

PENETRATION OF THE OPTIC NERVE BY AN INTERNAL CAROTID ARTERY-OPHTHALMIC ARTERY ANEURYSM: CASE REPORT AND LITERATURE REVIEW

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OBJECTIVE AND IMPORTANCE: Although it is well known that large or giant internal carotid artery-ophthalmic artery aneurysms can cause visual deficits, penetration and schism of the optic nerve by an aneurysm are very rare.

CLINICAL PRESENTATION: A 48-year-old man presented with an acute onset of right visual deterioration after an episode of severe headache. Magnetic resonance imaging demonstrated penetration of the right optic nerve by an intracranial aneurysm. Cerebral angiography revealed an internal carotid artery-ophthalmic artery aneurysm of 12 × 7 mm. The aneurysm was directed superomedially and appeared to have a “waist” within the penetration.

INTERVENTION: Intraoperatively, we observed that part of the aneurysm wall was visible through the optic nerve fibers at the junction with the optic chiasm.

CONCLUSION: Although there was no direct evidence of subarachnoid hemorrhage on imaging scans or with operative exploration, we think that the patient must have experienced sentinel hemorrhaging, leading to visual deterioration. We describe the case in detail and review the world literature.

KEY WORDS: Ophthalmic artery aneurysm, Optic neuropathy, Penetration of the optic nerve, Sentinel hemorrhage

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Internal carotid artery (ICA)-ophthalmic artery aneurysms represent a small proportion of intracranial aneurysms. Reportedly, they constitute 0.3 to 1% of intracranial aneurysms and 0.9 to 6.5% of aneurysms of the ICA (7). When aneurysms do form in the ophthalmic segment of the supraclinoid ICA, however, it is not unusual for the patients to experience monocular visual disturbances attributable to optic nerve and/or optic chiasm compression by aneurysms of more than 1 cm, before overt aneurysm rupture (1, 6, 8, 9). Yaşargil (10) reported that 18% of patients with aneurysms of the ophthalmic segment presented with visual symptoms. Day (4) reported that 30% of a series of 80 patients with aneurysms of the ophthalmic segment demonstrated visual symptoms at the time of presentation. It is rare, however, for the aneurysm to penetrate or physically split the optic apparatus. There have been only a few case reports illustrating optic nerve penetration by an ophthalmic artery aneurysm (2, 3, 5, 7).

We report a case of an ICA-ophthalmic artery aneurysm with penetration of the optic

nerve. This is the first reported case in which penetration of the optic nerve was demonstrated with magnetic resonance imaging (MRI).

CASE REPORT

The patient was a 48-year-old man with no significant medical history. He had presented to the emergency room with one episode of severe headache 3 weeks earlier, with definite neck stiffness. The headache was accompanied by a marked change in visual acuity in the right eye, which spontaneously resolved 2 days later. The deterioration in the right eye returned 10 days later; it was unaccompanied by other symptoms but it failed to improve. During the physical examination performed 3 weeks after the initial onset, the patient was awake, alert, and oriented. He exhibited a right afferent pupillary defect. His visual acuity was 20/800 on the right and 20/25 on the left. Extraocular movements were intact. An ophthalmoscopic examination demonstrated a pale, poorly circumscribed, optic nerve head.

The rest of the neurological examination results were unremarkable. Formal visual field testing with Goldman perimeter fields demonstrated a large central scotoma in the right eye. Computed tomographic scans of the brain with contrast agent administration demonstrated a right suprasellar mass of approximately 1 cm. MRI scans demonstrated a 1-cm cerebral aneurysm arising from the wall of the right ICA (Fig. 1). The aneurysm, represented by a signal void, appeared to be splitting the right optic nerve into two unequal bundles, with the medial component being larger than the lateral component. Therefore, it appeared on MRI scans that the fundus of the ICA aneurysm had pierced the right optic nerve. Cerebral angiograms confirmed that the ICA aneurysm originated from the ophthalmic segment, just distal to the origin of the ophthalmic artery, and measured 12 × 7 mm (height × width), with a 3-mm neck (Fig. 2). In addition, the aneurysm seemed to exhibit a narrowing (a "waist") where it was compressed by two parts of the split optic nerve. The prominence of the temporal horns of the lateral ventricles bilaterally and the entire ventricular system on computed tomographic and MRI scans suggested a mild degree of communicating hydrocephalus, which also might be consistent with previous "sentinel bleeding" or mild subarachnoid hemorrhage (SAH). Cerebrospinal fluid analysis demonstrated no xanthochromia or red blood cells, with normal glucose and protein levels, but indicated reactive lymphocytosis, which again might suggest prior SAH, with clearing of red blood cells and their breakdown products from the cerebrospinal fluid during prompting of an inflammatory reaction. The spinal tap was performed 3 weeks after the first headache and days after the second visual deterioration.

