Original Article

Immediate results of microsurgical clipping of posterior communicating artery aneurysms using the pretemporal transclinoidal approach

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Abstract

Background: We evaluated adverse ischemic events as early surgical results of microsurgical clipping of 44 and 34 posterior communicating artery (PComA) aneurysms through the pterional transsylvian and pretemporal transclinoidal approach, respectively, between January 2007 and October 2010.
Methods: Patients undergoing PComA aneurysm clipping were divided into two groups, and their immediate surgical results were compared and analyzed. Those who underwent the pterional transsylvian approach (group A) comprised 42 patients with 44 PComA aneurysms (24 ruptured and 20 unruptured). Those who underwent the pretemporal transclinoidal approach (group B) comprised 32 patients with 34 PComA aneurysms (20 ruptured and 14 unruptured).
Results: The immediate postoperative total occlusion rates were 97.7% in group A and 100% in group B. The pretemporal transclinoidal approach significantly reduced the overall risk of silent and symptomatic ischemic strokes ($p = 0.04$) in ruptured PComA clippings and tended to lower the incidence of intraoperative aneurysm rupture ($p = 0.07$) as well as the overall ischemic events ($p = 0.06$) in a total of 78 aneurysm clippings, as compared with the pterional transsylvian approach. Although not significantly, the pretemporal transclinoidal approach also tended to have a lower incidence of intraoperative aneurysm rupture in ruptured aneurysm clippings ($p = 0.11$), which were mainly responsible for the symptomatic ischemia. The pretemporal transclinoidal approach had no additional advantage over the traditional pterional transsylvian approach in unruptured PComA aneurysm clippings in the present study.
Conclusion: The pretemporal transclinoidal approach achieved better visualization of the vital neurovascular structures surrounding PComA aneurysms, which might be a key improvement in lowering the risk of intraoperative aneurysm rupture and obtaining significantly satisfactory immediate surgical results in the microsurgical clipping of PComA aneurysms, especially ruptured ones.
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Keywords: ischemia; posterior communicating artery aneurysm; pretemporal transclinoidal approach

1. Introduction

Intracranial aneurysms arising from the supraclinoid carotid artery close to the emergence of the posterior communicating artery (PComA) account for between 20% and 30% of all cerebral aneurysms.[1−3] In spite of their high incidence and the ease with which they may be exposed, the neurovascular structure surrounding these aneurysms makes it particularly challenging to place clips without causing complications,[2,3] and they require a high degree of skillful surgical management.

While there has been technological progress in endovascular coil therapy, microsurgical clip exclusion—provided that

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it can be carried out safely—remains the optimal strategy for dealing with cerebral aneurysms. Microsurgical clipping remains the only viable means of attaining the complete mechanical uncoupling of the aneurysm tissue from intracranial circulation. It is also still the only means of achieving results that can be confirmed by angiographic testing and obtaining an immediate, long-lasting cure.

To refine the outcome of microsurgical clipping, we adopted the pretemporal transclinoidal approach to PComA aneurysms, and the immediate results as to ischemic strokes were analyzed and compared with those of the traditional pterional transsylvian approach.

2. Methods

2.1. Demographic data and statistical method

Seventy-four patients undergoing post-operative diffusion-weighted imaging (DWI) of magnetic resonance imaging (MRI) studies, with a combined total of 78 PComA aneurysms experienced between January 2007 and October 2010, were included in this study. Forty-two patients with 44 aneurysms comprised group A and underwent microsurgical clipping via the traditional pterional transsylvian approach. Thirty-two patients with 34 aneurysms comprised group B and underwent operations through the pretemporal transclinoidal approach. The immediate surgical results—including the number of ischemic events, total occlusion rate, and intra-operative rupture rate—were evaluated and compared between these two groups by chi-square test. Significance was defined by $p < 0.05$. The age and aneurysm size between these two groups were compared by t-test. Only those ischemic strokes that occurred corresponding to the territory of PComA or anterior choroidal artery were deemed most likely associated with the surgery-related ischemia. Silent ischemia was defined as documented ischemic strokes without clinical symptoms and signs, such as motor—sensory or language deficits, whereas symptomatic ischemia was strokes with clinical presentations. The total occlusion rate of each aneurysm was studied by computed tomography angiography or conventional angiography. Total occlusion was defined as no residual aneurysm neck or sac visualized on the imaging studies. All 74 patients were informed of detailed surgical procedures and related risks, and returned completed consent forms before the surgery.

