Anterior paraclinoid aneurysms

HIROYUKI KINOUCHI, M.D., PH.D., KAZUO MIZOI, M.D., YOSHIHIDE NAGAMINE, M.D., NORITACA YANAGIDA, M.D., SHIGEKI MIKAWA, M.D., AKIRA SUZUKI, M.D., PH.D., TOSHI SASAJIMA, M.D., PH.D., AND TAKASHI YOSHIMOTO, M.D.

Department of Neurosurgery, Akita University School of Medicine, Akita; Department of Neurosurgery, Tohoku University School of Medicine, Sendai; and Department of Neurosurgery, Kohnan Hospital, Sendai, Japan

Object. The characteristics of a previously unclassified paraclinoid aneurysm arising from the anterolateral (dorsal) wall of the proximal internal carotid artery were retrospectively analyzed in seven patients (five women and two men) who were treated surgically for an aneurysm in this unusual location.

Methods. One patient presented with subarachnoid hemorrhage (SAH) caused by rupture of this aneurysm. The lesions were found incidentally (five cases) or during investigation of SAH due to another aneurysm (one case). There was a female predominance in this series; all female patients harbored multiple aneurysms. All patients underwent surgery. Removal of the anterior clinoid process was necessary because the proximal neck of the aneurysm was closely adjacent to the dural ring.

Conclusions. This special group of aneurysms is very rare, is located exclusively in the intradural space, and carries the risk of SAH. The results of surgical treatment for this aneurysm are quite satisfactory.

KEY WORDS • aneurysm • internal carotid artery • ophthalmic segment of internal carotid artery • dural ring

The portion of the proximal intradural ICA adjacent to the anterior clinoid process is called the paraclinoid segment. Aneurysms of the paraclinoid segment are usually located in the intradural space and their rupture will cause SAH. Some paraclinoid aneurysms, however, are considered unclippable or surgical treatment results in disastrous outcomes due to the location of the aneurysm. Therefore, the classification of these aneurysms according to the origin of their necks or their relationships with anatomical landmarks is particularly important to select the optimum neurosurgical intervention.

The paraclinoid segment gives rise to the OphA and the SHA. The OphA typically originates from the anteromedial surface of the ICA and the SHA usually arises from the posteromedial wall of the ICA, just distal to the dural ring. Therefore, no aneurysms are located at branching sites on the anterolateral aspect of the ICA. Ventral (inferior) paraclinoid CA aneurysms and carotid cave aneurysms have no relationship to arterial branches in this segment and are thus classified into separate categories. These aneurysms arise from the medioposterior surface of the ICA. Aneurysms arising from the anterior (dorsal)-to-lateral surface of this segment of the ICA with no relationship to arterial branches are extremely rare; there is only one reported case of an anterior (dorsal) paraclinoid aneurysm.

Here, we describe a series of seven patients who were surgically treated for anterior paraclinoid aneurysms that arose from the anterolateral surface of the ICA at nonbranching sites in the paraclinoid segment. In one case the aneurysm came to our attention because its rupture produced an SAH; in the other cases the lesions were incidental findings.

Clinical Material and Methods

A total of 3651 patients with cerebral aneurysms were surgically treated at our institutions between 1961 and 2000. Seven patients with anterior paraclinoid aneurysms were treated between 1993 and 2000. During the same time period, 1164 patients were treated for cerebral aneurysms.

In the seven patients who comprise our series, the aneurysms originated on the anterolateral surface of the ICA and were adjacent to the anterior clinoid process, and had no relationships with the OphA, PCoA, SHA, or other arterial branches along the intradural paraclinoid segment (Figs. 1–3).

Clinical findings in the seven patients are summarized in Table 1. All five women harbored multiple aneurysms. One patient presented with an SAH caused by rupture of the anterior paraclinoid aneurysm. The other patients the aneurysms were all incidental findings, although in one patient (Case 5) an SAH was related to another aneurysm. There were no visual symptoms caused by the anterior paraclinoid aneurysm.

Abbreviations used in this paper: CA = carotid artery; CT = computerized tomography; ICA = internal CA; MCA = middle cerebral artery; OphA = ophthalmic artery; PCoA = posterior communicating artery; SAH = subarachnoid hemorrhage; SHA = superior hypophyseal artery.
Results

Ipsilateral pterional craniotomy was performed in all patients by using various techniques for proximal control of the ICA. Temporary balloon occlusion was used in Case 1. The balloon catheter was introduced into the ICA just proximal to the OphA. Inflation of the balloon resulted in a decrease in stump pressure from 110 to 60 mm Hg. The cervical CA was compressed by hand in Case 2, without exposure of the ICA in the neck. The cervical ICA was exposed in the neck in Cases 3 through 7. Temporary proximal occlusion of the ICA was effective to reduce tension in the aneurysm during dissection, which was performed between the distal dural ring and the aneurysm, and aneurysmal clipping in all patients. The sylvian fissure and carotid cistern were opened, and the frontal base was dissected from the optic nerve. All aneurysms were located on the anterolateral surface of the ICA, just above the anterior clinoid process, and thus the aneurysms were usually visualized at this stage. Drilling of the anterior clinoid process and removal of the anterolateral portion of the distal ring was necessary to obtain sufficient space in which to place the aneurysm clips in all patients. All aneurysms were obliterated by application of straight or angled clips parallel to the ICA to avoid the formation of “dog ear” aneurysms.

