CONTEMPORARY NEUROSURGERY
A BIWEEKLY PUBLICATION FOR CLINICAL NEUROSURGICAL CONTINUING MEDICAL EDUCATION
VOLUME 41 • NUMBER 16
November 15, 2019

Paraclinoid Aneurysms: Part II—Inferior Paraclinoid

Ali F. Krisht, MD, and Sanford P.C. Hsu, MD

Learning Objectives: *After participating in this CME activity, the neurosurgeon should be better able to:*
1. *Describe the classification of paraclinoid aneurysms.*
2. *Identify the anatomic and radiologic features of the inferior type of paraclinoid aneurysms.*
3. *Explain how to make and apply a treatment plan for patients with the inferior type of paraclinoid aneurysms.*

This article is the second of 4 parts.

Inferior paraclinoid aneurysms are intradural carotid aneurysms that arise proximal to the posterior communicating artery and diametrically opposite to the take-off point of the ophthalmic artery (Figure 1). Patients with these aneurysms typically present with headaches or bleeding, but they can grow very large before becoming symptomatic. These aneurysms are also described as ventral type aneurysms, and they have been described previously as paraophthalmic, paraclinoid, and superior hypophyseal aneurysms. They comprised 22% of aneurysms in our series.

Anatomic Considerations

The dome of the inferior paraclinoid aneurysm is completely intradural and projects inferiorly (Figure 2). The distal dural ring, which extends over the medial and inferior aspects of the internal carotid artery and incorporates into the skull base dura, covers the medial wall of the cavernous sinus and tightens the space between the dural wall of the cavernous sinus and the proximal aspect of the aneurysm neck (Figure 3). The dome of the aneurysm is usually embedded within the dura that covers the medial wall of the cavernous sinus. As this aneurysm grows, its dome can project either medially or posteriorly (Figure 4).

A medially projecting inferior paraclinoid aneurysm of significant size may occupy the suprasellar region and can lead to compression of the optic chiasm (Figure 4D), but it should not be confused with the superomedial (true ophthalmic) aneurysm or the superior hypophyseal artery aneurysm. The medially projecting inferior aneurysm can be distinguished from the superomedial (true ophtahlmic) aneurysm, as they rarely present with visual deficits. However, it can be difficult to differentiate from a large superior hypophyseal artery aneurysm. Intraoperatively, these two types differ in their relationship to the location of the superior hypophyseal artery perforators, and evidence of an elevated carotid artery proximal to the neck of the aneurysm indicates that the aneurysm is likely the inferior type. Inferior aneurysms arise from a ventral location, and as they grow, they tend to elevate the superior hypophyseal branches that are usually draped over the medial surface of the aneurysm dome (Figures 4B–4E). This characteristic makes it particularly demanding to preserve those perforators during the clipping process.

Large inferior aneurysms may extend posteriorly and even compress the brainstem region (Figures 4E and 5C).

Dr. Krisht is Professor and Director, Arkansas Neuroscience Institute, St. Vincent Hospital, #5 St. Vincent Circle, Suite 503, Little Rock, AR 72205; E-mail: akrisht.ani@stvincenthealth.com; and Dr. Hsu is Neurosurgeon, Division of General Neurosurgery, Neurological Institute, Taipei Veterans General Hospital, and Professor, National Yang-Ming University School of Medicine, Taipei, Taiwan.

The authors, faculty, and staff in a position to control the content of this CME activity and their spouses/life partners (if any) have disclosed that they have no financial relationships with, or financial interests in, any commercial organizations relevant to this CME activity.

This article is reprinted from a classic *Contemporary Neurosurgery* article published in 2008.

