Carotid Cave Aneurysm

Critical Review

Paulo Henrique Aguiar, MD, PhD, Gustavo Isolan, MD, PhD,† and Adriana Tahara, MD**

Abstract: Paraclinoid aneurysms are frequently encountered at the carotid siphon. The clinoid segment of the internal carotid artery (ICA) is situated at the transition of the artery from the cavernous sinus to the subarachnoid space and has been poorly understood because the anatomy of this region is extremely complex and variable. Understanding the clinoidal segment is important for correctly diagnosing and managing these aneurysms because the risks of aneurysm rupture vary with the specific location of lesions along this small segment of the ICA. The site of origin, projection, and relationship of aneurysms arising from the ophthalmic segment of the ICA to adjacent structures are heterogeneous. The complex anatomy of the paraclinoid ICA makes the surgical management of aneurysms arising from this segment difficult. The main features of successful surgical treatment of these lesions include establishing control of the proximal artery, adequate exposure of the aneurysm neck, and successful obliteration of the aneurysm with minimal manipulation of the optic nerve. The carotid cave is a virtual space, immersed in a small segment of the ICA, the clinoid segment. The clinoid segment is situated inside the clinoid space. This short segment has been poorly understood and for this reason the nomenclature of aneurysms of this area is extremely confusing. This paper reviewed the microsurgical anatomy of the carotid cave, the paraclinoid region, the clinoid space, and the clinical significance of the anatomy in accord with aneurysm growth.

Key Words: carotid cave aneurysms, aneurysms, anterior clinoid process, internal carotid artery

(*Neurosurg Q* 2008;18:239–245)

In 1968, Drake et al[1] wrote the first report of carotid-ophthalmic aneurysms as a distinct entity, offering however no classification scheme. The first classification was proposed by Kothadaram et al in 1971.[2] They classified carotid-ophthalmic aneurysms into 3 groups according to their relationship with the optic chiasm (subchiasmal, suprachiasmal, and parachiasmal), based on intraoperative observations. In 1976, Almeida et al[3] classified their experience with carotid-ophthalmic aneurysms into 2 groups, again based on the relation between the aneurysm and the optic chiasm: latero-optochiasmatic and suboptochiasmatic. Also in 1976, Thurel et al[4] added 2 other groups: suprachiasmal and global types.

The location of the clinoid segment is a controversial topic. On the basis of anatomic studies, we considered the clinoid space as a no cavernous segment, extradural, being a transitional segment, and the lateral wall of the carotid artery has an adjacent relation with the anterior clinoid process. The clinoidal segment is situated immediately proximal to the ophthalmic artery (OA), which originates in the posterior medial wall, and the superior pituitary artery, which originates from the ventromedial wall.

The anterior clinoidal process is projected posteromedially from the optic strut to the minor sphenoid wing. As the internal carotid artery (ICA) emerges from the cavernous sinus, it lies on the opposite side of the inferomedial surface of anterior clinoid. By the level of the anterior genu, the ICA curves from anterior to posterior and from lateral to medial; distally to the anterior looping it curves from medial to lateral.

The extent of clinoidal segment compounds the dural rings, which are named superior and inferior carotid rings[5] (Fig. 1). The inferior ring forms the roof of the cavernous sinus, continuing with the dura that covers the inferolateral surface of the anterior clinoid; the superior ring is another dural cap, which medially forms the falciform ligament and covers the optic nerve and with the dura that recovers the superomedial surface of the anterior clinoidal process. The plan of the superior ring inclines following a posteromedial direction. The superior ring mixes with the inferior ring posteriorly to separate anteriorly.[6,7]

The superior ring adheres strongly to the adventitia of the lateral surface of the ICA, becoming redundant in the medial face, where it could build the virtual space called carotid cave. Kobayashi et al,[8] in 1989, denominated the clinoidal space as the lateral face of the ICA, considering that it is extracavernous and extradural. Even today many authors suggest that the clinoidal space is intracavernous, and in this point of view, the clinoidal segment would be placed inside of a ring composed by a dural roof of the medial surface of the anterior clinoidal

From the *Neurosurgery, Hospital São Camilo, São Paulo; and †Division of Neurosurgery, Hospital das Clínicas de Porto Alegre, Rio Grande do Sul, Brazil.
Reprints: Adriana Tahara, MD, Av. Henrique Broseghini, 243, Osasco, SP, Brazil 06030-340 (e-mail: adrianatahara@yahoo.com.br).

