Subclindoid aneurysms

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Object. This study was undertaken to analyze the features that define subclindoid aneurysms.

Methods. Five cases of laterally directed carotid artery (CA) aneurysms adjacent to the anterior clinoid process (ACP) were identified in a series of approximately 1400 surgically treated aneurysms. These cases were selected because the aneurysms had the same features as the only previously described “subclindoid” aneurysm. The angiographic and anatomical features of the five cases were analyzed.

Conclusions. Subclindoid aneurysms are a unique group of congenital berry aneurysms. They originate from the lateral surface of the CA adjacent to the ACP. They are partially or completely hidden from view at surgery by the ACP and are partially or completely proximal to the distal dural ring of the CA. The proximal neck of these lesions is located at the same level of the CA cut perpendicular to its axis of blood flow as the origin of the ophthalmic artery (OphA), but they do not originate at that or any other branch of the CA. They can only be definitively differentiated from OphA, anterior paraclinoid, and blister-like aneurysms at surgery.

Key Words • aneurysm • internal carotid artery • anterior clinoid process • dural ring

The paraclinoid CA gives rise to a number of different types of aneurysms. An important differentiating feature of these aneurysms is their direction of projection as they appear on angiograms. The projection is inferior for the ventral paraclinoid aneurysm, inferomedial for the SHA (carotid cave) aneurysm, superomedial for the OphA aneurysm, and superior for anterior CA and blister-like aneurysms. A single case of a paraclinoid aneurysm that projected laterally was described by Korosue and Heros in 1992. They named this aneurysm “subclindoid” because it lay beneath the ACP. In the present paper I present a small series of this unique type of aneurysm and define its characteristics.

Clinical Material and Methods

Five patients harboring subclindoid aneurysms were identified from among approximately 1400 cases of aneurysms that were surgically treated by my colleagues and me during the last 20 years. These cases were selected because of their radiographic and anatomical similarities to the case described by Korosue and Heros. The features of these aneurysms included an origin on the anterolateral surface of the CA and a projection in a superolateral direction in the vicinity of the ACP. The direction of aneurysm projection was evaluated on anteroposterior angiograms and its relationship to the ACP was determined on lateral projections as described by Tanaka, et al. The position of the ACP was identified on films produced before addition of contrast agent (Fig. 1A), because this structure was obscured by the aneurysm and by angiographic contrast material flowing in the overlying artery during the arterial phase (Fig. 1B). The position of the aneurysm clip on the CA in postoperative angiograms helped localize the site of the aneurysm neck (Fig. 2). Tracings of the preoperative angiograms, including the ACP and the clip on the aneurysm neck, were superimposed to show the relative positions of the anatomical structures (Fig. 3). The analysis of angiographic data, clinical characteristics of the patients, and anatomical findings at surgery are the subject of this study.

Results

Clinical Data

The clinical data are summarized in Table 1. Four patients were female. Two patients presented with SAH from the subclindoid aneurysm. In one of these (Case 1) the aneurysm was completely proximal to the distal dural ring and, thus, it was difficult to understand how the SAH had occurred. Nevertheless, there was some lateralization of blood to the appropriate side observed on the CT scan, and the patient has been followed for 8 years with angiography because a residual aneurysm neck was identified on postoperative angiograms, despite no evidence of any other cause of the SAH. The patient in Case 4 presented with a partial ipsilateral third cranial nerve paralysis manifested by ptosis and paralysis of upward gaze. In the other two cases, the diagnosis was made after magnetic resonance imaging had been performed for unrelated reasons. In Cases 2 and 5, there were multiple aneurysms.
All cases were treated with surgical clipping of the aneurysm. There was a small amount of residual aneurysm neck in the patient in Case 1. Removal of the ACP was necessary for exposure in all cases. In two patients (Cases 3 and 5), part of the dissection was performed during temporary trapping of the aneurysm by occlusion of the internal CA in the neck and of the intracranial CA distal to the aneurysm. In Case 1, the CA was isolated in the neck, but not occluded during surgery. In no case did the aneurysm appear to be unusually friable.

