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Conventional microsurgical treatment of paraclinoid aneurysms: state of the art with the use of the selective extradural anterior clinoidectomy SEAC

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Summary

Surgical treatment of paraclinoid aneurysms is considered to be difficult due to their complicated anatomical location in the vicinity of important neural, vascular and bony structures. We present our clinical experience of the past 10 years of conventional microsurgical treatment of 81 paraclinoid aneurysms in 75 patients with the use of selective extradural anterior clinoidectomy SEAC and discuss the method of therapy option by reviewing recent reports on results of endovascular coiling method and the combination of these with conventional microsurgical therapy. The favorable surgical results with the use of SEAC and no recurrence of the treated aneurysm after clipping procedure in our series indicate that direct surgery can still be a standard technique for paraclinoid aneurysms in view of the fact that the endovascular aneurysm coiling methods are still associated with a considerable percentage of incomplete occlusion and present the problem of coil packing.

Keywords: Paraclinoid aneurysm; clipping; SEAC; endovascular surgery; outcome; complication.

Introduction

Paraclinoid aneurysm is a term coined for aneurysms arising from the segment of the internal carotid artery as it exits from the cavernous sinus (CS) to the point of origin of the posterior communicating artery. The internal carotid artery ICA in this segment runs through the clinoid space and the subarachnoid space. Aneurysms of this paraclinoid segment remain to be one of the technically challenging topics for neurosurgeons [4, 18, 35, 39, 45]. Before the development of microsurgical cranial base techniques, direct access to these aneurysms was often hampered by the obstructing anterior clinoid process (ACP). Satisfactory clipping was also technically difficult in terms of preservation of patency of the ICA and its branches due to existence of considerable number of giant or large aneurysms with or without partial thrombosis in this region [1, 24, 29]. In 1997, the technique of selective extradural anterior clinoidectomy SEAC was reported by our group. This technique facilitates both radical removal of tumors and radical neck clipping of aneurysms in the supra- and parasellar regions by providing a wide operative exposure and hence better illumination, and therefore making this method suitable for routine use in the treatment of these lesions [46].

On the other hand, endovascular aneurysm embolization with Guglielmi detachable coils (GDCs) has become an alternative treatment in the management of cerebral aneurysms [5, 17–19]. This endovascular method of treatment has many advantages not only for patients who are at a high risk for surgery, but also in cases of aneurysms where surgery is difficult due to their special location, size and form. However, the method of obliteration of aneurysms with this treatment is not the same as with surgery. Indeed, it has also been reported that embolized aneurysms often recanalize, i.e. the well known problem of coil packing or coil compaction, where remnants of aneurismal necks have been observed, especially in cases of large and giant aneurysms [13, 23, 26, 43], making the optimal treatment for these lesions still open to evaluation [25, 26], although treatment modality of combined surgical and endovascular approaches are also being tried and reported [1, 34, 42].

In this study was review our recent experience using a pure surgical approach to paraclinoid aneurysms using SEAC in order to assess the role of direct surgery for these aneurysms.

Table 1. *Patients and total number of aneurysms*

75 patients: 60 female (80%) vs 15 male (20%). Age: 50.9 ± 10.9 (mean ± SD)

Multiplicity	Number of patients	Number of aneurysms
1	43 (57.3%)	43
2	19 (25.3%)	38
3	7 (9.3%)	21
4	3 (4.0%)	12
5	3 (4.0%)	15
Total	75	129

Patients

From 1993 to March 2003, 81 aneurysms in the paraclinoid segment of the ICA in 75 patients were treated in the Department of Neurosurgery, University Hospital Zurich. Of these 75 patients, 53 patients presented with subarachnoid hemorrhage (SAH) and 22 were diagnosed as having paraclinoid aneurysms during routine neuroradiological examinations for various neurological symptoms and signs or other reasons. Fourty nine patients presenting with SAH were admitted to our hospital within 3 weeks after the ictus (average: 4.7 days), these were classified into the SAH group. Four patients with SAH were admitted at 2 months, 3 months, 5 months and 4 years after SAH, respectively, and were classified into the "non" SAH group together with 22 patients with non ruptured aneurysms. Glasgow Coma Scale (GCS) of the SAH patients on admission was 3–15 points (average: 12.3 points). Of the 26 patients from the non SAH group, all but five had no neurological deficits on admission; four patients presented with visual disturbance and one with a left hemiparesis due to thalamic hemorrhage.