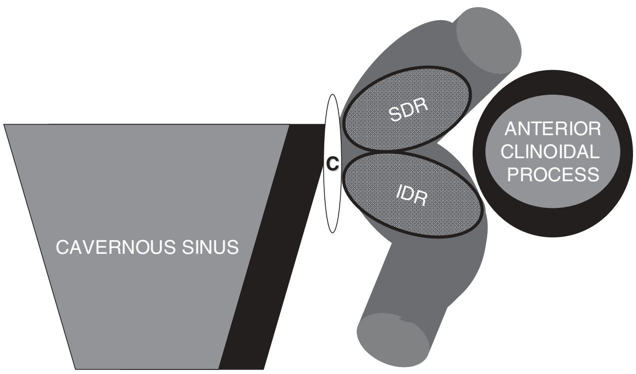

FIGURE 1. Schematic figure shows the relationship between the left cavernous sinus, anterior clinoidal process, superior dural ring (SDR), inferior dural ring (IDR), and the virtual space of the carotid cave (C). Carotid artery is shown.

process, the posterior surface of the optic strut, and the superior portion of the carotid groove.[9]

A rare case of a 62-year-old woman harboring a left carotid cave aneurysm is presented, and the authors emphasize the surgical treatment and the difficulties of endovascular management.

INCIDENCE

Paraclinoid aneurysms arise from the proximal ICA between the site of emergence of the carotid artery from the roof of the cavernous sinus and the posterior communicating artery. Surgery of these aneurysms presents special difficulties because of its complicated osseous, dural, and neurovascular structures; sella turcica, cavernous sinus, optic nerve.[10]

Sohn et al in 1996[10] studied the clinical and radiologic characteristics of 27 patients with paraclinoid aneurysms. They were reviewed and classified into 4 subgroups according to their branch of origin in this segment: (1) carotid cave aneurysm (2 cases), (2) OA aneurysm (11 cases), (3) superior hypophyseal artery aneurysm (11 cases), and (4) proximal posterior carotid artery wall aneurysm or global type aneurysm (3 cases). The authors emphasize that surgery required orbital unroofing and removal of the anterior clinoid process with release of dural ring. To provide easy proximal control, exposure of cervical carotid artery was helpful in some cases. According to them, preoperative balloon occlusion testing is mandatory.[10] We do not agree with their opinion and rarely use occlusion test, except for complex and giant paraclinoid aneurysms.

Shunsuke et al in 2003[11] have identified in their casuistic of 42 paraclinoid aneurysms: ophthalmic aneurysms (29%), followed by superior hypophyseal (17%), carotid cave (17%), anterior carotid wall (17%) aneurysms, posterior wall aneurysms (12%), lateral wall aneurysms (7%), and genu aneurysms (5%).[11]

CLASSIFICATION OF PARACLINOID ANEURYSMS

The aneurysms may be divided into 4 major types according to Barami et al[12]: types Ia and Ib projected superiorly and arise from the dorsal surface of C6. Type Ia was related to the ophthalmic artery. Type Ib aneurysms were sessile and had no branch relations. Type II aneurysms were related to the ventral wall of the C6 segment without any branch relation. Type IIIa variant arises from the medial wall of the C6 segment and was related to the superior hypophyseal artery. Type IIIb arose from the medial wall of the C5 segment below the dural reflection without any branch relation. Large type IV aneurysms arose from the C5 and C6 segments, widening the distal dural ring.

ANATOMY

We followed the nomenclature of the carotid segments by Bouthillier et al,[13] C4 being the intracavernous ICA, C5 the clinoidal segment, and C6 the ophthalmic segment of the ICA. The complete authors' classification has the following 7 segments: C1, cervical; C2, petrous; C3, lacerum; C4, cavernous; C5, clinoid; C6, ophthalmic; and C7, communicating. This classification is practical, accounts for new anatomic information and clinical interests, and clarifies all segments of the ICA.

The clinoidal segment is the small transitional segment of the ICA from the cavernous sinus to the subarachnoid space. The clinoidal segment is named for its relationship to the anterior clinoidal process, which is closely juxtaposed to the lateral wall of the artery. This segment is just proximal to the usual location of the ophthalmic artery, which originates from the dorsomedial wall, and to the superior hypophyseal artery, which originates from the ventromedial wall.[14]

The anterior clinoid process projects posteromedially from the medial aspect of the lesser wing of the sphenoid. As the ICA emerges from the cavernous sinus, it is closely opposed to the inferomedial surface of the anterior clinoid process. At the anterior genu, the ICA curves anterior to posteriorly and also lateral to medially. Just distal to the anterior genu, it curves medial to laterally.[14]

Two dural rings form the boundary of the clinoidal segment. The proximal dural ring forms the roof of the cavernous sinus and is continuous with the dura covering the inferolateral aspect of the anterior clinoid process. The distal dural ring is another layer of dura that is continuous with the falciform ligament medially (overlying the optic nerve) and with the dura investing the superomedial aspect of the anterior clinoid process. The plane of the distal dural ring is inclined in the posteromedial direction. The distal dural ring is fused with the proximal dural ring posteriorly but separated from it anteriorly to a variable degree. The lateral segment of the ICA between the 2 rings is termed the (lateral) clinoidal segment.