The outcome of surgery was good in four of the five patients. After surgery, ipsilateral oculomotor nerve function was partially paralyzed in one patient (Case 1; superior division innervated muscles) and completely paralyzed in another (Case 5). In neither patient was the cavernous sinus packed, but in one (Case 1) the nerve was exposed in its canal to determine its exact relationship to the aneurysm. In both cases oculomotor function recovered fully. In Case 5, the patient also experienced a permanent ipsilateral visual loss from optic nerve manipulation. In Case 1 there was some residual unclipped portion of the aneurysm neck; its appearance has remained unchanged on follow-up angiograms obtained during an 8-year period. The preoperative third cranial nerve deficit observed in one patient (Case 4) also recovered postoperatively. The patient in Case 2 has permanent cognitive deficits. A large amount of subarachnoid blood was identified on the initial CT scan obtained in this patient and she was very sleepy preoperatively. She experienced a stormy postoperative course thought to be in part due to vasospasm.

Radiographic Findings

Preoperative CT scans were obtained in Cases 1, 2, and 4. In Case 1, there was a finding suggestive of an erosion of the ACP by the aneurysm (Fig. 4); however, the finding was found only on a thin section and could have represented a natural irregularity in the bone surface. At surgery, an indentation of the bone caused by the aneurysm was found, but an exact correlation with the site of the CT finding was not certain.

Tracings of the angiograms from the five cases are shown in Fig. 3. The aneurysms arose from the anterolateral surface of the CA, adjacent to the ACP. On the anteroposterior view, these lesions are shown to originate just proximal to the bend where the CA turns in a lateral direction to course around the ACPs. In Cases 1, 3, and 5, the aneurysm is projecting superolaterally. This is seen on the anteroposterior view in Cases 3 and 4 and on the lateral view in Case 5.

Surgical Findings

On initial exposure at surgery the aneurysm was completely hidden by the ACP in Cases 1, 3, and 5, and partially hidden in Cases 2 and 4. After removal of the ACP, the aneurysm was found to be completely proximal to the distal dural ring in Cases 1 and 5. In the other cases, a portion of the aneurysm was proximal to the ring. The ACP was detached by drilling through the optic strut, dissected from the aneurysm and CA, and removed en bloc. In one patient (Case 3), it was also necessary to fracture an attachment to the middle clinoid process before removal. In Cases 1 and 2, the ACP was detached in its neck, but not occluded during surgery. In no case did the aneurysm appear to be unusually friable.
3, the removed ACP had a small indentation adjacent to the aneurysm. In all but one (Case 3), the origin of the OphA was seen and was distant from the neck of the aneurysm. No other adjacent branch vessels were seen.

**Discussion**

**Paraclinoid Aneurysms**

The paraclinoid CA is defined as constituting the clinoidal segment plus the ophthalmic segment. The clinoidal segment of the CA lies between the proximal and distal dural rings. At this site, the ACP is attached to the lateral CA surface. The ophthalmic CA is the segment between the distal dural ring of the CA and the origin of the posterior communicating artery. The OphA usually originates medially on the CA just distal to the dural ring. When the ACP is seen on the lateral projection of an angiogram, its position on the CA can overlap parts of the clinoidal and/or ophthalmic segments, but its exact anatomical relationship to these segments can only be defined by direct observation at dissection.