Patients included 60 females (80%) and 15 males (20%) with mean age of 50.9 ± 10.9 years. Among the 75 patients, 32 patients (42.6%) had multiple aneurysms (Table 1).

The paraclinoid aneurysms were diagnosed as follows: (unruptured 37 (46%); SAH caused by their rupture 35 (43%); symptomatic i.e. visual disturbance 6 (7%) and incidental 3 (4%). Unruptured aneurysms were aneurysms associated with ruptured aneurysms at other sites and one with a ruptured arteriovenous malformation. Three incidental aneurysms (two at the time of headache work-up and one at the time of a hypertensive thalamic hemorrhage) were also found.

In 4 cases, coil embolization had been attempted by neuroradiologists. Two aneurysms were successfully embolized, but recanalized during follow-up period. In the other 2 cases, embolization was attempted but failed.

Methods

Classification of paraclinoid aneurysms

We defined paraclinoid aneurysms as those aneurysms arising from the segment of the internal carotid artery (ICA) that runs through the clinoid space and subarachnoid space between its point of exit from the the cavernous sinus (CS) with the landmark of proximal dural ring and the point of origin of the posterior communicating artery, corresponding with the C3 and C2 segments of the internal carotid artery after Fischer [14]. The lesions that originated in the CS and extended into the subdural space (so-called transitional aneurysms), and the lesions located completely within the CS were excluded. We used the anatomical land marks for classification of paraclinoid aneurysms based on the aneurysm's presumed origin on the ICA.

Clinoid aneurysms arise from the ICA segment between the proximal and distal dural rings, namely C3 segment. Carotid cave aneurysms arise at the pouch of the distal dural ring of the ICA including also the so called superior pituitary artery aneurysms. IC-ophthalmic aneurysms arise from the origin of the ophthalmic artery. Superior carotid wall aneurysms on the superior wall of the ICA distal to the dural ring and project superiorly. Inferior carotid wall aneurysms arise on the inferior wall of the ICA and project inferiorly.

The locations of the 81 paraclinoid aneurysms were grouped; clinoid 8 (10%), carotid cave 5 (6%), IC-ophthalmic 34 (42%), inferior wall 17 (21%) and superior wall 17 (21%) as is shown in Fig. 1. Of the 81 aneurysms, 16 (20%) were large (12–25 mm), and 3 (4%) were giant (>25 mm) aneuryms.

Surgical treatments

Most of cases were operated upon by the senior author Yonekawa [46, 47]. Direct neck clipping was attempted on all aneurysms and this could be done in 76 aneurysms (93%), wrapping was performed in one aneurysm with atheromatous and calcified wall and neck (1%) and the 4 remainig aneurysms were treated with trapping combined with extracranial-intracranial EC-IC arterial bypass (5%); three large clinoid aneurysms, in which two were partially thrombosed and one large IC-ophthalmic aneurysm of early case of this series. In patients with SAH, the ruptured aneurysm was initially clipped, followed by clipping of other aneurysms, when possible, through the original craniotomy and in the same session. The mean GCS just before operation was 12.3 ± 3.8 points in the SAH patients.

Our procedure of SEAC has been reported elsewhere previously [46]. This procedure enables exposure of the clinoid segment of the ICA (C3) and aneurysm dissection of this segment. So the proximal control at the clinoid segment becomes secure. Better mobilization of the optic nerve and of the ICA yields additional working space and better illumination.