The distal dural ring firmly adheres to the adventitia of the lateral aspect of the ICA but is redundant on the medial aspect, forming the potential space of the carotid cave. Kobayashi et al reserve the term "clinoid space" for the lateral aspect of the ICA, which is typically considered extracavernous and extradural. In contrast, the carotid cave can contain the subarachnoid space. A recent report has slightly modified the view of the clinoidal segment, suggesting that it is intracavernous. From this perspective, the clinoid segment is located within a collar formed from the dura lining the medial surface of the anterior clinoid process, the posterior surface of the optic strut, and the upper part of the carotid sulcus. The upper dural ring adheres to the wall of the artery, but the lower ring is separated from the lower margin of the clinoidal segment by a narrow space that transmits venous tributaries of the cavernous sinus.

Clinical Significance of Anatomy

Aneurysms arising from the clinoidal segment of the ICA may have a somewhat lower risk of rupturing into the subarachnoid space compared with supraclinoid ICA aneurysms. The risks of rupture associated with aneurysms arising from the medial clinoidal segment (carotid cave) and the lateral clinoidal segment (clinoidal space) may also differ. Aneurysms on the lateral clinoidal segment are extradural and extracavernous and may be relatively protected from subarachnoid rupture. Those in the carotid cave may also be partially protected but are associated with a risk of subarachnoid hemorrhage if the aneurysm extrudes through the cave.[14]

Aneurysms in the carotid cave may arise due to the turbulence of blood flow related to its change in course at the genu of the ICA. One cadaver dissection documented small vessels in the carotid cave coursing anteriorly to the dura of the anterior sellar region (unpublished data). Growth of carotid cave aneurysms is restricted because they are bounded by the carotid sulcus of the sphenoid bone medially and by the ICA laterally. Thus, they may be relatively protected from rupture. Continued ventromedial growth of a carotid cave aneurysm may cause it to extend into the cavernous sinus whereas continued growth superiorly may cause it to extend out of the carotid cave. Characteristically, carotid cave aneurysms project medially on anteroposterior (AP) angiographic views and are either superimposed on the ICA or project posteriorly on lateral views.

Distinguishing carotid cave aneurysms from other proximal ICA aneurysms can sometimes be difficult. OA aneurysms arise at the origin of the artery and usually project dorsally or dorsomedially. They tend to close the carotid siphon. Aneurysms that arise in relation to the superior hypophyseal artery can be further subdivided into paraclinoid and suprasellar. The paraclinoid variant projects inferiorly or inferomedially toward and beneath the anterior clinoid process and can be confused with a cavernous ICA aneurysm. This variant tends to open the siphon. The suprasellar variant is a true superior hypophyseal aneurysm and extends medially or superomedially into the suprasellar space. The paraclinoid space is delineated by the ventral ICA surface (just distal to the distal ring) superiorly, the roof of the cavernous sinus inferiorly, and the anterior petroclinoid ligament laterally. Ventral paraclinoid aneurysms originate from the inferior wall of the ICA opposite to the origin of the OA and project inferiorly, or inferiorly and slightly medially. They frequently grow toward the cavernous sinus. Their growth is limited laterally by the petroclinoid ligament.

REPORT OF A CASE

Clinical Findings and Diagnosis

C.R.B., a 62-year-old woman complaining of chronic headache, was investigated by computed tomography (CT) angiogram with 3-dimensional reconstruction, CT, and magnetic resonance imaging. The neurologic examination was absolutely normal. The radiologic findings demonstrated a small carotid cave aneurysm. Digital subtraction angiogram confirmed the diagnosis. The patient understood the risk of endovascular procedure and the surgical risk of clipping, and she decided for surgery. The digital subtraction angiogram is shown in Figures 2A and B, AP view and lateral view, respectively. The CT angiogram with 3-dimensional reconstruction is demonstrated in Figures 3A and B, where the left-sided aneurysm may be identified as having maximum diameter of 6 mm. Preoperative serum tests as well as cardiac and anesthesiologic evaluation were performed.

Surgical Technique Postoperative Course

Under general anesthesia she underwent orotracheal tube placement, and after that the head was cleaned with propylene glycol and iodine and the curvilinear incision marked on the left side.

The patient was placed in the supine position with the head held in Mayfield 3-point fixation or Sugita multiple point fixation. The head was gently rotated 30 degrees toward the contralateral shoulder. The head was flexed slightly to bring the chin toward the ipsilateral clavicle and extended to bring the maxillary eminence to the highest point in the field.

