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Original Article

Recovery of Oculomotor Nerve Palsy after Endovascular and Surgical Treatment of Posterior Communicating Artery Aneurysms: A Single Institutional Experience

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Abstract

Introduction: Surgical oculomotor nerve palsy(ONP), defined by ptosis, ophthalmoplegia, diplopia and pupillary dilatation, is associated with intracranial aneurysms, especially posterior communicating artery (PcomA) aneurysms. Treatment of PcomA aneurysms include endovascular coiling and surgical clipping. This study retrospectively compared the recovery of ONP in patients who underwent endovascular coiling or surgical clipping. **Methods:** A retrospective review of patients with PcomA aneurysms who presented with ONP between 1998 and 2012 in the National Neuroscience Institute, Singapore, was performed. Inclusion criteria included adult patients of age above 21 who have radiologically confirmed PcomA aneurysms with presentation of ipsilateral ONP. The aneurysms may be unruptured or ruptured with WFNS grade 2 subarachnoid hemorrhage (SAH) or better. Only patients with completely surgically or endovascularly obliterated PcomA aneurysms with regular follow-up are included. **Results:** A total of 22 patients were recruited. They were treated by either endovascular coiling or surgical clipping. The two groups of patients were demographically comparable, with 11 patients in each arm. 13 (59%) patients had unruptured aneurysms and 9 (41%) had WFNS grade 2 or better SAH. 13 (59%) patients presented with complete ONP and 9 (41%) had partial ONP. 64% of patients who underwent surgical clipping had resolution of ONP completely, compared to 18% of endovascularly coiling ($P = 0.03$) at 1-month follow-up. **Conclusion:** Compared to endovascular coiling, surgically clipped PcomA aneurysms are associated with a faster rate of full recovery of ONP.

Keywords: *Endovascular coiling, intracranial aneurysms, oculomotor nerve palsy, posterior communicating artery aneurysms, surgical clipping*

Introduction

Surgical oculomotor nerve palsy (ONP), defined by ptosis, ophthalmoplegia, and pupillary dilatation, is a well-known clinical presentation often associated with posterior communicating artery (PComA) aneurysms. Recovery of ONP associated with intracranial aneurysms, after both endovascular coiling and surgical clipping treatment, is well documented in previous literature. After the publication of the International Subarachnoid Aneurysm Trial (ISAT) study in 2006, treatment of ruptured aneurysms has swayed toward endovascular treatment. However, it remains unclear if patients who present with ONP would have a better rate of recovery after surgical clipping. The aim of our study is to assess the outcome of ONP recovery after surgical clipping or endovascular coiling of PComA aneurysms in our institute.

Patients and Methods

The study is approved by the Institutional Ethics Review Board. A retrospective review of patients with PComA aneurysms was performed using the International Classification of Disease-10 code and patient database of the National Neuroscience Institute in Singapore between 1998 and 2012. This allows for a minimum follow-up period of 2 years. Patients' inpatient medical records, operative or endovascular procedure reports, radiological images, and the outpatient clinic notes on follow-up were reviewed by two independent investigators.

The inclusion criteria for this study were as follows: Age above or equal to 21 years old, radiologically confirmed PComA aneurysms presenting with ipsilateral ONP. These may be unruptured or ruptured aneurysms with good World Federation of Neurological

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Surgeon (WFNS) Grade 1 or 2. This allows inclusion of cooperative patients for complete ONP assessment. Only patients with complete endovascularly coiled or surgically clipped PComA aneurysms with regular follow-up are included. Exclusion criteria included aneurysms other than PComA aneurysm, multiple aneurysms, and patients who were followed-up for <2 years.

Complete ONP is defined as the presence of ptosis, ophthalmoplegia or diplopia, and pupillary dilatation. Partial ONP refers to the presence of one or two of the three signs. Complete recovery is defined by resolution of all of the above symptoms, and partial recovery means an improvement from pretreatment symptoms but not achieving complete resolution. All endovascular coiling were performed by two senior interventional radiologists, and all surgical clipping were performed by four senior neurovascular surgeons in our institute. Patients were followed up after hospital discharge in a clinic at 1-month, 3-month, 6-month, 12-month, and annually thereafter.