Among 76 clipping procedures, one wrapping procedure and 4 trapping and EC-IC bypass procedures for 81 paraclinoid aneurysms, in 70 aneurysms (86.4%), the SEAC procedures were performed. Seven paraclinoid aneurysms (8.6%) were occluded from the contralateral side at the time of clipping of ruptured and/or larger aneurysms of ipsilateral side.

Results

Angiographic results

Follow-up cerebral angiography was performed routinely postoperatively around 1 week after sur-

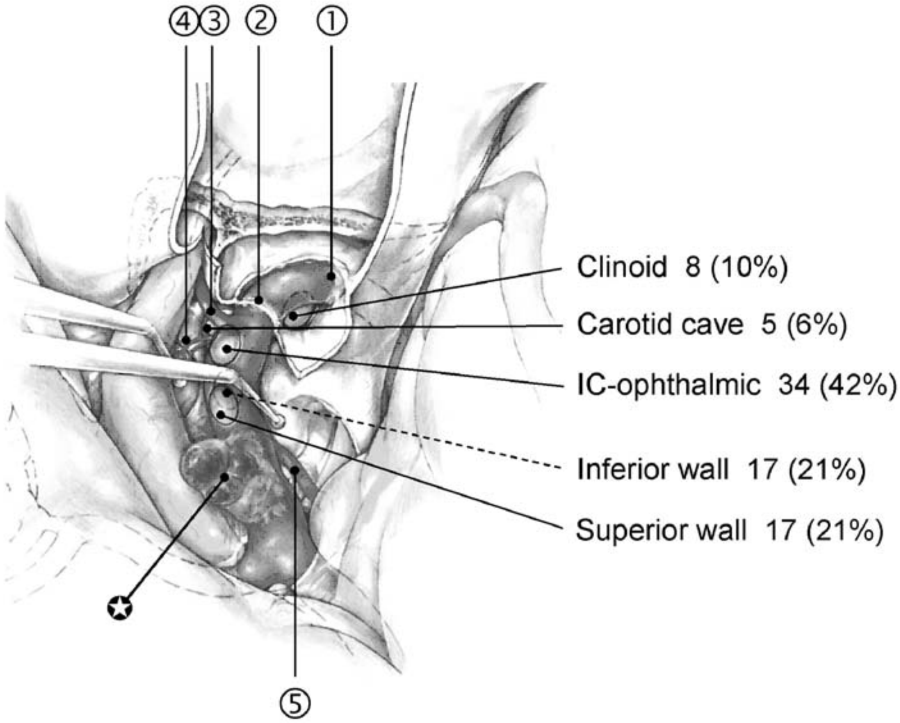

Fig. 1. Schematic drawing of aneurysm locations and their distribution in this study. Site of predilection of the blistering aneurysm "chimame aneuysm" is also indicated as star symbol, Also the proximal and distal dural rings ① and ②, the ophthalmic artery ③ and the superior hypophyseal artery ④ and posterior communicating artery ⑤ are also migrated respectively

gery in all patients but one, who rejected this examination.

Clipping condition assessed by postoperative angiography is as follows: Neck clipping was performed in 76 procedures, and complete clipping was confirmed in 73 (96%) cases. In the 2 patients whose aneurysms recanalized after previous embolization with coils, complete obliteration of the aneurysm was obtained by direct surgery. One of them had both recanalization of the aneurysm and migration of the placed coils from the aneurysm extending to the M2 segment. Neck clipping was successfully performed without removal of intraluminal coils in the MCA segment because of tight adhesion of the coils to the arterial wall (Fig. 2). Small neck remnant was demonstrated in 4 patients (5.1%) on postoperative angiography. One patient in which whole dome opacification was demonstrated due to the slipping out was reoperated for complete clipping. The other 3 patients received further clinical and angiographic follow-up, and no regrowth of the aneurysm was observed on repeated angiography usually at three months then a year later. In one patient, angiography could be performed 5 years after the operation, showing no change in the size of this residual neck.