Category: Cerebrovasular

Key Words: Paraclinoid; Ophthalmic; Aneurysm; Microsurgery

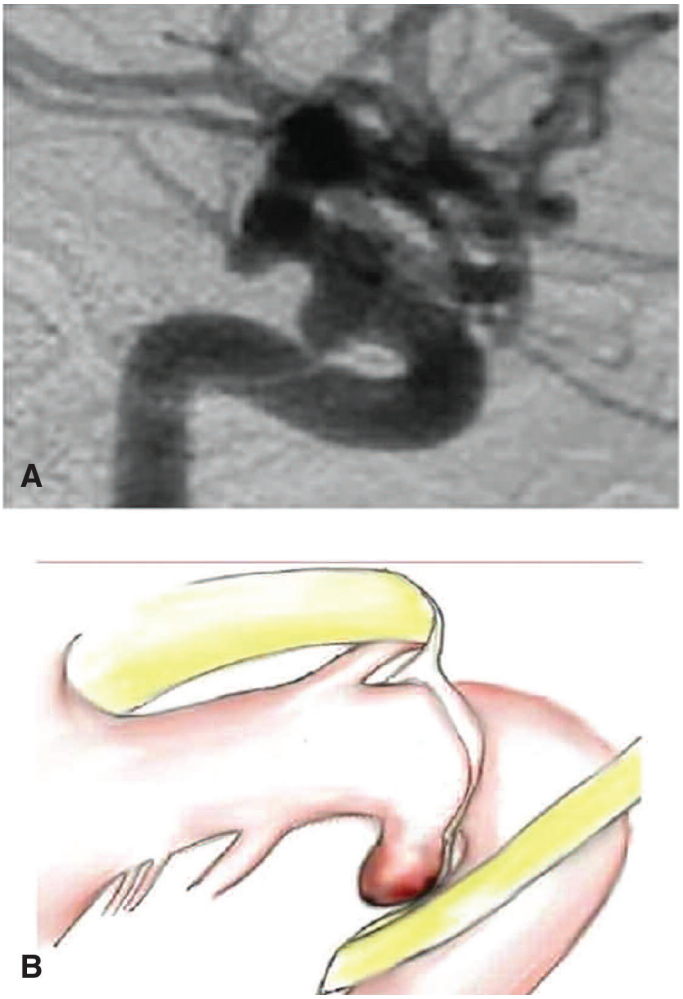


Figure 1. *A*, Internal carotid injection of internal carotid artery angiogram showing a small inferior type paraclinoid aneurysm (ventral type). Note its relationship to the take-off point of the posterior communicating artery, which is associated with a small infundibulum in this case. *B*, Diagram of the expected intraoperative findings after removal of the anterior clinoid process.

These aneurysms are typically proximal to the take-off point of the posterior communicating artery with the neck opposite to the take-off point of the ophthalmic artery. They bear the same relationship to the superior hypophyseal artery branches as do the medially projecting inferior aneurysms.

Radiologic Considerations

To use angiography most effectively to identify inferior paraclinoid aneurysms, one must first become familiar with the variations found on angiograms. Three-dimensional CT angiograms simplify the recognition of features specific to this type of aneurysm. Two angiographic characteristics worth noting are: (1) on medially projecting inferior aneurysms, the carotid artery is visible along the superior surface of the aneurysm (Figure 2); and (2) a posteriorly projecting inferior aneurysm may easily be confused with a posterior communicating artery aneurysm (Figures 5A–5C) An oblique view is sometimes needed to identify the exact relationship of the parent internal carotid artery to the aneurysm.

Surgical Considerations

Small-sized inferior paraclinoid aneurysms with small necks can be treated successfully and safely with endovascular coiling. In such aneurysms, coiling has a very low rate of recanalization and can spare the patient from a more involved surgical procedure (Figure 1). However, a good number of inferior paraclinoid aneurysms present with a wide neck and a large or giant-sized dome. In those aneurysms, the chance of complete obliteration of the aneurysm with endovascular coiling is in the range of 50% with a high recanalization rate (up to 60% in giant aneurysms). More recently, advanced endovascular techniques with stent application and coiling are being used. Although this combination is supposed to decrease the chance of recanalization, in our experience, the aneurysms persist when the neck is wide, leading to their growth and future need of additional endovascular treatments. More recently, liquid

The continuing education activity in *Contemporary Neurosurgery* is intended for neurosurgeons, neurologists, neuroradiologists, and neuropathologists.

Contemporary Neurosurgery (ISSN 0163-2108) is published bi-weekly by Wolters Kluwer Health, Inc. at 14700 Citicorp Drive, Bldg 3, Hagerstown, MD 21742. **Customer Service: Phone (800) 638-3030, Fax (301) 223-2400, or E-mail customerservice@lww.com.** Visit our website at www.lww.com.

Wolters Kluwer

Publisher: Randi Davis

Subscription rates: *Individual*: US $891, international $1247. *Institutional*: US $1519, international $1569. *In training:* US $164, international $165. Single copies: $85. GST Registration Number: 895524239. Send bulk pricing requests to Publisher.