**Clinical characteristics of five patients with subclinoid aneurysms**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Side of Lesion</th>
<th>Associated Aneurysms</th>
<th>Symptom</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60, F</td>
<td>lt</td>
<td>none</td>
<td>SAH</td>
<td>transient CN III paralysis†</td>
</tr>
<tr>
<td>2</td>
<td>50, F</td>
<td>lt</td>
<td>ACoA</td>
<td>SAH</td>
<td>vasospasm‡</td>
</tr>
<tr>
<td>3</td>
<td>46, F</td>
<td>lt</td>
<td>none</td>
<td>incidental finding</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>78, M</td>
<td>lt</td>
<td>lt MCA, rt ICA bif</td>
<td>CN III paralysis†</td>
<td>CN II damage, transient CN III paralysis</td>
</tr>
<tr>
<td>5</td>
<td>55, F</td>
<td>rt</td>
<td>none</td>
<td>incidental finding</td>
<td>none</td>
</tr>
</tbody>
</table>

* CN = cranial nerve; ICA bif = internal CA bifurcation.
† Partial involvement of nerve with ptosis and paralysis of upward gaze.
‡ Vasospasm resulting in permanent cognitive deficit.
There is no definitive classification of aneurysms of the paraclinoid CA. A confusing issue is the definition of direction of projection around the circumference of the CA. There is agreement concerning both medial and lateral directions; however, the terms inferior, ventral, or posterior are variably used for the surface of the CA that is adjacent to the dural roof of the cavernous sinus, as opposed to superior, dorsal, or anterior, which apply to the opposite surface. Most aneurysms in the region originate just distal to the distal dural ring. Many are related to the named branches of the CA. Ophthalmic artery aneurysms are usually directed in a superomedial direction. Aneurysms related to the takeoff of the SHA, also known as carotid cave aneurysms, project inferomedially. The ventral paraclinoid aneurysm, which projects directly inferior with some fundus in the cavernous sinus, is probably a variant of the carotid cave aneurysm. Lesions that are not associated with named CA branches tend to project superiorly and are called anterior CA aneurysms. Some of these are very fragile aneurysms and have been called “blister-like” aneurysms. These lesions usually arise at a more distal location on the CA.

**Subclinoid Aneurysms**

Subclinoid aneurysms are different from those described earlier. The first and only description of this aneurysm type was in a case report by Korosue and Heros. Their patient presented with an SAH. The angiogram revealed a CA aneurysm distal to the OphA. At surgery, the aneurysm lay completely hidden by the ACP. While trying to remove the ACP the surgeon drilled into the aneurysm, resulting in a bad outcome. In retrospect, they realized that the preoperative CT scan demonstrated an erosion of the ACP that had been caused by the aneurysm. In their report Korosue and Heros emphasized the importance of proximal control of the CA during surgery for these cases.

Because the findings of Korosue and Heros formed the selection criteria for the present series, the appearance of the aneurysms is the same. It is possible, however, to add the following details to their description. These aneurysms arise on the lateral surface of the CA just proximal to the bend of this artery seen on the anteroposterior view, where the artery turns in a lateral direction around the ACP to become intradural. They are situated at the clinoidal or infraclinoidal level on the lateral angiogram. At surgery, they are proximal to the dural ring. They are not in contact with the origin of the OphA.

An important differentiating feature of the various paraclinoid aneurysms is the direction in which the aneurysm projects. A study by Tanaka, et al., defines the projection of various types. These authors did a retrospective radiometric analysis of 85 intradural paraclinoid aneurysms, of which 60 were located at the clinoidal or infraclinoidal level on lateral angiograms. The 60 cases included 38 SHA aneurysms, 16 OphA aneurysms, and six aneurysms unrelated to a branch vessel. All SHA aneurysms projected inferomedially. Thirteen of the OphA aneurysms projected superomedially and three projected superolaterally. Of the lesions unassociated with a branch vessel, three projected superomedially and three superolaterally. The latter three cases are probably the same as the anterior paraclinoid aneurysms described by Kinouchi, et al. These authors consider anterior paraclinoid aneurysms to be a unique type and point out that they must be differentiated from friable (blister-like) aneurysms, which are usually located more distally on the CA. None of the lesions in the present series were friable aneurysms. It is the lesions that project superolaterally at the clinoidal and infraclinoidal level that have the same angiographic features as subclinoid aneurysms. In summary, these include a minority of OphA aneurysms, some anterior paraclinoid aneurysms, and, possibly, some blister-like aneurysms.