Clinical outcome

Patient outcomes were evaluated at three months and expressed as a score calculated according to the Glasgow Outcome Scale (GOS). A GOS score of 5 is an outcome of good recovery GR, 4 is moderately disabled MD, 3 severely disabied SD, 2 vegetative state VS, and 1 death D.

The clinical outcome was evaluated at 3 months after surgery and expressed by the GOS score. Among 29 patients of the non SAH group, clinical outcomes were: GR (GOS 5) in 23 (79.3%), and MD (GOS 4) in 4 (13.7%). In two patients (4.2%), whose outcome was GOS 3, the pre-exisiting neurological deficit did not change by the clipping procedure. There was no mortality. Surgery-related permanent morbidity was observed in 4 patients (13.7%); visual field defect in 2 patients, deterioration of visual acuity and oculomotor nerve palsy in another patients respectively. Among 46 patients of the SAH group, clinical out-

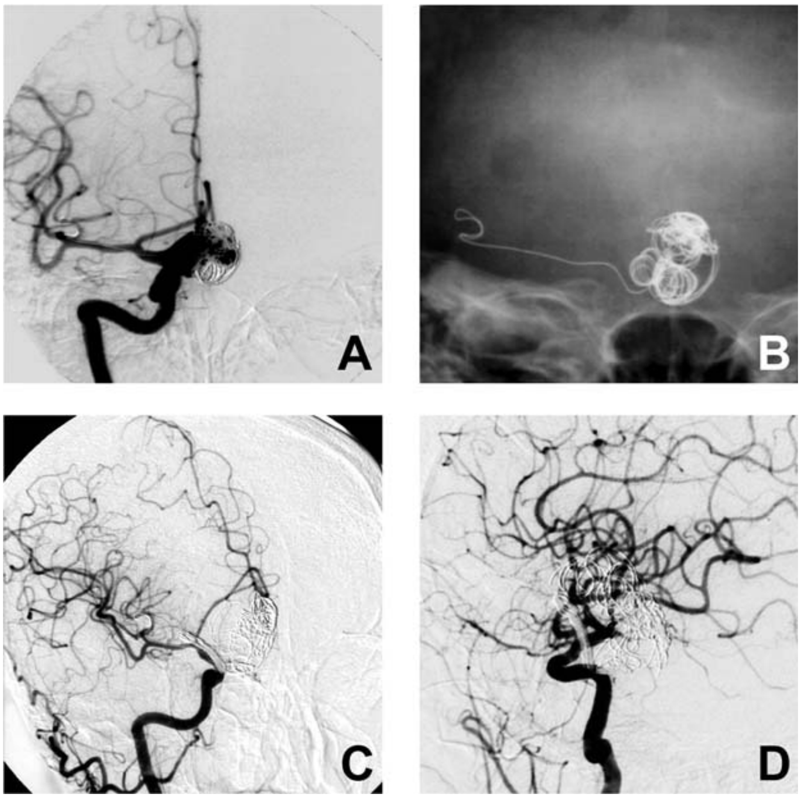

Fig. 2. A 66-year-old female. Preoperative right internal carotid angiogram (A) and skull X-ray (B) showing recanalization and regrowth of the aneurysm which was successfully embolized previously with Guglielmi detachable coils. Migration of the coil from the aneurysm lumen to the left M2 segment of the middle cerebral artery *(MCA)* can be seen. Postoperative A-P (C) and lateral (D) carotid angiograms showing complete clipping of the aneurysm, remaining migrated coil in the internal carotid artery to the MCA

comes were: GR (GOS 5) in 28 patients (60.8%), MD (GOS 4) in 10 (21.7%), SD (GOS 3) in 4 (8.6%), and death (GOS 1) in 4 (8.6%). Surgery-related permanent morbidity was observed in 6 patients (13.0%); ischemic stroke in 5 patients, including 2 patients with probable thorombus migrations from the aneurysms, and visual field defect in one patient. Surgery related mortality rate was 0%.