2.2. Operative techniques

We followed the pretemporal transclinoidal approach as refined by Dr Krisht.[4] The procedures for the pretemporal transclinoidal approach to PComA aneurysms were briefly described as follows. The pretemporal transclinoidal approach was based on the pterional approach but extended in a more anterolateral direction. We flattened the sphenoid ridge, removed the posterior third of the superior and lateral orbital walls, and then coagulated and divided the meningo-orbital artery. After this, we extradurally peeled off the dura propria of the temporal lobe from the superior orbital fissure and the anteromedial aspect of the lateral wall of the cavernous sinus (Fig. 1A). In this way, we formed a corridor that afforded a more anterolateral route to the carotico-oculomotor window. Carrying out these steps also assisted in proceeding to the next phase of extradural anterior clinoidectomy.

We disconnected the three surgical anatomic attachments of the anterior clinoidal process (ACP) (the orbital roof, the sphenoid wing, and the optic strut) in order to remove it entirely (Fig. 1B). After carrying out extradural bony work, we then opened the dura, firstly in a linear fashion, following the indentation of the sphenoid wing down to the dural ring around the carotid artery. The cut of the dura then continued laterally toward the third nerve and medially toward the optic nerve. We then opened the arachnoid membrane overlying the chiasmatic cistern and optic nerve to allow cerebrospinal fluid drainage. As soon as the brain was slack, we brought the microscope to the center of the surgical field around the carotico-oculomotor window. This afforded unobstructed anterior-to-posterior and lateral-to-medial views toward the lateral aspect of the carotid artery (Fig. 1C). This enabled us to clearly identify, in the majority of cases, where the P-com and anterior choroidal arteries emerged. This pathway of visualization also enabled us to identify the configuration of the aneurysm. As a result of this procedure, we obtained a good understanding of the surgical anatomy of the area around the aneurysm. In this way, we were able to develop an optimal
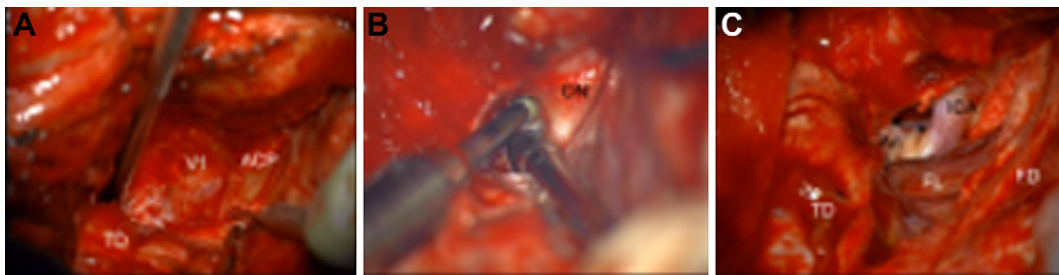

Fig. 1. Pretemporal transclinoidal approach to a left PComA aneurysm. (A) After the temporal extradural dissection, the lateral wall of the cavernous sinus as well as ACP were nicely exposed. (B) The ACP was removed by disconnecting its three bony attachments. (C) The aneurysm and origin of PComA (asterisk) were well visualized through an unobstructed angle of view into the carotico-oculomotor window. (ACP = anterior clinoidal process; An = aneurysm; FD = frontal dura; FL = frontal lobe; ICA = internal carotid artery; ON = optic nerve; TD = temporal dura; V1 = first branch of trigeminal nerve.)

clipping strategy without difficulty. The whole procedure of the aneurysm neck dissection and clipping was managed so as to take place almost like an entirely extradural undertaking.