The patient was taken to the operating room for a right pterional craniotomy, with exposure of the right cervical carotid

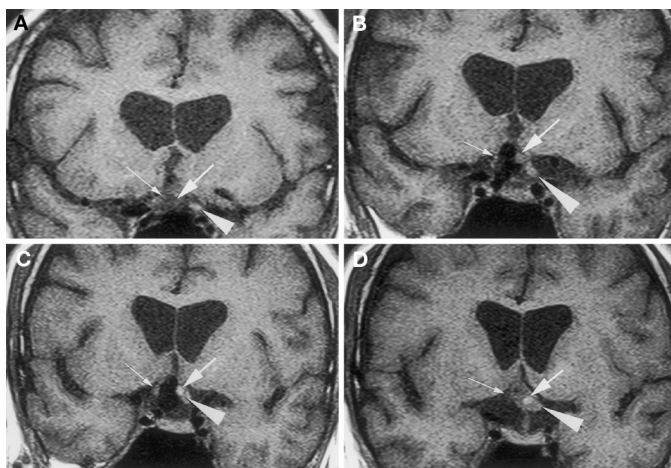


FIGURE 1. A–D, sequential coronal slices of the sella in T1-weighted, non-enhanced, MRI scans, in the anterior-to-posterior direction, demonstrating a signal flow void representing the 1-cm anterior circulation aneurysm, with one bundle of the right optic nerve displaced upward and medially (thick arrows), encroaching on the left optic nerve (arrowheads), and the other optic nerve bundle on the lateral side of the aneurysm (thin arrows).

artery for proximal control and aneurysm clipping. The dissection was continued to the right optic nerve-chiasm junction. It was immediately apparent that it would be necessary to drill the anterior clinoid process to uncover the proximal neck; this was performed completely. The clinoid process proved to be extremely aerated with the lateral recess of the sphenoid sinus and was almost paper-thin. The sphenoid sinus entry was later packed with muscle and fibrin glue during closure. The large aneurysm emerged from the medial wall of the ICA, distal to the origin of the ophthalmic artery. A reddish aneurysm mass, approximately 4 mm in diameter, was observed to be projecting through the fibers of the right optic nerve at the chiasmal junction (Fig. 3). It was readily apparent that the small protruding mass was a direct extension of the large ophthalmic artery aneurysm inferior to the optic apparatus. The patient underwent successful clipping of the aneurysm, with temporary cervical ICA control and application of a straight Sugita clip under the right optic nerve. The dome of the aneurysm was punctured, and the optic nerve was decompressed. Postoperative cerebral angiography demonstrated complete obliteration of the aneurysm. The patient's postoperative course was uneventful, and his visual acuity and field deficit remained unchanged at the 3-month follow-up examination.

DISCUSSION

Four cases of penetration of the optic apparatus by an

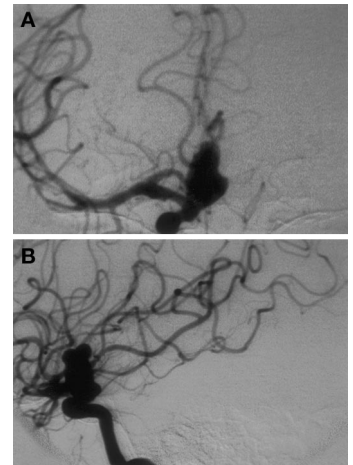


FIGURE 2. Anteroposterior (A) and lateral (B) projections of right ICA injection angiograms, demonstrating the 12 × 7-mm aneurysm directed anteriorly, superiorly, and medially. The 3-mm neck of the aneurysm was located just distal to the origin of the right ophthalmic artery. A reddish aneurysm mass, approximately 4 mm in diameter, was observed to be projecting through the fibers of the right optic nerve at the chiasmal junction (Fig. 3). It was readily apparent that the small protruding mass was a direct extension of the large ophthalmic artery aneurysm inferior to the optic apparatus. The patient underwent successful clipping of the aneurysm, with temporary cervical ICA control and application of a straight Sugita clip under the right optic nerve. The dome of the aneurysm was punctured, and the optic nerve was decompressed. Postoperative cerebral angiography demonstrated complete obliteration of the aneurysm. The patient's postoperative course was uneventful, and his visual acuity and field deficit remained unchanged at the 3-month follow-up examination.