All aneurysms were the typical thin-walled berry type, without signs of arteriosclerosis or infectious processes. The aneurysm sac was completely located in the intradural space and the neck of the aneurysm was adjacent to the anterior clinoid process on the anterolateral wall of the ICA. There was no relationship between the neck and the origins of the OphA, PCoA, or SHA.

Postoperatively, all patients had uneventful recoveries and remained neurologically intact. Postoperative angiography confirmed that all clipped aneurysms had been completely obliterated.

Illustrative Cases

Case 4

This 68-year-old woman was transferred from another hospital 24 hours after onset of SAH. She was semicomatose, but displayed no focal neurological deficits and the hemorrhage was classified as Hunt and Hess’s clinical Grade IV. Computerized tomography scans revealed SAH predominantly in the basal and left ambient cisterns. Angiograms revealed one aneurysm at the left anterior paraclinoid segment and another at the MCA bifurcation (Fig. 2A and B). Aneurysm surgery was performed 35 days following

[Images of angiograms are shown, indicating aneurysms located on the anterolateral wall of the paraclinoid segment of the ICA.]
onset of the SAH, after the patient’s status had returned to normal. The distal sylvian fissure was first opened through a left pterional approach. The left MCA aneurysm was small and round, and was not adherent to the adjacent pia mater of the temporal lobe, indicating that the aneurysm was unruptured. After opening the sylvian fissure and carotid cistern, the anterior paraclinoid aneurysm was easily exposed. This aneurysm was 15 mm in diameter; the tip of the sac wall was very thin and blood flow could be seen within. An old yellowish clot was attached to the aneurysm sac and we believed that this aneurysm was the one that had ruptured. The aneurysm neck and sac were located intradurally on the anterior surface of the ICA, but the proximal neck of the lesion was adjacent to the anterior clinoid process. The proximal neck was adherent to the dura mater lying over the anterior clinoid process (Fig. 4B). The anterior clinoid process was drilled out and the anterolateral portion of the distal dural ring was resected to create enough space between the anterior clinoid process and the proximal neck of the aneurysm (Fig. 4C). The

**Case 6**

This 64-year-old man was referred to our institution from another hospital with the diagnosis of unruptured ICA aneurysm after he had undergone a magnetic resonance imaging examination for headache. On admission, angiograms (Fig. 3A and B) and three-dimensional CT scans (Fig. 4A) depicted a left anterior paraclinoid aneurysm arising superiorly from the anterolateral surface of the ICA, adjacent to the anterior clinoid process. The OphA was separate from the aneurysm neck. A left pterional craniotomy was performed to expose the ICA in the neck and clip the aneurysm. After dissection of the sylvian fissure and the carotid cistern, the anterior paraclinoid aneurysm was exposed on the anterolateral surface of the ICA. The aneurysm sac was located in the intradural space and the neck was adjacent to the anterior clinoid process. The proximal neck was adherent to the dura mater lying over the anterior clinoid process. The anterior clinoid process was clipped. Postoperative angiograms confirmed complete obliteration of both aneurysms (Fig. 2C and D). The patient’s postoperative course was uneventful and she was discharged ambulatory without any morbidity.
proximal neck was some distance from the OphA. Two right-angled Sugita clips and a booster clip were applied parallel to the ICA and placed in the proximal-to-distal direction (Fig. 4D). Angiograms obtained after the operation confirmed complete obliteration of the aneurysm (Fig. 3C and D). The patient's postoperative course was uneventful and he was discharged ambulatory without any morbidity.