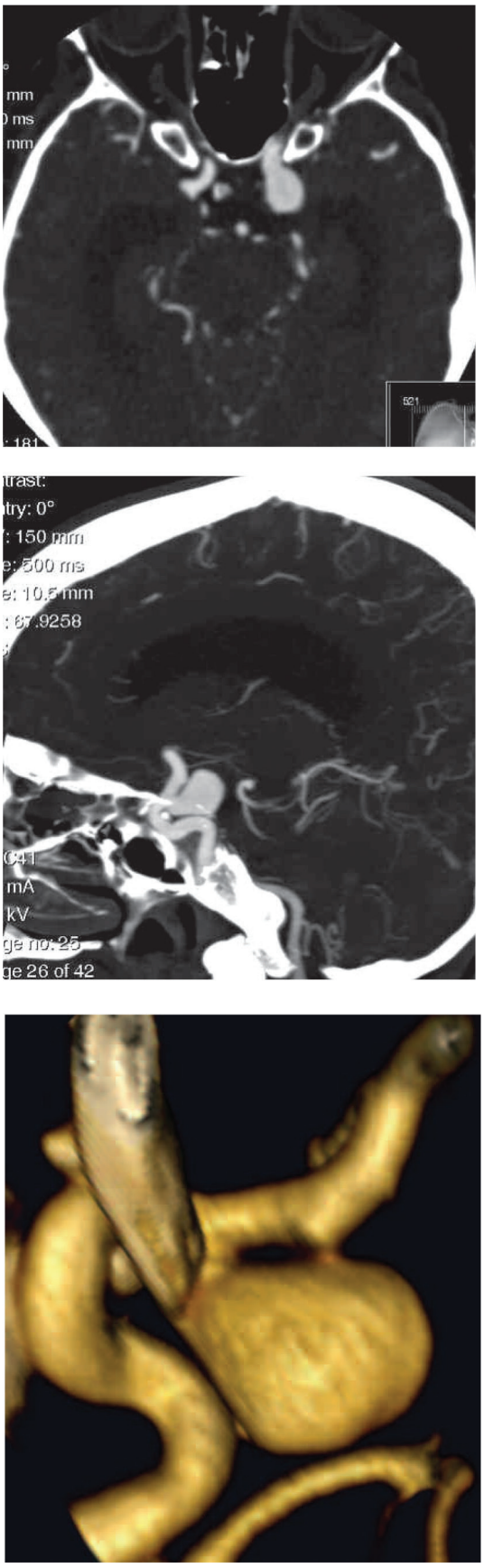


Figure 2. CT angiography of posteriorly projecting inferior-type paraclinoid aneurysm. *A*, Axial CT angiogram. *B*, Sagittal CT angiogram. *C*, Three-dimensional reconstruction showing the expected intraoperative surgical view and the relationship of the neck of the aneurysm to the anterior clinoid process.

