial recovery) and 11 patients treated in the latter half (2015–2020; four total, five subtotal, and two partial recovery).

Factors involved in the improvement of ONP in coil embolization include the degree of ONP before treatment, the time from the onset of ONP to treatment, development of subarachnoid hemorrhage, age, and the presence of risk factors for cardiovascular disease.[1,4,5,8–11] In this report, all three patients who failed to achieve satisfactory improvement in ONP had CP ONP preoperatively, and the result of aneurysm embolization was BF. Many reports suggest that the degree of preoperative ONP is related to postoperative improvement in ONP, leading to a better outcome especially when no pupillary symptoms are observed, because this indicates that both the functions of peripheral oculomotor nerve fibers and microvascular circulation are maintained.[12] With respect to the results of aneurysm embolization, the BF state immediately after the procedure was associated with less improvement in ONP with a significant difference. Our extensive review of the literature revealed no study reporting a relationship between the results of aneurysm embolization and improvement in ONP. One of the mechanisms underlying improvement in ONP with coil embolization is the reduction of stimulation to the oculomotor nerve by preventing the aneurysm from pulsating. If embolization is incomplete, the aneurysm may continue

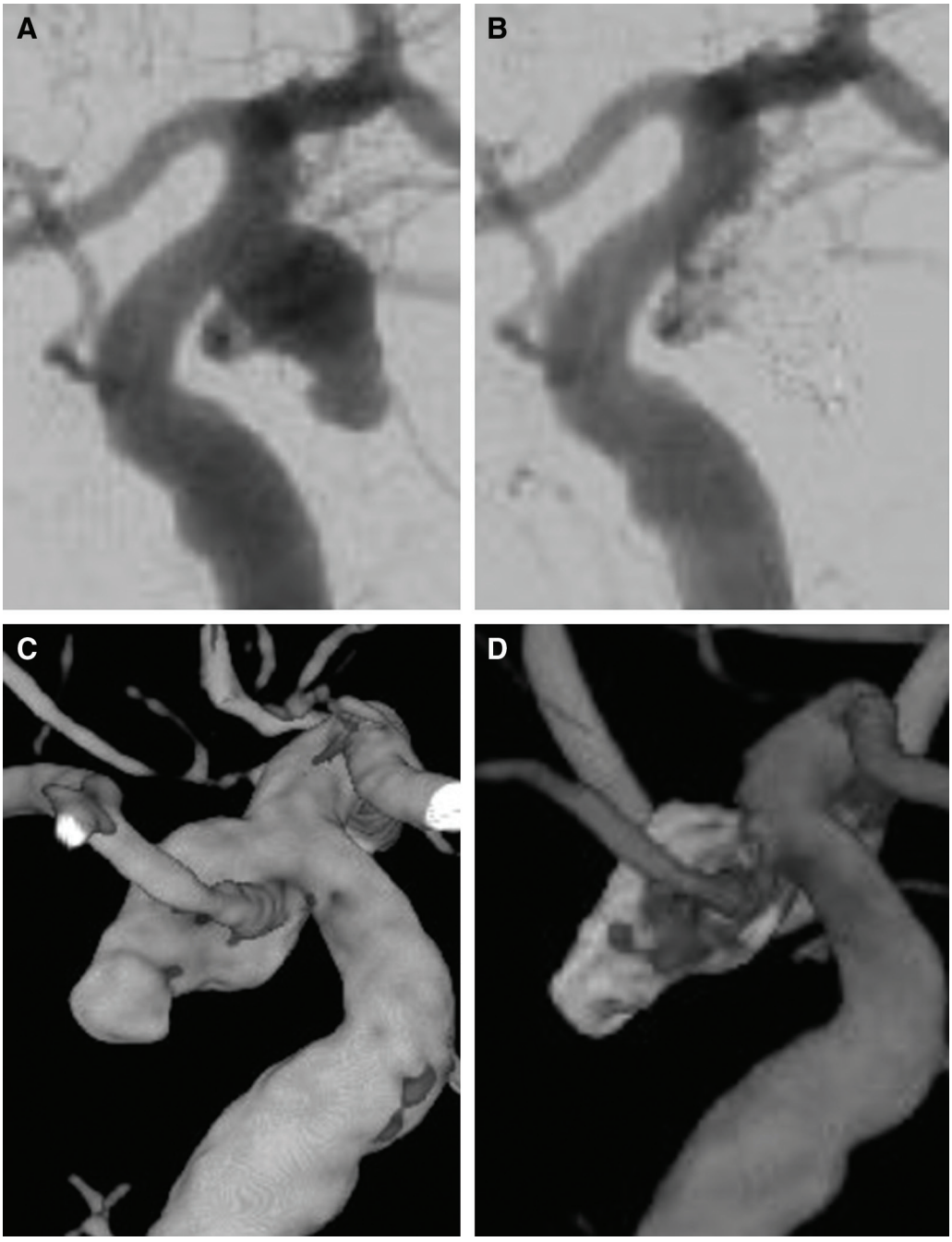

Fig. 1 Case 3. (**A** and **C**) Pre-procedural left internal carotid arteriography showed a cerebral aneurysm 8.5 mm in diameter at PComA. (**B** and **D**) Coil embolization was performed with an outcome of NR. NR: neck remnant; PComA: posterior communicating artery