Furthermore, in the SAH group, 12 patients (25.6%) showed ischemic symptoms and signs due to severe cerebral vasospasm. 11 of those 12 patients were treated with intraarterial infusion of papaverine and balloon angioplasty, barbiturate coma and hypothermia therapy according to our structured vasospasm therapy protocol [47]. Ischemic neurological deficits persisted in 6 patients resulting in permanent morbidity in 4 patients and death in 2. One patient died of direct hemorrhagic injury. Another patient death resulted from rebleeding from a ruptured small aneurysm of the posterior cerebral artery, which could not be detected on the preoperative anigography, but was confirmed at autopsy. Thus, overall morbidity was 12 (26.0%) and mortality was 4 (8.7%) in this group.

As far as the size of aneurysms is concerned, surgical outcomes of the large and giant aneurysm were analyzed. In the non-SAH group, complete clipping was performed in all 4 cases and trapping combined with EC-IC bypass in 3 cases. Ipsilateral visual disturbance complicated in a case of the former (25%) and a case in the latter (33%). In the SAH group, neck clipping was performed in 10 of 11 patients. In the remaining case, wrapping was performed due to severe calcification especially at the neck of the aneurysm. In one of the patients (9%) treated with neck clipping, a small infarction at the genu of the internal capsule causing a hemiparesis of mild degree was seen.

Discussion

Paraclinoid aneurysms were historically treated by Hunterian ligation of proximal occlusion of the ICA or the common carotid artery and recently endovascu-

Table 2. *Recent comparable treatment series*

	Cases	Treated aneurysms	SAH	Clip	Wrap	Coil	Occl.	Morbidity	Mortality
Day 1990	80	54	35%					7%	6%
Batjer 1994	89	89	44%				4	12%	1%
De Jesus 1999	28	35	24%				3	18%	4%
Roy 1997	26	28	30%			25		4%	0%
Thornton 2000	71	61	18%			49	12	3%	2%
Hoh 2000	216	238	25%	180		57	1	6%	0.4%
Park 2001	70	73	11%	3		84		8.3%	0%
Iihara 2003	112	111	0%	35		77		5.4%	0%
Present series	*75*	*81*	*61%*	*76*	*1*		*4*	*12%*	*0%*

larly [7, 10, 15, 30, 33, 41], also in use with combination with EC-IC bypass, especially for large and giant aneurysms of this location in cases where clipping is unfeasible [2, 16, 27, 38, 39]. However, this method does not always prevent ischemic complications [21]. Also late occurrence of hemodynamically induced aneurysms after the carotid ligation have been reported experimentally and clinically [10, 22]. Therefore, neck clipping of the aneurysm with preservation of patency of the ICA is the most appropriate treatment, although this has been considered and reported to be technically difficult.

Complete neck clipping with partial clinoidectomy [3, 35] and use of specially formed clips [40] have been the subsequent technical development in combination with microsurgery followed by the extensive clinoidectomy to be credited to Dolenc [9].