3. Results

The demographic data for the two groups, which included sex, age, laterality, rupture/unrupture ratio, and aneurysm size, showed no significant difference (Table 1). For all 78 aneurysms, we achieved successful clipping using either the pterional transsylvian or pretemporal transclinoidal approach. The total occlusion rate was 97.7% in group A and 100% in group B ($p > 0.99$). One residual aneurysm was found in group A. In this case, intraoperative rupture also occurred because the ruptured aneurysm was flimsy. Silent ischemic events were indentified in 5 (11.4%) surgical procedures in group A and in 1 (2.9%) in group B ($p = 0.22$). Symptomatic ischemic strokes occurred also in 5 (11.4%) cases in group A and in 1 (2.9%) case in group B ($p = 0.22$). The overall risks of silent and symptomatic ischemic strokes were 22.7% and 5.9% in group A and group B, respectively ($p = 0.06$). Intraoperative aneurysm ruptures occurred in 11.4% of group A patients and none in group B ($p = 0.07$) (Table 2). Considering ruptured aneurysms only, silent ischemic strokes occurred in 4 out of 24 (16.7%) and 1 out of 20 (5.0%) cases in groups A and B, respectively ($p = 0.36$). Incidences of symptomatic stroke were 20.8% (5 cases) and 5.0% (1 case) in groups A and B, respectively ($p = 0.20$). Overall adverse ischemic events occurred in 37.5% of patients in group A and 10.0% in group B ($p = 0.04$). The intraoperative aneurysm rupture rate was 16.7% and also related to 4 out of 5 symptomatic ischemic strokes in group A. No intraoperative aneurysm rupture occurred in ruptured aneurysm clippings of group B ($p = 0.11$; Table 3), whereas among a total of 34 unruptured aneurysms, 1 in group A (5.0%) and none in group B were complicated with silent ischemic strokes ($p > 0.99$). The occurrence rate of symptomatic event was zero in both groups A and B. Incidence of overall adverse ischemic events was 5.0% in group A and none in group B ($p > 0.99$). The intraoperative aneurysm rupture rate was also 5.0% in group A and 0% in group B ($p > 0.99$; Table 4).

4. Discussion

Hemodynamic stress, especially where there is vascular tissue vulnerability, such as sites of turbulent blood flow that

can be imposed by vessel tortuosity, causes vessel walls to dilate over time and aneurysms to develop. A notable site of turbulent blood flow and significant hemodynamic stress is the posterior carotid artery wall. It is characterized by sharply defined, posteriorly oriented convexity and carries substantial cerebral inflow. Transmural pressure is greatest at the apex of this convexity, and it is here that aneurysms are most likely to form. Emerging at this location, the PComA carries considerable potential for the development of aneurysms.[5]

The projection of PComA aneurysms varies. Yasargil[3] classified the fundus projection into five general categories: anterolateral, superolateral, posterolateral superior, posterolateral inferior, and posteromedial inferior direction. A posterolateral inferior projection with potential compression of the oculomotor nerve is most common, being present in approximately 85% of cases.[2] Most PComA aneurysms may be easily exposed and clipped using the traditional pterional transsylvian approach. However, when its posterior-to-anterior visualization trajectory is along the axis of the internal carotid artery, the PComA is usually hidden behind the overlying aneurysm and its origin from the carotid artery is therefore obscured, especially when the aneurysm has a posterolateral inferior projection (Fig. 2A). The PComA may be inadvertently occluded if the neurosurgeon mistakes it as part of the aneurysm. Failure to correctly identify the PComA and occlude it may result in ischemic strokes in the thalamus, hypothalamus, or midbrain, with disastrous consequences.[1,2,6,7] The pretemporal transclinoidal approach, by contrast, follows a trajectory of visualization in an anterolateral-to-posteromedial direction to the carotico-oculomotor window and provides an almost direct view of the emergence of PComA. By using this route, neurosurgeons may have a better chance to identify and preserve the PComA at the beginning of the clipping procedure, and thus minimize the risk of adverse ischemic events.

Nowadays, perfusion- and diffusion-weighted MR imaging (PWI and DWI) are considered important imaging tools in detecting acute ischemic strokes.[8,9] Only patients with PComA aneurysm clipped receiving post-operative

Table 2
Adverse ischemic events and intraoperative rupture rate in groups A and B.

	Group A ($n = 44$)	Group B ($n = 34$)	p
Silent	5 (11.4%)	1 (2.9%)	0.22
Symptomatic	5 (11.4%)	1 (2.9%)	0.22
Overall ischemic	10 (22.7%)	2 (5.9%)	0.06
Intraoperative rupture	5 (11.4%)	0 (0.0%)	0.07

Table 1
Demographic data in groups A and B.