All statistical tests were performed using IBM SPSS Statistics for Macintosh, Version 22.0 (Armonk, NY: IBM Corp). Comparisons between complete and incomplete ONP recovery patient group at different follow-up intervals was made using the Fisher's exact test. All values are expressed as mean and percentage where appropriate. Differences were considered statistically significant at $P < 0.05$.

Results

A total of 22 patients met the inclusion criteria and were recruited for the study. The patients were divided according to the treatment modality, surgical clipping, or endovascular coiling. The two treatment groups were demographically comparable [Table 1]. The mean age for the surgical group was 57.9 years old and for the endovascular group was 59.6 years old ($P = 0.724$). Overall, 13 (59%) patients presented with unruptured aneurysms while 9 (41%) patients had WFNS Grade 1 or 2 subarachnoid hemorrhage (SAH). Partial ONP was found in 9 (41%) patients while 13 (59%) presented with complete ONP. Eleven (50%) patients underwent surgical clipping of aneurysm, and 11 (50%) underwent endovascular coiling.

Five (45.5%) of the patients in the surgical treatment arm achieved complete ONP recovery within 1 week postclipping. This was compared to 0% recovery in the endovascularly treated group ($P = 0.011$). The difference in the rate of complete recovery of ONP remained significant at 1-month postsurgery (63.6% vs. 18.2%, $P = 0.030$). At 1-year follow-up, all patients who underwent surgical clipping achieved complete recovery whereas 27.3% of endovascularly coiled patients remained symptomatic [Table 2].

In a subgroup analysis of the patients who presented with ruptured PComA aneurysm, all patients who underwent surgical clipping achieved complete ONP recovery, and 80% of them were within the 1st week after surgery [Table 3]. In those patients who underwent endovascular coiling, none of them recovered within 1 week, and two patients (33.3%) did not achieve complete recovery after 1 year. Interestingly, this trend was not observed in patients who presented with unruptured aneurysms, for which the rates of recovery of ONP were comparable between the surgically and endovascularly treated groups [Table 4].

We did another subgroup analysis by dividing patients according to the oculomotor nerve status upon

Table 1: Comparison of baseline characteristics of patients who underwent surgical clipping versus endovascular coiling of PcomA aneurysms

	Surgical Clipping (*n*=11)	Endovascular coiling (*n*=11)	*P*
Mean Age (years)	57.9 (42-76)	59.6 (45-72)	0.724
Gender (male: female)	4:7	2:9	0.635
Ethnicity (Chinese: Malay: Indian: Others)	6:4:1:0	8:2:0:1	0.399
Ruptured: Unruptured (aneurysm)	5:6	6:5	1.000
ONP (complete: partial)	6:5	7:4	0.665
Left: Right	3:8	3:8	1.000

Table 2: Rate of recovery of ONP in surgical clipping and endovascular coiling

	Surgical Clipping (*n*=11)	Endovascular coiling (*n*=11)	*P*
1-week	5 (45.5%)	0 (0%)	0.011
1-month	7 (63.6%)	2 (18.2%)	0.030
3-month	8 (72.7%)	6 (54.5%)	0.375
6-month	10 (90.0%)	8 (72.7%)	0.269
1-year	11 (100.0%)	8 (72.7%)	0.062

Table 3: Recovery of ONP in Ruptured PcomA aneurysms

	Surgical Clipping (*n*=5)	Endovascular coiling (*n*=6)	*P*
1-week	4 (80.0%)	0 (0%)	0.006
1-month	4 (80.0%)	1 (16.7%)	0.036
3-month	4 (80.0%)	3 (50.0%)	0.303
6-month	5 (100.0%)	4 (66.7%)	0.154
1-year	5 (100.0%)	4 (66.7%)	0.154