A curvilinear skin incision was made behind the hairline. The incision began just anterior to the tragus of the ear and was extended below the zygomatic root to protect the branches of

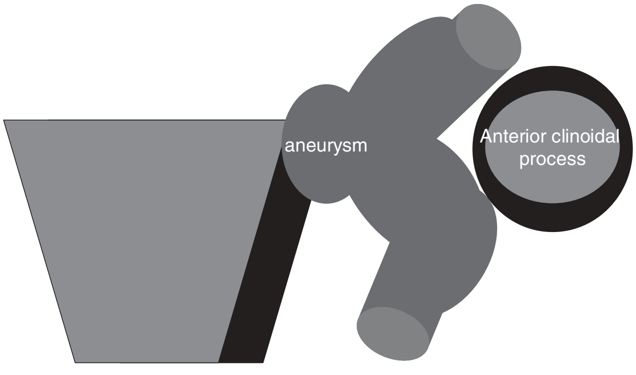

FIGURE 2. The schema shows the position of a carotid cave aneurysm.

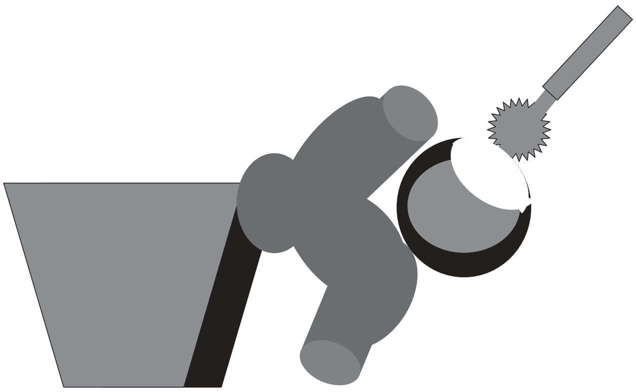

FIGURE 3. The schema shows the resection of anterior clinoidal process by means of diamond burr in a high speedy drill.

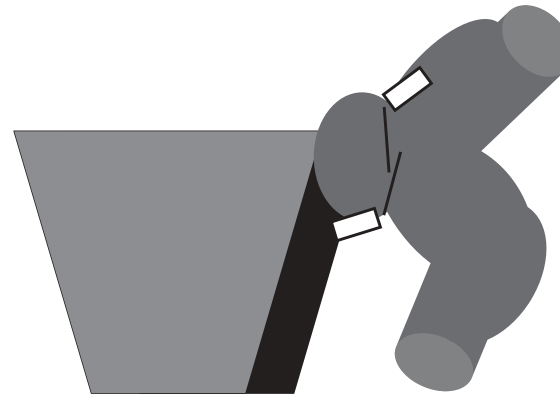

FIGURE 4. The schema shows the surgical option of aneurysm occlusion with multiple clips.

the facial nerve. The incision was made as close as possible to the tragus. We avoided transecting the underlying branches of the superficial temporal artery. The skin flap was reflected anteriorly along with the pericranium. At the supraorbital ridge, care was taken to identify and preserve the supraorbital nerve and vessel passing through the supraorbital foramen or notch. As the skin is reflected anteriorly, the galea merged with the superficial layer of the temporalis fascia. A curvilinear incision was made into the superficial fascia layer at the keyhole and carried toward the zygomatic root. Anterior elevation of this fascia and fat pad away from the underlying temporalis muscle avoided injury to the frontalis branch of the facial nerve that runs in this fat plane. The temporalis muscle was elevated as a separate layer and reflected anteriorly and inferiorly to expose the supraorbital ridge with special hooks (Sugita hook) and to expose the lateral rim of the orbit.

The craniotomy is accomplished with 4 burr holes and by means of a craniotome; as a rule we use Midas Rex, with a cut burr. With a diamond burr in a high-speed drill, we removed the clinoidal anterior process and the optic strut over the left ICA by microscopic magnification. Surgicel was inserted in the deep portion behind the clinoidal process. Typically, the dura mater is open in an inverted T-shaped fashion with its base along the sphenoid ridge. It was reflected anteriorly and anchored with stay sutures. Under operating microscope, the sylvian fissure was opened. Further dissection allows visualization of the carotid optic triangle and the carotid-oculomotor triangle. A self-retractor is placed under the frontal lobe to expose the olfactory nerve. The optic carotid cistern and carotid oculomotor cistern came into view easily with little retraction. With the use of fine microdissectors, the arachnoid between the optic nerve and frontal lobe was incised and opened. The dissection of the arachnoid continues across the carotid artery to the region of the third nerve, thus opening the optic carotid and carotid oculomotor cisterns. The aneurysm could not be visualized at first because it was located behind the left optic nerve. After the dura over the optic canal had been opened, a relatively large portion of roof of the canal and orbit was removed with a diamond drill. The dura propria of the optic nerve in the canal was opened. Adhesion of the optic nerve to the still unexposed aneurysm was dissected carefully, while the nerve was retracted medially with a tip of microsurgical aspirator. Retraction was performed for no more than 5 minutes at a time. The OA was identified and the aneurysm was found ventromedially to it. A Sugita clip bent sideways L-shaped no. 21, a miniclip no. 81 in superior residual neck, and a J-shaped clip in inferior residual neck were applied so that the blades were as parallel to the carotid artery as possible. Although the postoperative course was uneventful she developed a complete third nerve at the same side of clipping. She was discharged at the tenth postoperative day with slow recovery of the third nerve palsy.