pulsating to stimulate the nerve. However, Shimoda et al. reported that patients with a volume embolization rate of ≥35% after coil embolization were likely to exhibit incomplete improvement in ONP, thus discouraging excessive coil insertion as it may increase mechanical compression on the oculomotor nerve.[13] Recurrent aneurysm early after treatment may have prevented the improvement of ONP in the cases where embolization immediately after treatment ended up with BF. However, the re-enlargement of aneurysms is not noted for all three cases achieving partial recovery of ONP in this report. One patient (Case 19, CO, subtotal) had recurrent aneurysm with the onset of subarachnoid hemorrhage six years after the initial treatment and the status of ONP was unchanged. Zhong et al. proposed that assessment of postoperative improvement in ONP would require at least

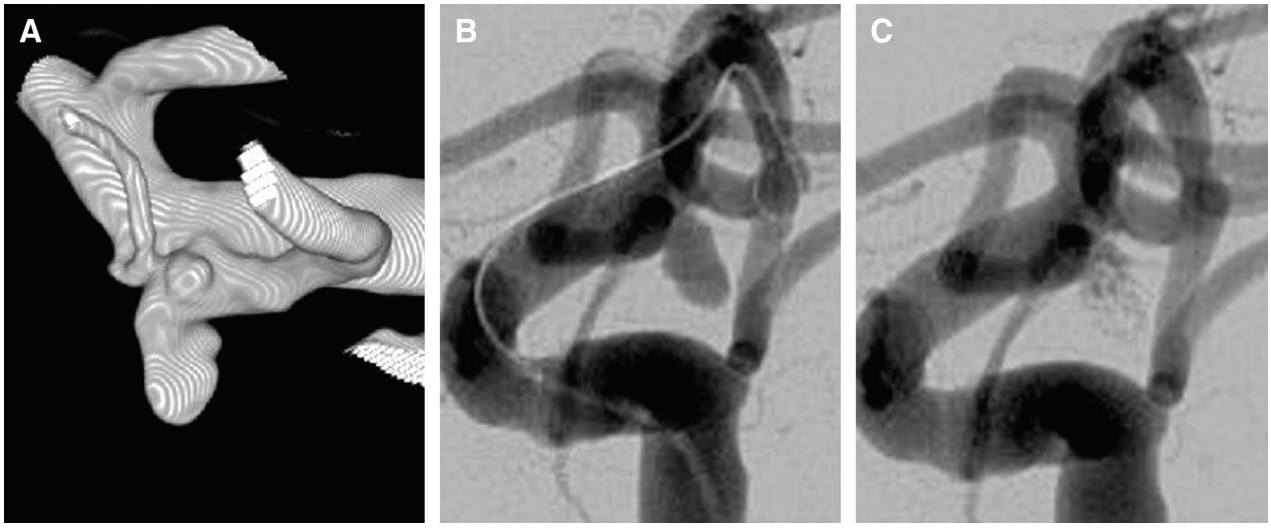

Fig. 2 Case 21. (**A** and **B**) Pre-procedural left internal carotid arteriography showed a cerebral aneurysm 6 mm in diameter at PComA. (**C**) Coil embolization was performed with an outcome of BF. BF: body filling; PComA: posterior communicating artery

12 months of follow-up, while two cases (Cases 10 and 21) had been followed up for less than 12 months in this report, which may have led to an underestimation of the magnitude of ONP improvement.[5] It is suggested that the pathogenesis of ONP is different between unruptured and ruptured aneurysms. Kassis et al. reported that subarachnoid hemorrhage was a significant factor related to ONP recovery and discussed that if a hematoma from a ruptured aneurysm caused compression on the oculomotor nerve, the paralysis was supposed to resolve with the reabsorption of hematoma.[1] Moreover, since ONP that developed with subarachnoid hemorrhage necessarily requires a shorter time period from the onset to treatment, this can cause a bias in the duration of disease.

The limitations of our report include the retrospective nature of the study, small sample size, and short follow-up periods in some of the patients included. Separate analysis of unruptured and ruptured aneurysms with a larger number of samples may allow more accurate assessment.

Conclusion

Coil embolization for PComAAn with ONP resulted in satisfactory improvement in ONP in 87% of the cases and was therefore demonstrated to be an effective treatment for ONP. Considering that the immediate post-procedural embolization state plays a key role in improving ONP, it is recommended to completely embolize the target aneurysm taking care not to insert an excessive amount of coil into the lesion.

Disclosure Statement

All authors have completed a self-report of conflict of interest (COI) to the Japan Neurosurgical Society. There are no COI to declare in publishing this paper.

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