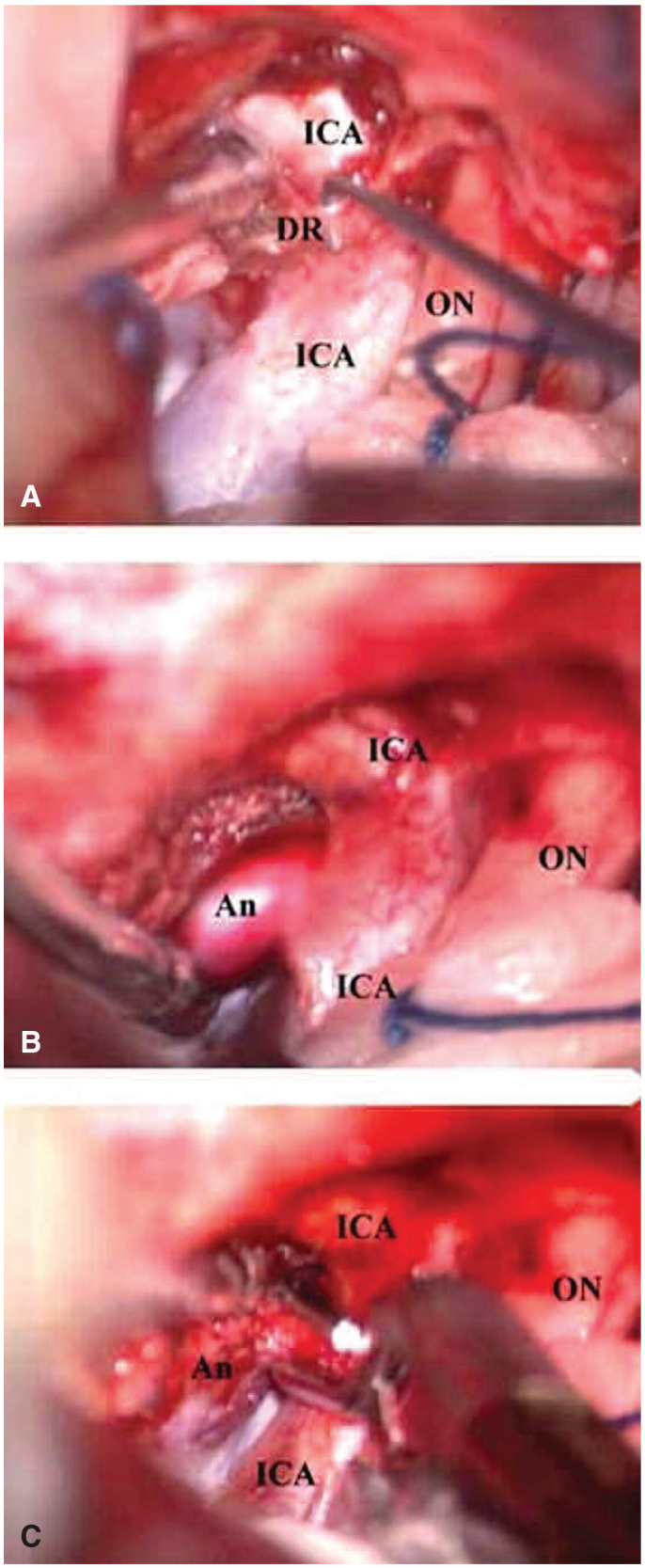


Figure 3. Intraoperative photographs of a left inferior-type paraclinoid aneurysm. *A*,The optic nerve (ON) and both clinoidal and supraclinoid segments of the internal carotid artery (ICA) are separated by the dural ring (DR), which is being elevated by a small sharp hook. *B*, The aneurysmis fully exposed and the dural ring completely cleaned from around the internal carotid and the proximal aspect of the neck of the aneurysm (An). *C*, A curved clip is applied to the neck of the aneurysm.

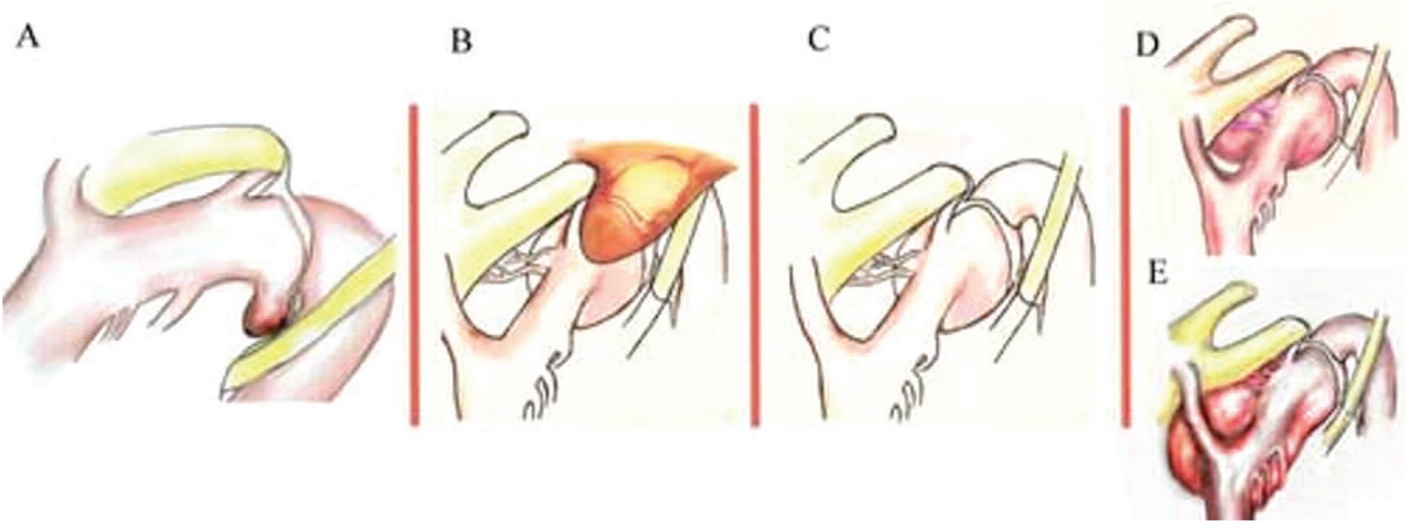


Figure 4. *A*, Diagram showing small inferior-type paraclinoid aneurysm. *B*, A large inferior-type aneurysm before removal of the clinoid process. *C*, After removal of the anterior clinoid process. Note the relationship of the dural ring to the proximal aspect of the neck of the aneurysm. If this part of the dural ring is not removed, it may hinder the closure of the clips or lead to stenosis of the internal carotid due to the "sling effect" by the ring. *D*, A very large inferior type paraclinoid aneurysm with medial projection under the optic apparatus. *E*, Posteriorly projecting inferior paraclinoid aneurysm. Note the location of the superior hypophyseal branches, which need to be preserved while the fenestrated clips are applied to reconstruct the parent artery.

embolic material has been used with some improvement in the recanalization rates. This rate of recanalization continues to be as high as 30% in giant aneurysms treated by very experienced hands.