DISCUSSION

Carotid Cave

Kobayashi et al[8] introduced the term “carotid cave” as a virtual space, composed by a dural duplication located in the medial surface of the superior ring. The cave is limited laterally by the ICA and medially by the carotid groove.[8] Recently, anatomic studies showed the incidence of carotid cave in 68% to 77% of specimens.[15,16]

The cave turned toward into cavernous sinus and its apex is formed by connective tissue, which is crossed and communicates with the clinoidal venous plexus. This fact may explain the cause for enormous aneurysms in this area, which could expand to extradural and intradural spaces.

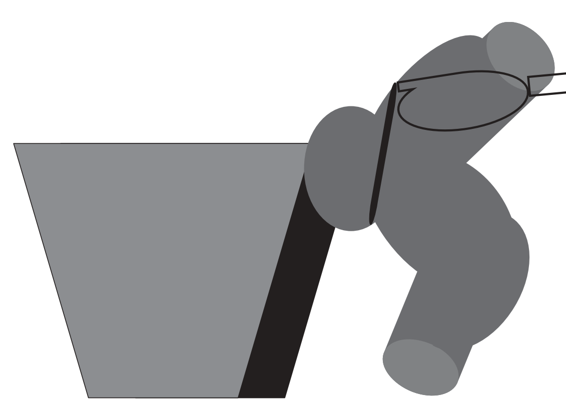

FIGURE 5. The schema shows the option of aneurysm occlusion with a single angle fenestrated clip.

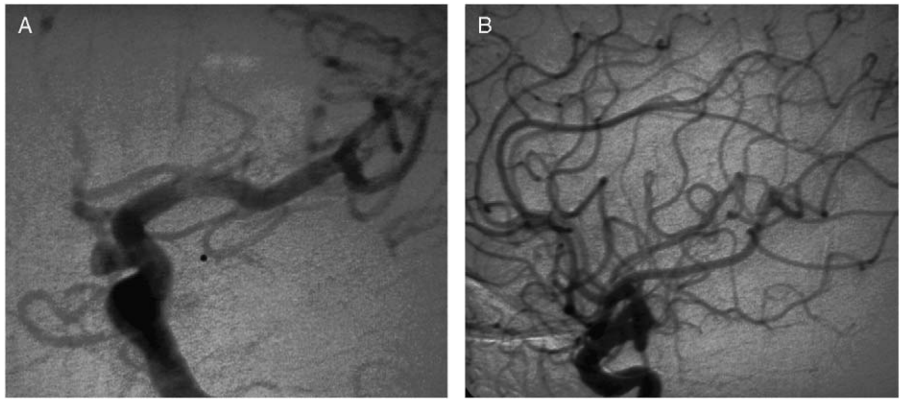

FIGURE 6. A, Digital subtraction angiogram in anteroposterior view showed an aneurysm projected to the carotid cave, medially. B, The lateral view of digital subtraction angiogram showed posterior communicating artery aneurysm, however, the carotid cave aneurysm is not visible in this angiographic view.

Clinoidal Space

The ideal approach for these aneurysms is based on anterior extradural clinoidectomy as described by Dolenc et al[17] (1985) and pterional craniotomy (Figs. 2, 3). The surgical view created by this approach allows identification of the clinoidal space, involved by the external dural lamina superiorly and by the internal dural lamina inferiorly. This is an interdural space, extracavernous, developed by means of surgery. It may be divided into 3 regions.[16]

The first one is anterolateral, previously occupied by the body of the anterior clinoidal apophysis; the second is posterior, occupied by the posteromedial projection of the clinoid tip; and the last is anteromedial, and exists only in the presence of the medial clinoidal apophysis. If there is a true clinoid carotid foramen, the posterior space is connected with the anteromedial (Figs. 4, 5).

Neurosurgical Purposes of Microsurgical Anatomy

The main risk of rupture of these aneurysms is due to the invasion of subarachnoid space into the cavum. The aneurysms are originated by the turbulence of blood flow related to the changing of course of the ICA. The growth of the aneurysms in the carotid cave is limited by the same limits of the cave, medially by the carotid groove in the sphenoid wing, laterally by the ICA, and thus frequently protected against a rupture. Ventromedial growth may provoke extension to the cavernous sinus and, superiorly, growth outside the carotid cave. The digital angiogram generally shows these aneurysms projected medially in AP view, and either no identification or projection to posterior direction may be observed in lateral views of angiogram (Fig. 6).