	Group A ($n = 44$)	Group B ($n = 34$)	p
Sex (female)	30 (68%)	22 (65%)	0.10
Age (y)	56.5	55.1	0.66
Laterality (right)	16 (36%)	16 (47%)	0.91
Unruptured aneurysm	20 (45%)	14 (41%)	0.14
Aneurysm size (mm)	5.78	6.48	0.11

Table 3
Adverse ischemic events and intraoperative rupture rate of subgroup of ruptured aneurysm clippings in groups A and B.

	Group A ($n = 24$)	Group B ($n = 20$)	p
Silent	4 (16.7%)	1 (5.0%)	0.36
Symptomatic	5 (20.8%)	1 (5.0%)	0.20
Overall ischemic	9 (37.5%)	2 (10.0%)	0.04
Intraoperative rupture	4 (16.7%)	0 (0.0%)	0.11

Table 4
Adverse ischemic events and intraoperative rupture rate of subgroup of unruptured aneurysm clippings in groups A and B.

	Group A (n = 20)	Group B (n = 14)	p
Silent	1 (5.0%)	0 (0.0%)	>0.99
Symptomatic	0 (0.0%)	0 (0.0%)	
Overall ischemic	1 (5.0%)	0 (0.0%)	>0.99
Intraoperative rupture	1 (5.0%)	0 (0.0%)	>0.99

DWI of MRI were enrolled in this study. However, it was not feasible for every rupture case to take post-operative MRI within 3 days after the surgical procedures, beyond which vasospasm might have begun to occur. For those patients with ruptured aneurysms in which subarachnoid hemorrhage might cause vasospasm and resultant strokes as well, we generously regarded all the abnormal findings of ischemia or infarct on the DWI of MRI as surgical complications, unless the location of perfusion deficit was irrelevant to the territory of the PComA or anterior choroidal artery. Obviating the bias from the vasospasm-related strokes, the data of the subgroup of unruptured aneurysm clippings might reflect the nearly realistic incidence of ischemic complications of microneurosurgery on PComA aneurysms in our institution, which was comparable to those reported in the literature[10] (Table 4).

In the present series, the pretemporal transclinoidal approach, although not significantly, tended to present a lower rate of overall ischemic events than the pterional transsylvian approach in a total of 78 aneurysm clippings ($p = 0.06$). The results reached significance in the subgroup of ruptured aneurysm clippings because group B was significantly less risky than group A for overall ischemic strokes ($p = 0.04$). On the contrary, if only unruptured aneurysm clippings were considered to offset the vasospasm-related ischemic effect, the pretemporal transclinoidal approach had no significant advantage over the pterional transsylvian approach in regard to silent, symptomatic, or overall ischemic strokes (Table 4). Our data indicate that for the prevention of total number of ischemic injuries, clipping of PComA aneurysms, especially ruptured ones, may benefit from using the pretemporal transclinoidal approach.