In view of the added complexity needed for the endovascular treatment of these aneurysms, and persistent high recanalization rate, and based on experience with a high clipability rate and comparable risks, we think that surgical clipping should continue to be an important and durable treatment option for patients with inferior-type paraclinoid aneurysms.

When surgically treating a patient with an inferior paraclinoid aneurysm, it is essential that the proximal section of the aneurysm neck be exposed via removal of the anterior clinoid process and distal dural ring to reveal the clinoidal segment of the carotid artery. If the proximal segment of the neck is inadequately exposed, the clips may not close proximally, and part of the aneurysm filling will remain. In addition, proper exposure allows for a thorough cleaning of the area; without such a cleaning, the "sling effect" will cause a narrowing of the artery following closure of the clips.

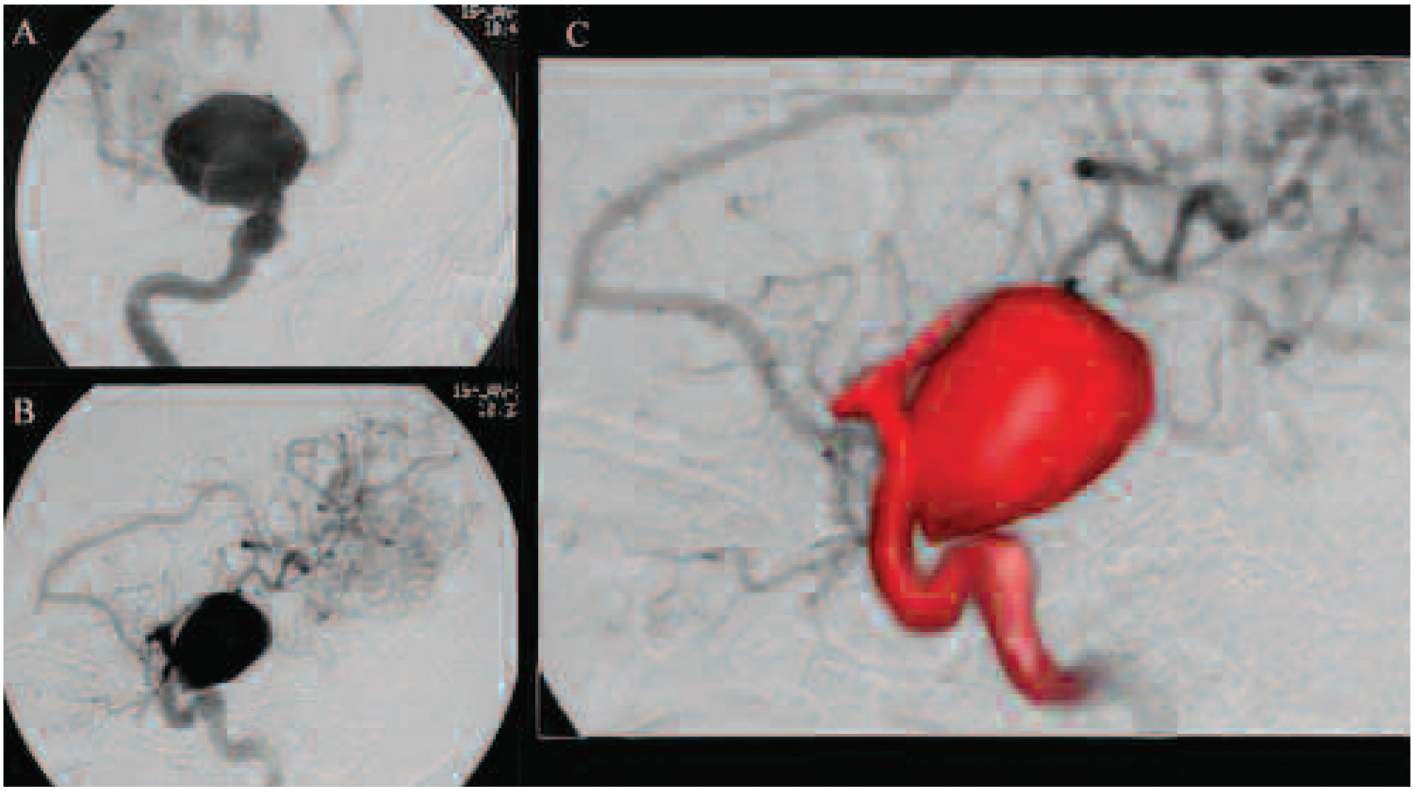
Once proper exposure of the aneurysm neck is obtained, the clipping process may be performed without risk of compromise to the artery. When large or giant in size, both types of inferior paraclinoid aneurysms require fenestrated clips to reconstruct the internal carotid artery lumen (Figure 5D). During the clip application process, it is important to apply the clips in a fashion to reconstruct the lumen of the parent artery and preserve the blood flow within the superior hypophyseal branches. In the majority of these cases, an intraoperative angiogram is helpful to confirm adequate flow within the parent vessel. More recently, we have been using intraoperative fluorescein angiography, which has proven very useful in such cases. The use of fluorescein angiography and intraoperative micro-Doppler scans can spare the patient from undergoing conventional angiography with its potential risks.