Because the angiographic features of subclinoid aneurysms are shared with other types of aneurysms, additional information is necessary to differentiate between them. The finding of a mushroom-cap appearance or an erosion of the ACP are additional signs suggestive of a subclinoid aneurysm. The interpretation of these findings, however, is
subjective and they are not always present. The mushroom cap was seen in three of the five cases in the present series. Erosion of the ACP was only seen in one of the three cases in which a preoperative CT scan was available and was noted at surgery in another case in which preoperative CT scanning was not performed.

The characteristics of the subclinoid aneurysm that definitively differentiate it from anterior paraclinoid, CA–OphA, and blister-like aneurysms include a location proximal to the distal dural ring, the lack of a relationship with the OphA, and the nonfriable nature of the aneurysm. Because there is no radiological marker of the distal dural ring and the exact relationship of the OphA to the aneurysm cannot be defined on angiography, the definitive classification of the aneurysm can only be made at surgery.

The ACP must be removed for the surgical exposure and clipping of a subclinoid aneurysm. This is a risky procedure because the aneurysm can be tightly attached to or embedded in the bone. Exposure of the CA in the neck is advisable to allow trapping of the aneurysm in the case of a difficult dissection or hemorrhage while removing the ACP. A preoperative test of tolerance to CA occlusion should be considered in case permanent trapping becomes necessary. Removal of the ACP should be performed via an intradural approach by drilling through its attachment at the optic strut and then dissecting the isolated tip from the aneurysm. Thinning out the clinoid process over the aneurysm can result in rupture and should be avoided.

The oculomotor nerve is adjacent to the inferolateral surface of the ACP. The fibers of the superior division of the nerve are closest to the bone, as seen when the nerve divides into two divisions at the level of the optic strut. Loss of superior division function causes a paralysis of upward gaze and ptosis. Therefore, it is easy to explain the presenting oculomotor signs in the patient in Case 4 by compression of the nerve by the subclinoid aneurysm. We have also experienced transient postoperative paralysis after removal of the ACP as seen in Cases 1 and 5. This is often a partial involvement of the nerve affecting only the superior division (Case 1). Third cranial nerve complications may be more common when the nerve canal is opened as it was in Case 1.

Conclusions

Subclinoid aneurysms are a unique group of lesions whose characteristics are defined by the present series of cases. They originate from the lateral surface of the CA just proximal to the lateral turn that the artery takes around the ACP when viewed on anteroposterior angiograms. The aneurysms project superolaterally. On lateral angiograms, they are located just distal to the level of the CA cut perpendicular to its axis of blood flow at the origin of the OphA and are situated at or below the level of the ACP. At surgery, they are partially or completely hidden from view by the ACP and are partially or completely proximal to the distal dural ring of the CA. They do not originate at the OphA or at any other branch of the CA.

**Fig. 5. Case 3.** Left: Lateral angiogram revealing the aneurysm (identified by the overlying arrow), which is pointing to the origin of the OphA. Right: Anteroposterior angiogram (orientation: lateral on the right). The open arrows outline the fundus of the aneurysm demonstrating its mushroom-cap appearance. The black arrowhead marks the bend of the CA at the ACP, the white arrowhead the PCA, and the white arrow the CA.
Subclinoid aneurysms can be definitively differentiated from other aneurysm types that share their angiographic features. These include OphA, anterior paraclinoid, and blister-like aneurysms. Subclinoid aneurysms are not friable and, therefore, are probably congenital berry aneurysms. They are not associated with the OphA. Also, they are not completely intradural as are other types. Regardless, definitive differentiation can only be made at surgery.

Surgical treatment of subclinoid aneurysms requires removal of the ACP, which is attached to the aneurysm dome. Preparation for temporary occlusion of the CA proximal to the aneurysm increases the safety of the procedure.

References

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