FIGURE 3. Intraoperative view (A) and artist's rendition (B), showing the left optic nerve (L), the right optic nerve (R), the ICA ophthalmic segment aneurysm neck (n), and the dome of the aneurysm (An) protruding through the dissected fibers of the right optic nerve. The ICA can be observed, with the right A1 segment of the anterior cerebral artery and the frontal lobe (Fr).

intracranial aneurysm have been reported (2, 3, 5, 7). Two were ICA-ophthalmic artery aneurysms, one was an anterior communicating artery aneurysm, and one was an ICA anterior wall aneurysm. *Table 1* summarizes the clinical and operative findings for these cases.

Our case is interesting in two respects. First, the preoperative MRI scans enabled us to identify optic nerve penetration and splitting by the aneurysm. To the best of our knowledge, this is the first case of optic nerve penetration by an aneurysm demonstrated with MRI. Second, although there was no direct evidence of previous rupture, we think that the patient experienced a sentinel or warning bleeding episode, which initiated the visual symptoms.

The case reports we reviewed described one of four mechanisms for optic nerve penetration. The first mechanism involves perforating vessels supplying the optic apparatus. These vessels are embryological remnants. Aneurysms can develop on these perforating fetal vessels, resulting in penetration of the optic nerve or chiasm (7).

The second mechanism of optic nerve penetration occurs with developmental fenestration of the optic nerve. This normal variant would allow a mass such as an aneurysm to pass between tandem bundles of the optic nerve (7). This mecha-

nism might be closely associated with the first mechanism, with an embryological vascular remnant penetrating the optic nerve and creating developmental fenestration in the bundle of nerve fibers.

The third mechanism of optic nerve penetration is related to overt SAH. Presumably, a stream of blood under arterial pressure chisels through the optic nerve, creating a gap between the fibers of the optic nerve. This newly created opening could allow the aneurysm or part of the aneurysm to herniate through the optic nerve (3).

The fourth mechanism of optic nerve penetration occurs with a rapidly expanding unruptured aneurysm. There has been only one case report in which this mechanism was described. The authors in that instance (5) described the potentially aggressive behavior of unruptured aneurysms of the ophthalmic segment and theorized that a rapid increase in aneurysm size allowed the aneurysm to push through the tightly bound fibers of the optic nerve

It is difficult to conclusively prove the exact mechanism of optic nerve penetration/splitting/schism in this and other rare cases. We do not favor sudden parting of the optic apparatus, because of either sudden aneurysmal expansion or a jet of blood, as a likely mechanism. Aneurysms do not generally

TABLE 1. Clinical and operative findings for previously published cases of optic nerve penetration by an aneurysm^a

Series (ref. no.)	Age (yr)/sex	Presentation	Radiological findings	Intraoperative findings
Beatty, 1986 (2)	66/F	Headache, dysphasia, and right arm clumsiness, without visual disturbances	CT: calcified mass (4-cm diameter) surrounded by edema and evidence of blood leakage along anterolateral margin; cerebral angiography: neck of aneurysm pointing directly upward	Giant left ICA-ophthalmic artery aneurysm splitting left optic nerve in equal portions for 5–7-mm length
Date et al., 1997 (3)	40/M	Abrupt right visual deterioration to finger-counting only and left homonymous hemianopsia	CT: suprasellar lesion thought to be AComA aneurysm; right ICA angiography: 7-mm AComA aneurysm projecting inferiorly	Aneurysm at junction of right A1 and A2 segments of ACA, protruding downward, penetrating right side of optic chiasm, and compressing right optic tract
Kanamaru et al., 2001 (7)	73/F	Loss of consciousness after SAH	CT: diffuse thick SAH; left ICA angiography: large aneurysm from anterior wall of ICA, with superior projection	Saccular aneurysm arising from anterior wall of left ICA, splitting and penetrating left optic nerve
Fujita et al., 2002 (5)	70/F	Progressive loss of visual acuity in left eye in several months	CT: no calcification or mass lesion in suprasellar region; MRI: flow void appearance in suprasellar area, with no evidence of associated thrombus; left ICA angiography: 5.5 × 9.5-mm aneurysm of ophthalmic segment, projecting superomedially	Complete penetration of optic chiasm by fundus of aneurysm, which had penetrated from posterior half of optic chiasm into posterior portion of left optic tract

^a CT, computed tomography; ICA, internal carotid artery; AComA, anterior communicating artery; SAH, subarachnoid hemorrhage; ACA, anterior cerebral artery; MRI, magnetic resonance imaging.

behave in such a manner. Even when they rupture into frank SAH, they are not thought to instantaneously enlarge. As a matter of fact, the prevailing opinion is that there is very little size change or possibly a decrease in overall volume at the time of rupture.