The differentiation between carotid cave aneurysms and others originated in the proximal segments of the ICA might be the source of many doubts. The carotid ophthalmic aneurysms are originated in the OA exit and

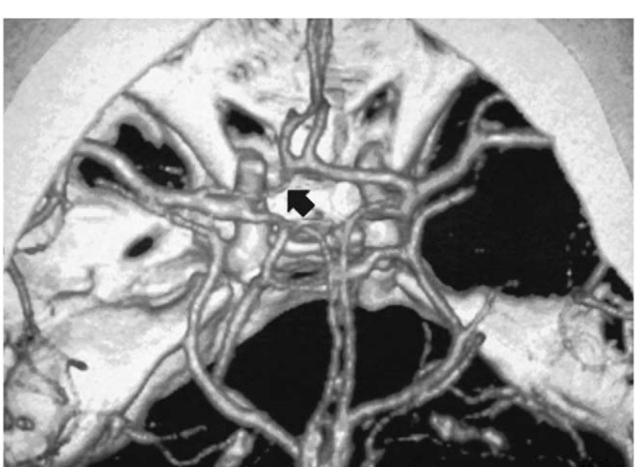

FIGURE 7. Computed tomography angiogram showing the carotid cave aneurysm and its relation with the osseous structures (arrow).

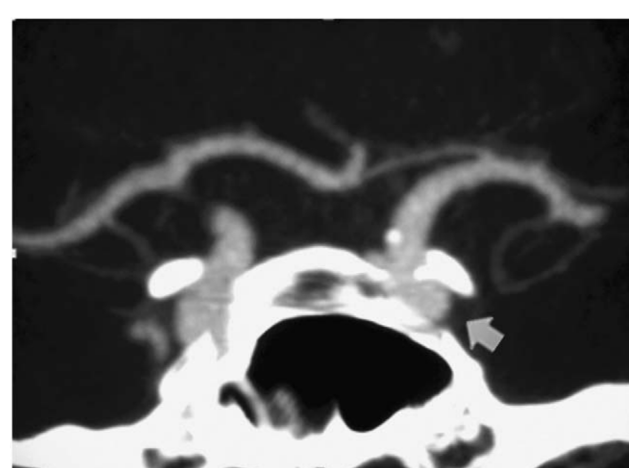

FIGURE 8. Computed tomography coronal view (arrow).

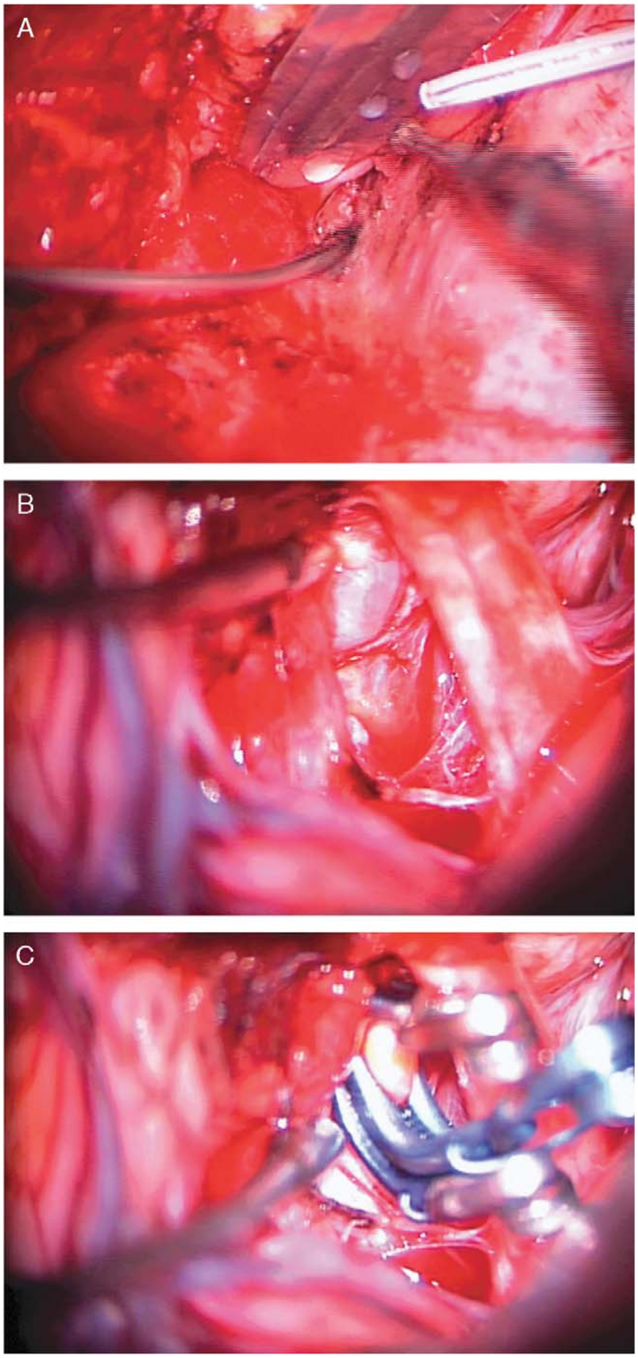

FIGURE 9. Microsurgery view after standard pterional approach. A, Dolenc under continuous irrigation; B, aneurysm exposition; C, clip placement.