Small aneurysms are best approached laterally to the internal carotid artery after excising the dural ring and exposing the proximal aspect of the neck of the aneurysm (Figure 3).

The neck of large aneurysms must be viewed from four different locations, including the medial and lateral aspects of the internal carotid artery as well as the proximal and distal aspects of the aneurysm neck. In such cases, the circumferential removal of the distal dural ring and mobilization of the internal carotid artery becomes significant. This allows: (1) better visualization of the proximal aspect of the neck; (2) complete removal of the distal dural ring to prevent stenosis of the internal carotid artery after the aneurysm is clipped; (3) good visualization for reconstruction of the lumen of the internal carotid to most effectively obliterate the aneurysm; and (4) better visualization of the superior hypophyseal artery perforators, which arise from the medial aspect of the internal carotid and drape over the medial aspect of the aneurysm neck and dome.

Complications and Their Avoidance

Complications related to the removal of the anterior clinoid process and the possibility of CSF leakage were addressed in part I of this article. Visual loss during clipping of inferior type paraclinoid aneurysms is primarily due to compromise of the blood supply of the optic nerve and/or the optic chiasm, secondary to inclusion of some of the superior hypophyseal perforator vessels within the aneurysm clips. This complication can best be avoided by circumferential excision and resection of the dural ring, mobilization of the internal carotid artery, and full visualization of the ophthalmic artery origin and the medially located superior hypophyseal branches. Avoidance of direct injury to the optic nerve while drilling the anterior clinoid process was addressed in part I.



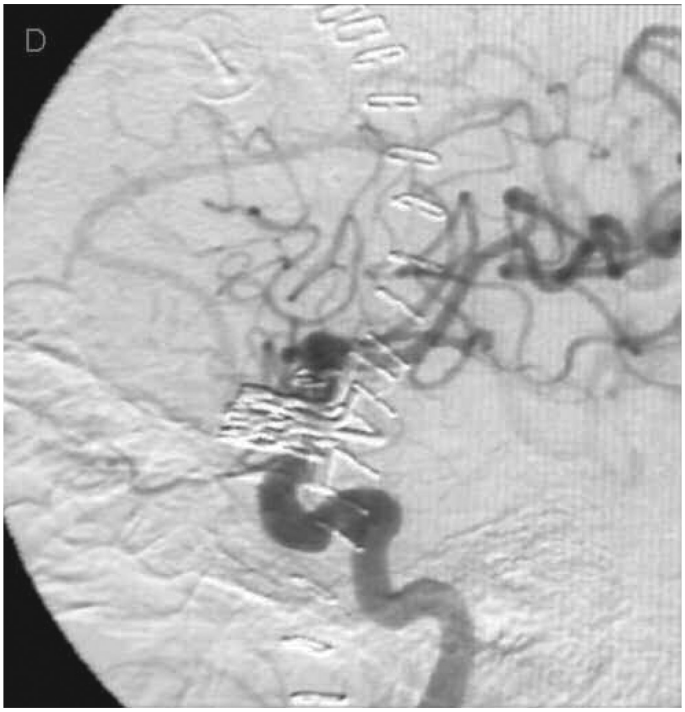


Figure 5. *A–C*, Very large, posteriorly projecting inferior type aneurysm in a patient who has an associated arteriovenous malformation. *A*, Anteroposterior projection. *B*, Lateral projection. Note that the supraclinoid internal carotid artery is superior to the aneurysm, unlike the true ophthalmic types, in which the distal supraclinoid segment is inferior to the aneurysm. *C*, Retouched illustration of the expected intraoperative findings of the aneurysm. *D*, Intraoperative angiogram obtained after reconstruction of the parent vessel with fenestrated clips.

Guidelines for decreasing the risk of ischemic cerebral complications during the clipping process of inferior type paraclinoid type aneurysms are similar to those previously described for superior type (true ophthalmic) paraclinoid aneurysms.

Readings

Allcock JM, Canham PB. Angiographic study of the growth of intracranial aneurysms. *J Neurosurg*. 1976;45:617-621.