As we have assumed, one of the beneficial effects of this approach to PComA aneurysms was the direct trajectory to and inspection of the PComA obtained at the beginning of the clipping procedures. In unruptured PComA aneurysm clippings, neurosurgeons are more encouraged to manipulate the aneurysm to identify the takeoff of PComA, and vital neurovascular structures are easily cleared off the aneurysm dome without causing intraoperative aneurysm rupture. However, in the scenario of subarachnoid hemorrhage, the clipping of ruptured aneurysms is more complicated and technically demanding because of the vital neurovascular structures that are obscured by sticky and dense hematoma and which are usually attached to the ruptured dome of the aneurysm. An intraoperative rupture of an already-ruptured aneurysm occurs more readily during aneurysm neck dissection or when advancing the clip blades. Without a good plan of defense, the rupture may cause disastrous brain damage, including severe ischemic strokes. In group A, 4 of 5 symptomatic strokes (80%) were related to an intraoperative aneurysm rupture (Table 3). For a highly experienced neurosurgeon, the incidence of intraoperative aneurysm rupture is estimated to be approximately 8.5%.[2] In the present study, the incidence of intraoperative aneurysm rupture was 11.4% and 0% in groups A and B, respectively. Group B patients tended to have a lower incidence of intraoperative aneurysm rupture than group A patients either in a total of 78 aneurysm clippings or 44 ruptured aneurysm clippings ($p = 0.07$ and 0.11, respectively). It is obvious that the avoidance of intraoperative ruptures minimizes the risk of adverse ischemic complications. The pretemporal transclinoidal approach has several advantages in lessening the occurrence of intraoperative ruptures. First, it provides a direct view to the caroticooculomotor window, so that not only the PComA but also the configuration of the aneurysm can be thoroughly inspected for neck dissection. Second, the created space following the pretemporal extradural dissection and anterior clinoidectomy is sufficiently wide to enhance the maneuverability of clipping and thus eliminates the need for excessive manipulation around the aneurysm. By contrast, when undertaking the typical pterional transsylvian approach, for example, to identify the origin of the PComA, one may gently deflect the
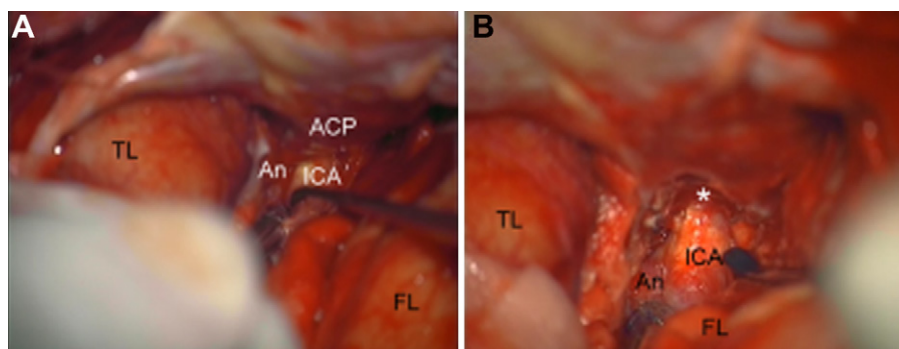

Fig. 2. Conventional transsylvian approach to a left PComA aneurysm. (A) The carotico-oculomotor window was narrowed by the limited axis of visualization along the axis of ICA and obstructed by the temporal lobe. (B) Maneuverability was better after removal of ACP (asterisk); however, the origin of PComA was still not well inspected. (An = aneurysm; FL = frontal lobe; ICA = internal carotid artery; TL = temporal lobe.)

aneurysm on its rostral side or mobilize the carotid artery medially toward the optic nerve. This kind of approach is necessary because maneuverability is limited and there is only a narrow angle to the carotico-oculomotor window. In carrying out such a manipulation, however, an intraoperative rupture of the aneurysm may occur.[2,3,11] Third, routine anterior clinoidectomy in such an approach provides neurosurgeons with temporary occlusion ready at hand if needed. Temporary clips may be used whenever further dissection of the neck of the aneurysm appears risky. While it is not necessary to remove the ACP in every PComA aneurysm case, it is still common—and not possible to anticipate from presurgical evaluations—that the ACP is so prominent or the aneurysm is so low-lying that temporary occlusion is not feasible, or it is difficult to advance a permanent aneurysm clip in a usual manner without the interference of the ACP[1–3,12–14] (Fig. 2B). In this study, a well-prepared surgical exposure and defense strategy for intraoperative aneurysm rupture by means of anterior clinoidectomy guaranteed us a safer aneurysm clipping in every one of our cases, and preparation for the possibility of unpredictable situations.

It is not adequate to draw a conclusion that pretemporal transclinoidal approach is better than pterional transsylvian approach since the present retrospective study was not designed on a randomized and prospective basis. Moreover, the design should be good in differentiating the vasospasm-related ischemia from surgery-related ones. Furthermore, the surgeons in the study should be familiar with both approaches and at a similar level of surgical experience and skills. Nevertheless, our study did provide surgeons an option for surgical alternative to PComA aneurysm clippings.

In conclusion, the pretemporal transclinoidal approach provides a widely exposed surgical field but is minimally invasive to the brain when dealing with P-com aneurysms. In terms of adverse ischemic complications, our preliminary data showed that this approach tended to lower the risk of overall ischemic strokes and intraoperative aneurysm ruptures in all PComA aneurysm clippings and significantly improved the surgical outcome related to the total number of ischemic events among ruptured aneurysm clippings. The better outcome came from the improved trajectory and visualization of PComA and aneurysm configuration and lower intraoperative aneurysm rupture rate. In this retrospective study,

aneurysm clippings were not done by only a single surgeon; care must be taken to compare the superiority between both surgical techniques.

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