as a rule they are projected dorsal or dorsomedially, occluding the carotid siphon. The hypophyseal artery aneurysms are related to their origin in the superior hypophyseal artery and are classified into 2 groups: paraclinoid and parasellar aneurysms.[6] The paraclinoid variant is projected in an inferior and inferomedial direction, and situated below the anterior clinoid process; sometimes they may be misdiagnosed as cavernous sinus aneurysms. They tend to open the carotid siphon. The suprasellar variant is a true superior hypophyseal aneurysm and it extends medially or superomedially inside the suprasellar area. It is limited by the ventral surface of the ICA, inferiorly by the cavernous sinus, and laterally by the petroclinoid ligament. The ventral paraclinoid aneurysms originate from the inferior wall of the ICA, in opposition to the origin of the ophthalmic artery, and are projected inferiorly or slightly medial and inferior. They usually grow inside the cavernous sinus, and their growth is laterally limited by the petroclinoid ligament.

Paraclinoid aneurysms arise from the proximal ICA between the site of emergence of the carotid artery from the roof of the cavernous sinus and posterior communicating artery. Surgery of these aneurysms presents special difficulties because of its complicated osseous, dural, and neurovascular structures; sella turcica, cavernous sinus, optic nerve.[10]

Zhang et al[18] showed their series of 21 cases with carotid cave aneurysms and 7 cases with ventral paraclinoid carotid aneurysms of less than 15 mm in diameter (Nutik aneurysm) operated upon in our unit during the last 14 years and they concluded based on reviewed images that predominant medial projection in the AP view and absence of space in the lateral view are 2 characteristic features of carotid cave aneurysms which can be used to differentiate them from most Nutik aneurysms (Figs. 7–10).

Aneurysms located at the carotid cave region may be approached easily and safely through a contralateral craniotomy with application of the aneurysm clip from an angle medial and inferior to the optic nerve. Between 1980 and 1998, Sheikh et al[19] have adopted the well known ipsilateral approach for exposure and securing of carotid cave aneurysms. However, in 4 patients, they had the opportunity to use a contralateral approach to carotid cave aneurysms, with easier dissection and application of a simple aneurysm clip. The authors demonstrated that the visual acuity of the patients did not deteriorate from the preoperative level.[19]

Therefore, the aneurysm may be clipped by catching the intact wall of the ICA beyond the lesion under the simultaneous monitoring of microscope and endoscopes as proposed by Hiroyuki and Kazuo.[20]

Regarding the surgical prognosis, Sohn et al[10] have found outcomes considered as good to fair in 19 patients, poor in 5, and death of 3 patients. The patients who had poor results were of poor preoperative status—4 were grade IV, 1 was grade II (Hunt-Hess grade). The causes of death were premature rupture (2 cases) and extensive vasospasm (1 case). Shunsuke et al[11] have found in their series, using the Glasgow Outcome Scale, that surgical outcomes were excellent or good, 81%; fair, 2%; poor, 7%; and death, 10%. Complications directly related to surgical procedures included transient oculomotor nerve palsy in 2 patients; new visual deficit in 1; cerebrospinal fluid leak in 2; and cerebral infarction in 1.