Almeida GM, Shibata MK, Bianco E. Carotid-ophthalmic aneurysms. *Surg Neurol*. 1976;5:41-45.

Batjer HH, Kopitnik TA, Giller CA, Samson DS. Surgery for paraclinoidal carotid artery aneurysms. *J Neurosurg*. 1994;80:650-658.

Benedetti A, Curri D. Direct attack on carotid ophthalmic and large internal carotid aneurysms. *Surg Neurol*. 1977;8:49-54.

Bouthillier A, van Loveren HR, Keller JT. Segments of the internal carotid artery: A new classification. *Neurosurgery*. 1996;38:425-433.

Cawley CM, Zipfel GJ, Day AL. Surgical treatment of paraclinoid and ophthalmic aneurysms. *Neurosurg Clin N Am*. 1998;9:765-783.

Day AL. Aneurysms of the ophthalmic segment: a clinical and anatomical analysis. *J Neurosurg*. 1990;72:677-691.

Day AL, Inoue T, Rhoton AL Jr, et al. Microsurgical anatomy and surgery of the paraclinoid area. In: *Proceedings of the Third Seminar on Microsurgical Anatomy, and Ninth Japanese Congress of Neurological Surgery*. Fukuoka, Japan, 1990.

De Jesús O. The clinoidal space: anatomical review and surgical implications. *Acta Neurochir (Wien)*. 1997;139:361-365.

Dolenc VV. A combined epi- and subdural direct approach to carotid-ophthalmic artery aneurysms. *J Neurosurg*. 1985;62:667-672.

Drake CG, Vanderlinden RG, Amacher AL. Carotid-ophthalmic aneurysms. *J Neurosurg*. 1968;29:24-31.

El-Kalliny M, Keller JT, van Loveren HR, Tew JM Jr. Anatomy of the anterior clinoid process: a surgical perspective. In: Samii M (ed). *Skull Base Surgery*. Basel: Karger, 1994, pp 75-77.

Flamm ES. Carotid artery aneurysms. In: Ransohoff J (ed). *Modern Technics in Surgery, Neurosurgery, Installment I*. Mt. Kisco, NY: Futura, 1979, pp 46-47.

Fox JL. Microsurgical treatment of ventral (paraclinoid) internal carotid artery aneurysms. *Neurosurgery*. 1988;22:32-39.

Gibo H, Lenkey C, Rhoton AJ Jr. Microsurgical anatomy of the supraclinoid portion of the internal carotid artery. *J Neurosurg*. 1981;55:560-574.

Hakuba A, Liu S, Nishimura S. The orbitozygomatic infratemporal approach: a new surgical technique. *Surg Neurol*. 1986;26:271-276.

Heros RC, Nelson PB, Ojemann RG, Crowell RM, DeBrun G. Large and giant paraclinoid aneurysms: surgical techniques, complications, and results. *Neurosurgery.* 1983;12:153-163.

Iwabuchi T, Suzuki S, Sobata E. Intracranial direct operations for carotid-ophthalmic aneurysm by unroofing of the optic canal. *Acta Neurochir (Wien).* 1978;43:163-169.

Jefferson G. Compression of the chiasma, optic nerves, and optic tracts by intracranial aneurysms. *Brain.* 1937;60:444-497.

Kim JM, Romano A, Sanan A. Microsurgical anatomic features and nomenclature of the paraclinoid region. *Neurosurgery.* 2000;46:670-682.

Knosp E, Muller G, Perneczky A. The paraclinoid carotid artery: anatomical aspects of a microsurgical approach. *Neurosurgery.* 1988;22:896-901.

Krayenbühl H, Yaçargil MG. Rontegenanatomie und topographie der hirngefasse. In: Huber P (eds). *Zerebrale Angiographie fur Klinik und Praxis.* Stuttgart: Georg Thieme, 1979, pp 238-246.

Krisht AF, Barrow DL, Barnett DW, Bonner GD. The microsurgical anatomy of the superior hypophyseal artery. *Neurosurgery.* 1994;35:899-903.

Kumon Y, Sakaki S, Kohno K, Ohta S, Ohue S, Oka Y. Asymptomatic, unruptured carotid-ophthalmic artery aneurysms: angiographical differentiation of each type, operative results, and indications. *Surg Neurol.* 1997;48:465-472.

Kyoshima K, Koike G, Hokama M. A classification of juxta-dural ring aneurysms with reference to surgical anatomy. *J Clin Neurosci.* 1996;3:61-64.

Morgan F. Removal of anterior clinoid process in the surgery of carotid aneurysm, with some notes on recurrent subarachnoid haemorrhage during craniotomy. *Schweiz Arch Neurol Neurochir Psychiatr.* 1972;111: 363-368.