Discussion

Nomenclature of Paraclinoid Segment Aneurysms

Aneurysms arising from the intradural portion of the ICA proximal to the origin of the PCoA are usually called ophthalmic\textsuperscript{3,5} or paraclinoid\textsuperscript{7} segment aneurysms. Two major arterial branches, the OphA and the SHA, arise from this segment. The OphA typically originates from the anteromedial surface of the ICA and the SHA usually arises from the posteromedial wall of the ICA, just distal to the dural

Table

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<th>Case No</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Symptom or Finding</th>
<th>Side</th>
<th>No. of Aneurysms (location of other lesions)</th>
<th>Surgical Clipping</th>
<th>Results</th>
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<td>rt</td>
<td>1</td>
<td>(lt ICA–SHA, ACoA)</td>
<td>success</td>
<td>excellent</td>
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<td>rt</td>
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<td>success</td>
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<td>62, F</td>
<td>incidental</td>
<td>rt</td>
<td>2</td>
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<td>4</td>
<td>68, F</td>
<td>SAH</td>
<td>lt</td>
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* ACoA = anterior communicating artery; PICA = posterior inferior cerebellar artery; VA = vertebral artery.
† Associated with the ruptured MCA aneurysm.
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The pathogenesis of saccular aneurysms may be multifactorial—including the combination of a predisposing congenital medial defect in the arterial wall, occasional arterial variations, and local hemodynamics—but the true cause of these lesions remains controversial.11,17 In the present series, although the number of patients was small, there was a female dominance similar to that observed in CA–OphA aneurysms. All women in our series harbored multiple aneurysms associated with the anterior paraclinoid lesion, and all of these were saccular aneurysms at the site of the common arterial branch. This clinical finding would suggest that genetic factors are involved in the genesis of anterior paraclinoid aneurysms.

Hemodynamic stress is the most likely acquired causative factor for the pathogenesis of saccular aneurysms unrelated to arterial branches concomitant with arteriosclerosis.3,17,21,23 Hemodynamic factors are important in the development of aneurysms at the abrupt curvature of the ICA.25,27 Two major bends along the paraclinoid ICA create hemodynamic vectors that promote aneurysm formation.3 The first and most dramatic bend occurs as the ICA ascends from the cavernous sinus and turns sharply posteriorly, creating an upward flow vector.3 A second more subtle lateromedial curve occurs as the ICA courses medial to the anterior clinoid process, creating a medially directed flow vector along the entire paraclinoid ICA. Paraclinoid aneurysms, including carotid cave aneurysms, ventral paraclinoid aneurysms, and SHA aneurysms, are usually located on the medial surface of the ICA; this is due to the more subtle medial hemodynamic vector created as the ICA turns medially during its ascent to pierce the dural ring.1 Infraclinoid aneurysms originating from the lateral surface of the ICA are caused by a superiorly directed hemodynamic stress vector along the anterior vertical portion of the infra cavernous ICA; they project superiority away from the cranial nerves of the cavernous sinus and toward the anterior clinoid process.3 In contrast, anterior paraclinoid aneurysms are located on the side opposite that of the usual paraclinoid aneurysm (lateral surface of the ICA). Whether hemodynamic stress is important in the formation of anterior paraclinoid aneurysms remains unclear; however, because the clinoidal segment only extends approximately 5 mm, the wall of the ICA around the neck of anterior paraclinoid aneurysms may also receive a superiorly directed hemodynamic stress vector similar to that of infraclinoid aneurysms. In our series, the sacs of anterior paraclinoid aneurysms were all directed superiorly, except in one case in which there was superolateral projection. This direction of aneurysm growth would support this hypothesis.

**Treatment of These Aneurysms**

Anterior paraclinoid aneurysms can be treated by clipping because these lesions are the true berry type, are directed upwards, and have no relationship to any arterial branch. In all our cases, however, the proximal neck adhered to the dura over the anterior clinoid process and required removal of this structure and resection of the dural ring, as in treatment of other paraclinoid aneurysms.3,5,6,18,19,30,35,36 The aneurysm is adjacent to the anterior clinoid process and is directed upward; thus removal of the process is safer with direct visualization of the lesion after complete dissection of the sylvian fissure and the carotid cistern, and confirmation of the anatomical relationship of the aneurysm to proximal control of the ICA. The surgical results achieved
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using this approach in the present series were quite satisfactory.

Drilling the anterior clinoid process to treat paraclinoid aneurysms can cause a catastrophic rupture of the aneurysm. One fatal case, in which a subclinoid CA aneurysm arose from the anterior portion of the ICA, just distal to the origin of the OphA, and extended superolaterally beneath the anterior clinoid process, has been reported. In that case, the aneurysm was located completely extradurally and eroded the anterior clinoid process from its inferior surface, leaving a very thin shell of bone at the superior aspect of the process. During surgery, drilling the thin anterior clinoid process caused a catastrophic rupture of the aneurysm. Although the aneurysms harbored by patients in our series were different from the subclinoid CA aneurysm, these lesions can adhere closely to the anterior clinoid process and, in fact, can erode the process. It is very important to evaluate the anatomical relationship between the aneurysm and the anterior clinoid process preoperatively.

References


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Address reprint requests to: Hiroyuki Kinouchi, M.D., Ph.D., Department of Neurosurgery, Akita University School of Medicine, 1-1-1 Hondo, Akita 010-8543, Japan. email: kinouchi@nsg.med.akita-u.ac.jp.