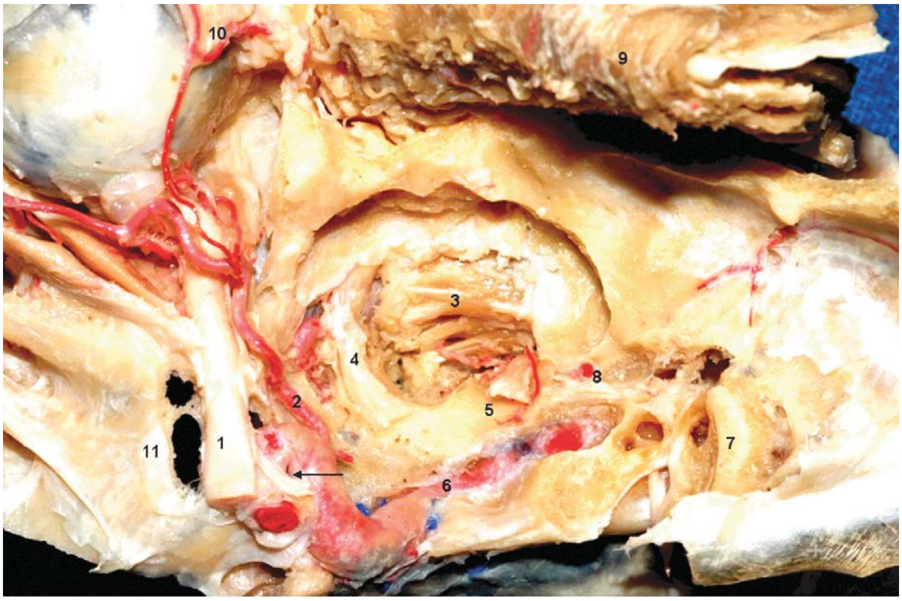

FIGURE 10. Superior view of the anterior and middle fossa after middle fossa peeling and individualization of the anatomic structures. The arrow indicates the carotid cave. 1, Optic nerve; 2, ophthalmic artery (in this specimen its origin is from the intracavernous carotid artery); 3, upper head of the lateral pterygoid muscle; 4, V2; 5, V3; 6, intrapetrous segment of the internal carotid artery; 7, superior semicircular canal; 8, middle meningeal artery; 9, temporal muscle; 10, lacrimal gland; 11, ethmoid sinus.

REFERENCES

1. Drake CG, Vanderlinden RG, Amacher AL. Carotid-ophthalmic aneurysms. *J Neurosurg*. 1968;29:24–31.
2. Kothadaram P, Dawson BH, Kruyt RC. Carotid-ophthalmic aneurysms. A study of 19 patients. *J Neurosurg*. 1971;34:544–548.
3. Almeida GM, Shibata MK, Bianco E. Carotid-ophthalmic aneurysms. *Surg Neurol*. 1976;5:41–45.
4. Thurel C, Rey A, Thiebaut J, et al. Anévrysmes carotido-ophthalmiques. *Neurochirurgie*. 1974;20:25–39.
5. Gadea NM. Anatomia microquirúrgica. Anillo superior y anillo inferior. El segmento clinoideo. *Neuroeje*. 2002;1:27–31.
6. Day AL. Aneurysm of ophthalmic segment. A clinical and anatomic analysis. *J Neurosurg*. 1990;72:677–691.
7. Gadea NM. Cavum carotídeo; controvérsia anatomia microquirúrgica. *Neuroeje*. 2005;19:28–31.
8. Kobayashi S, Kyoshima K, Gibo H, et al. Carotid cave aneurysms of the internal carotid artery. *J Neurosurg*. 1989;70:216–221.
9. Hitotsumatsu T, Natori Y, Matsushima T, et al. Micro-anatomical study of carotid cave. *Acta Neurochir [Wien]*. 1997;139:361–365.
10. Sohn MJ, Lee CH, Ra YS, et al. Classification and surgical treatment of paraclinoid aneurysms. *J Korean Neurosurg Soc*. 1996; 25:1828–1839.
11. Shunsuke K, Kazuo T, Kazuya N, et al. Paraclinoid carotid artery aneurysms: operative techniques and surgical outcome. *Surg Cerebral Stroke*. 2003;31:170–177.
12. Barami K, Hernandez VS, Diaz FG, et al. Paraclinoid carotid aneurysms: surgical management, complications, and outcome based on a new classification scheme. *Skull Base*. 2003;13:31–41.
13. Bouthillier A, van Loveren HR, Keller JT. Segments of the internal carotid artery: a new classification. *Neurosurgery*. 1996;38: 425–432.
14. Alleyne CH Jr, Coscarella E, Spetzler RF, et al. Microsurgical anatomy of the clinoidal segment of the internal carotid artery, carotid cave, and paraclinoid space. *Barrow Q*. 2002;18:8–10.
15. Kim JM, Romano A, Sanan A, et al. Microsurgical anatomic features and nomenclature of the paraclinoid region. *Neurosurgery*. 2000;46:670–680.
16. De Jesus O. The clinoidal space. Anatomical review and surgical implications. *Acta Neurochir [Wien]*. 1997;139:361–365.
17. Dolenc VV. A combined epi- and subdural direct approach to carotid-ophthalmic artery aneurysms. *J Neurosurg*. 1985;62: 667–672.
18. Zhang QJ, Kobayashi S, Toriyama T, et al. Angiographic differentiation of carotid cave aneurysms from ventral paraclinoid carotid aneurysms of Nutik type. *Neurosurg Rev*. 1993;16:283–289.
19. Sheikh B, Ohata K, El-Nagarr A, et al. Contralateral approach to carotid cave aneurysms. *Acta Neurochir (Wien)*. 2000;142: 33–37.
20. Hiroyuki K, Kazuo M. Intraoperative adjuncts for the unusual internal carotid artery aneurysms. *Surg Cerebral Stroke*. 2005;33: 229–234.