We therefore strongly favor the alternative explanation. The aneurysm in our case must have grown slowly with time, in a direction dictated by hemodynamic flow factors (such as shear stress and arterial curvatures) so that the vector of expansion was directed toward the part of the right optic nerve that eventually became the split. Whether that specific focus was also the embryological site of an arterial perforator that rendered the focus a "path of least resistance" or whether the configuration of the right optic nerve (length, thickness, and elevation) and chiasm (degree of pre- or postfixation), in relation to the aneurysmal dome, was such that the right optic nerve could not physically shift either medial or lateral to the expanding mass, cannot be determined. The absence of visual symptoms is not incompatible with chronic compensated optic nerve compression, as indicated by the many operative examples of grossly distorted optic nerves among patients with almost intact visual acuity.

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COMMENTS

The authors report a unique case in which preoperative magnetic resonance imaging studies clearly demonstrated penetration of the optic nerve by an irregular carotid-

ophthalmic aneurysm. I have seen a few cases in which such a phenomenon was discovered at operation but none in which the preoperative imaging studies clarified that unusual diagnosis. The discussion of potential pathophysiological mechanisms is complete and well thought out. On the basis of personal experience, it is important to remember that during surgical therapy for this condition, the previous damage and distortion to the optic nerve predispose to postoperative visual deterioration. It is key to aggressively unroof the optic canal to allow gentle mobilization and exposure of the proximal neck.

H. Hunt Batjer
Chicago, Illinois

The authors present a rare and interesting complication related to aneurysms of the origin of the ophthalmic artery. The clear delineation of the disruption of the optic nerve on magnetic resonance imaging is indeed the first demonstration of such a condition by imaging. We agree with the authors' assessment of the possible mechanisms of the splitting of the optic nerve. Each article in the literature has offered its own explanation, as the authors point out, but no conclusive argument has been made. In the absence of visual symptoms, one must favor slow growth and subsequent parting of the nerve fibers, as the authors propose, instead of rapid expansion of an unruptured aneurysm or shear force caused by subarachnoid hemorrhage. The authors' report is clear, appropriate, well organized, and with the magnetic resonance imaging, a complete description of a very rare entity.

Michael DiLuna
Murat Gunel
New Haven, Connecticut

Actual penetration of an aneurysm by the optic nerve is an extremely rare occurrence. In most cases, the nerve uniformly thins out as the large expanding mass of the aneurysm pushes on the undersurface of the nerve bundle. I have also seen one aneurysm that perforated through the optic nerve, splitting the fibers. I appreciate the authors' hypothesis as to why such an occurrence develops rather than the more common stretching of the nerve.

Robert A. Solomon
New York, New York

Jeon et al. have presented a most unusual and interesting case of an ophthalmic segment aneurysm piercing and penetrating the ipsilateral optic nerve. Of particular interest are the nice illustrations of the pathology and the preoperative depiction of the optic nerve violation on magnetic resonance imaging.

As discussed by the authors, the mechanism of this rare occurrence has been speculated on by others. I agree with the authors' conclusion that this most likely represents a gradual erosion through an optic nerve that is unable to be displaced

medially by the expanding aneurysm. We recently experienced a similar case in which an ophthalmic segment aneurysm had penetrated the optic nerve in a patient who had no previous evidence of subarachnoid hemorrhage, presenting only with ipsilateral visual loss. In addition, I have personally observed other cases in which an ophthalmic segment aneu-

rysm has markedly thinned the optic nerve without penetration rather than displacing the nerve medially, as is typical of an expanding ophthalmic segment aneurysm.

Daniel L. Barrow
Atlanta, Georgia



Equipment manager and head protection specialist Joseph Skiba develops individual customized helmet composites. An amalgam of proper design, fit, and maintenance is essential to optimize the protective capability of the helmet construct; however, this represents only one of many factors for establishing minimal opportunity for concussive injury. (Courtesy, Joseph Skiba and the New York Football Giants.)