Table 4: Recovery of ONP in Unruptured PComA aneurysms

	Surgical Clipping (*n*=6)	Endovascular coiling (*n*=5)	*P*
1-week	1 (16.7%)	0 (0%)	0.338
1-month	3 (50.0%)	1 (20.0%)	0.303
3-month	4 (66.7%)	3 (60.0%)	0.819
6-month	5 (83.3%)	4 (80.0%)	0.887
1-year	6 (100.0%)	4 (80.0%)	0.251

presentation (complete vs. partial ONP). Thirteen (59%) patients presented with complete ONP while 9 (41%) presented with partial ONP. Patients who presented with partial ONP had a significantly faster rate of complete ONP recovery after surgical clipping. By 1 month, all of the patients who underwent clipping would have full ONP recovery (P = 0.018). There was no significant statistical difference in the group of patients who presented with complete ONP. All of the patients who underwent surgical clipping achieved full ONP recovery at 1 year follow-up [Tables 5 and 6].

Discussion

PComA aneurysms are the second most common locations for intracranial aneurysms, representing 50% of all internal carotid artery aneurysms.[1] Because of the proximity of the PComA and the cisternal portion of the oculomotor nerve, ONP is a well-known presentation of PComA aneurysms. Approximately 13.8–20% of patients with PComA aneurysm present with ONP with or without SAH. Of these patients, 46–66% suffer complete ONP.[1,2] The sequence of oculomotor nerve impairment usually starts with pupillary dilatation, followed by ptosis and finally ophthalmoplegia affecting the medial, superior, inferior rectus and oblique muscles. The mechanism of ONP has been largely attributed to direct compression of the nerve by an enlarging aneurysmal sac, irritation by the aneurysm or subarachnoid blood if rupture occurs, transmitted pulsation of the aneurysm on the nerve, or a combination of the above mechanisms.[1] Often, the symptoms of ONP, especially that of diplopia, are greatly disabling to patients who are otherwise functionally intact. In addition, the development of ONP suggests conformational change in the dome of the aneurysm, indicating impending rupture.

Table 5: Recovery of ONP in patients who developed complete ONP

	Surgical Clipping (n=6)	Endovascular coiling (n=7)	P
1-week	1 (16.7%)	0 (0%)	0.338
1-month	2 (33.3%)	1 (14.3%)	0.416
3-month	3 (50.0%)	4 (57.1%)	0.797
6-month	5 (83.3%)	5 (71.4%)	0.612
1-year	6 (100.0%)	5 (71.4%)	0.155

Table 6: Recovery of ONP in patients who developed partial ONP

	Surgical Clipping (n=5)	Endovascular coiling (n=4)	P
1-week	4 (80.0%)	0 (0%)	0.016
1-month	5 (100.0%)	1 (25.0%)	0.018
3-month	5 (100.0%)	2 (50.0%)	0.073
6-month	5 (100.0%)	3 (75.0%)	0.236
1-year	5 (100.0%)	3 (74.0%)	0.236

As such, it is widely recommended that prompt treatment is instituted when ONP develops in association with PComA aneurysm.

It has been well documented in literature that surgical clipping of PComA aneurysms is associated with the recovery of ONP, with the main factors affecting outcome being the time to treatment and extent of pretreatment ONP and presence of SAH.[1,3-7] The recovery of ONP following surgical clipping is predictable, starting with ptosis, followed by ophthalmoplegia and finally mydriasis. The ONP recovery was present regardless of dissection of aneurysm after clipping.[8] A meta-analysis found that 63% of patients operated on within 2 weeks of ONP made complete recovery, and this reduced to 30% and 17% if they harbored symptoms for more than 2 weeks and 1 month, respectively.[5] This is due to a higher degree of nerve damage with treatment delays. Minor damage with neuropraxia and axonolysis may recover rapidly as long as the compression is relieved before further injury occurs. Surgical clipping obliterates the aneurysm sac and suppresses the transmission of pulsatile arterial force to the nerve, thus reducing the compressive effect and allowing recovery of the nerve.