Nutik SL. Removal of the anterior clinoid process for exposure of the proximal intracranial carotid artery. *J Neurosurg.* 1988;69:529-534.

Nutik SL. Ventral paraclinoid carotid aneurysms. *J Neurosurg.* 69:340-344, 1988.

Oikawa S, Kyoshima K, Kobayashi S. Surgical anatomy of the juxta-dural ring area. *J Neurosurg.* 1998;89:250-254.

Pia HW. Classification of aneurysms of the internal carotid system. *Acta Neurochir (Wien).* 1978;40:5-31.

Seoane ER, Rhoton AL Jr, de Oliveira E. Microsurgical anatomy of the dural collar (carotid collar) and rings around the clinoid segment of the internal carotid artery. *Neurosurgery.* 1998;42:869-886.

Sugita K, Kobayashi S, Kyoshima K, et al. Fenestrated clips for unusual aneurysms of the carotid artery. *J Neurosurg.* 1982;57:240-246.

White JC, Adams RD. Combined supra- and infra-clinoid aneurysms of the internal carotid artery. Report of a case of unusual congenital dilatation of intracranial portion of carotid artery and injuries to visual, oculomotor, sensory and taste fibres. *J Neurosurg.* 1955;12: 450-459.

Yaşargil MG. Inferior wall aneurysms of the internal carotid artery. In: Yaşargil MG (ed). *Microneurosurgery*. New York: Thieme-Stratton, 1984, vol II, pp 60-70.

Yonekawa Y, Ogata N, Imhof HG, Olivecrona M, Strommer K, Kwak TE, Roth P, Groscurth P. Selective extradural anterior clinoidectomy for supra- and parasellar processes. *J Neurosurg.* 1997;87:636-642.

To earn CME credit, you must read the CME article and complete the quiz and evaluation on the enclosed form, answering at least 70% of the quiz questions correctly. **Select the best answer and use a blue or black pen to completely fill in the corresponding box on the enclosed answer form.** Please indicate any name and address changes directly on the answer form. If your name and address do not appear on the answer form, please print that information in the blank space at the top left of the page. Make a photocopy of the completed answer form for your own files and mail the original answer form in the enclosed postage-paid business reply envelope. Your answer form must be received by Lippincott CME Institute by **November 14, 2021.** Only two entries will be considered for credit. All CME participants will receive individual issue certificates for their CME participation monthly. These individual certificates will include your name, the publication title, the volume number, the issue number, your participation date, and the AMA credit awarded. For more information, call (800) 638-3030.

Online quiz instructions: To take the quiz online, **log on to your account** at **www.contempneurosurg.com**, and click on the "CME" tab at the top of the page. Then click on "Access the CME activity for this newsletter," which will take you to the log-in page for **http://cme.lww.com**. Enter your *username* and *password*. Follow the instructions on the site. You may print your official certificate ***immediately.*** Please note: Lippincott CME Institute, Inc., **will not** mail certificates to online participants. **Online quizzes expire on the due date**.

The American Association of Neurological Surgeons (AANS) manually tracks *AMA PRA Category 1 Credits*™ earned from neurosurgery activities not sponsored or joint-sponsored by the AANS. As a service to AANS members, Lippincott CME Institute will continue to provide the AANS a monthly listing of their participants and the CME credits they earned so that AANS members do not have to send their individual certificates to the AANS for tracking.

1. Inferior paraclinoid aneurysms are extradural aneurysms.

True or False?

2. Coiling of large or giant inferior paraclinoid aneurysms demands complex endovascular steps and has a high recanalization rate.

True or False?

3. Inferior paraclinoid aneurysms are usually distal to the origin of the posterior communicating artery.

True or False?

4. Large inferior paraclinoid aneurysms usually require fenestrated aneurysm clips to obliterate the aneurysm and reconstruct the parent internal carotid artery.

True or False?

5. Posteriorly projecting inferior paraclinoid aneurysms can be confused with posterior communicating artery aneurysms.

True or False?

6. Clipping of small inferior paraclinoid aneurysms is easily done without removing the anterior clinoid process.

True or False?

7. Small inferior paraclinoid aneurysms with small necks treated with endovascular coiling have good durability with low canalization rate.

True or False?

8. Medially projecting inferior paraclinoid aneurysms can be confused with superior hypophyseal artery aneurysms.

True or False?

9. Superior hypophyseal artery perforators can be included in the aneurysm clips without significant risks of visual compromise.

True or False?

10. Removal of the dural ring when clipping inferior paraclinoid aneurysms avoids the occurrence of stenosis in the parent internal carotid artery.

True or False?