In this study, we reviewed our recent experience of surgical treatment for patients with paraclinoid aneurysms with or without SAH separately. Our surgical treatment provided favorable results in both groups. One possible reason to explain this good result is that we have routinely performed the SEAC for confirming aneurysmal shape, location and relationship between aneurysm and surrounding bone, neural and vascular structures. The SEAC gives a wider surgical working space hence also better illumination for careful observation and manipulation of the aneurysm and of the ICA branches and enables secure proximal control, leading to a better outcome. Sometimes the space gained by the SEAC procedure proved to be the only possible room available in which aneurysms could be managed in view of the swollen or angry brain in the SAH group. The SEAC procedure is less time-consuming (usually within 20 min.) and less extensive as compared with the method described by Dolenc [9] and Kattner [29]. This procedure, enables use of the trapping and "puncture and collapse" method of aneurysms obviating complicated and time consuming combined methods of endovascular temporary occlusion of the ICA and aspiration of blood-contents of large or giant aneurysms through an indwelling catheter [1, 34, 42]. In our series, the SAH group had more frequent complications as compared with the non SAH group. This can be well understood from the pathophysiological difference of the presenting disease back ground; combination or non combination of SAH. The former was complicated with perforating artery infarctions, bleeding from an untreated (preoperatively undetected) aneurysm in the acute stage and with devastating vasospasm in spite of our structured therapy. Postoperative persistent visual deterioration was observed in four cases (5%) so that the careful manipulation of the optic nerve at the time of drilling procedures of SEAC and of aneurysm clipping procedure can not be overemphasized in the presence already impaired optic nerve function or anatomical derangement [12, 31].

We reviewed recent comparable reports regarding treatment of paraclinoid aneurysms and have summarized them in Table 2. Day [6], Batjer [3], De Jesus [8] and Park [36] reported surgical results of paraclinoid aneurysm. On the other hand, endovascular embolization with GDC is gaining a considerable position as an alternative method in the treatment of aneurysms [17, 19]. As shown in Table 2, Thornton [43] reported their experience with endovascular treatment for paraclinoid aneurysms. Morbidity-mortality was impressively low (5.5%) in their series. 10 of 71 paraclinoid aneurysms (14.1%) showed regrowth of the aneurysms after embolization on repeat angiography. Roy [37] also reported low morbidity (4%) as compared to previous surgical series with complete occlusion in 14 of 28 aneurysms (50%). Ho [25] and

Iihara [28] have reported overall good results by selecting cases of high risk in the former or by selecting cases according to aneurysm projection in the latter for coil embolization. The rate of regrowth/coil compaction was 26% after successful embolization and 5 of their patients required retreatment, whereas no recurrence was observed in the surgical group [25].

These facts suggest that interventional risk is generally lower in coil embolization than in surgical clipping. However, aneurysms harboring broad neck have been reported to be difficult to have sufficient anatomical occlusion with embolization with GDC embolization. Paraclinoid aneurysms often present with large or giant aneurysms with broad neck, posing difficulties in complete obliteration by currently available coiling methods [44]. Acceptable coiling of aneurysms tends to be complicated with recanalization (coild packing or coil compaction and anreurysm regrowth. These facts suggest that current coil embolization technique is applicable principally only for narrow-necked (less than 4 mm) aneurysms even when neck plasty method with a balloon catheter is available [13]. This limitation may partially be overcome by development of new stent-assisted system in the near future [32], although additional interventional procedure can be a new source of further complication. Given the apparent difference between clipping and embolization in terms of recurrence of the treated aneurysms, underlying mechanisms for recanalization or regrowth of aneurysms should be further investigated to overcome this problem.

Therefore, one would consider the combination of coiling and clipping modalities in order to mutually compensate their disadvantages [20]. However, adhesion or incorporation of coils within the aneurysm wall and protrusion of coils into the vicinity of aneurysm neck would make future neck clipping more difficult, as was shown in our case of Fig. 2. Accordingly, especially in aneurysms with broad-neck, primary direct surgery is considered to be better as a first treatment.

Conclusion

Paraclinoid aneurysms are known to demand special therapeutic considerations due to their special location of close vicinity to bony structures and important neural and vascular structures. Most appropriate treatment is to occlude aneurysms without compromizing patency of the internal carotid artery and without causing any new neurological sequelae. The SEAC procedure enables appropriate surgical management of the aneurysms. Our results indicate that microsurgical aneurysm clipping in combination with this procedures can still be a standard treatment inspite of recent development of endovascular coiling procedures. In light of the contemporary evidence available, endovascular treatment does frequently present with incomplete occlusion and coil compaction for aneurysms of this location.

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