With increasing acceptance of endovascular technique since the 1990s, especially after the published data of the ISAT trial, endovascular coil embolization has become the treatment of choice for intracranial aneurysms.[9] This is due to the lower procedural risks and morbidity associated with endovascular treatment.[10] However, the effects of coil embolization on the recovery of ONP are less well documented. Unlike surgical clipping, endovascular coiling does not resolve all of the mass effects caused by an aneurysm. Paradoxically, the coil mass itself could contribute to further mass effect.[11] The results of endovascular coiling on ONP have been less convergent, with some authors reporting recovery of ONP[12] and others reporting the inability to achieve complete resolution.[13] It has been postulated that the recovery of ONP could be due to the elimination of aneurysmal pulsatility of arterial flow within the aneurysm. Nevertheless, compared to surgical clipping, the rate of ONP recovery was associated with partial recovery and longer follow-up duration. The type of endovascular treatment, aneurysmal rupture at presentation, and timing of treatment were not associated with recovery.[14]

Chalouhi *et al*. showed in a series of 37 patients who underwent endovascular coiling that 37.8%, 51.4%, and 10.8% of patients achieved complete, partial, and no ONP recovery, respectively,[14] with most ONP recovery occurred within the 1st year of follow-up. The study also summarized results of previously published literature, which concluded that complete ONP recovery was seen in 43.2% of patients who underwent endovascular coiling, with another 43.2% achieving partial recovery. 13.6%

of patients had no sign of ONP recovery.[14] In a separate study, Stiebel-Kalish *et al*. showed that complete resolution of ONP did not occur in their case series of patients who underwent endovascular coiling of PComA. However, the residual ONP was minimal and hence did not result in any significant functional impact.[13]

In recent years, several studies have attempted to compare the effects of surgical clipping and endovascular coiling in the treatment of PComA aneurysm associated with ONP. These have yielded conflicting results. A Korean study by Nam *et al*. compared the outcomes of 19 patients with ONP and unruptured intracranial aneurysms, who underwent clipping or coiling and found no significant difference between the two groups.[2] Ahn *et al*. also showed that both techniques were equivalent in terms of recovery of ONP.[15] However, Chen *et al*. showed that surgical clipping of PComA aneurysms was associated with a higher probability of complete recovery from ONP when compared to coiling (85 vs. 33% ONP recovery).[16] This difference remained significant at 1 year postintervention. This result was supported by a meta-analysis by Khan *et al*., in 2013, which showed that complete resolution of ONP was more common in surgical clipping than endovascular coiling of PComA.[17]

Our institute has employed the use of both surgical and endovascular techniques in the treatment of aneurysms since the 1990s. In addition, due to the small geographical size of our country and swift accessibility to medical services, most patients present to our institute within a short interval from symptom onset and are followed-up for many years following treatment. With these unique characteristics of our patient database, we retrospectively investigated the long-term effects of surgery and endovascular coiling in these patients. Our results reflect that of Chen *et al*. and Khan *et al*., which showed that surgical clipping was associated with a higher rate of ONP recovery, at an earlier time interval posttreatment.[16,17] In addition, 2 of 11 patients who underwent endovascular coiling required repeat intervention due to recurrence of the aneurysm despite initial complete obliteration.

Our study is limited by its retrospective nature and small sample size. However, despite the small sample size, we were able to show a statistically significant difference in outcomes between the two groups. The difference in ONP recovery suggests that surgical clipping relieves the compressive effect of aneurysm on the oculomotor nerve more quickly and with a more lasting effect, allowing for full recovery of ONP at a shorter duration. This may be an important consideration to functionally well patients who are severely disabled by the symptoms of ONP. However, due consideration should be also made on the risks of surgery and endovascular coiling when deciding the form of treatment in patients who present with ONP in association with PComA aneurysms.

Conclusion

Although surgical clipping and endovascular coiling are both effective treatment modalities of PComA aneurysms, the former is associated with a higher rate of complete recovery of ONP at a shorter duration. This effect is long-term and may last beyond 1 year. This may be important in the preoperative counseling of patients prior to treatment.

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Conflicts of interest

There are no conflicts of interest.

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