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SHORT COMMUNICATION

Optic nerve compartment syndrome in a patient with optic nerve sheath meningioma

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PURPOSE. *To report a patient with optic nerve (ON) sheath meningioma, unilateral optic disc swelling, and inhomogeneous cerebrospinal fluid (CSF) composition between lumbar CSF and CSF from the subarachnoid space (SAS) of the affected ON.*
METHODS. *A 39-year-old woman presented with unilateral optic disc swelling and slight deterioration of visual function in the left eye. Extensive laboratory workup and magnetic resonance imaging (MRI) of the brain and orbits were performed. As radiotherapy was refused by the patient, ON sheath fenestration (ONSF) was offered and performed in order to stop deterioration. CSF from the SAS of the ON was sampled.*
RESULTS. *Laboratory workup was within normal limits. MRI of the left orbit demonstrated enhancement of the dura in the precanalicular portion of the ON and distension of the SAS, most prominent in the bulbar portion of the ON. On lumbar puncture the opening pressure measured 19 (cm H2O). Compared to the lumbar CSF the CSF of the affected ON SAS showed markedly elevated measurements for albumin, IgG, and beta-trace protein. Visual function remained stable over a follow-up time of 18 months.*
CONCLUSIONS. *Composition of CSF is considered to be homogenous throughout all CSF spaces. In this patient the authors found a marked concentration-gradient of albumin, IgG, and beta-trace protein between the CSF in the spinal canal and the CSF in the SAS of the affected ON. Based on the radiologic features of the left ON and the dissociated beta-trace protein concentrations in the CSF of the SAS of the ON and the lumbar CSF, the diagnosis of an ON sheath compartment syndrome due to an ON sheath meningioma was made. (Eur J Ophthalmol 2007; 17: 454-8)*

KEY WORDS. *Beta-trace protein, Cerebrospinal fluid, Optic nerve compartment syndrome, Lymphatic clefts, Optic disc swelling, Subarachnoid space*

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INTRODUCTION

Cerebrospinal fluid (CSF) is considered to communicate between all CSF compartments (1). CSF components are blood or brain derived (2). Beta-trace is the most abundant brain derived protein. It is identified as a prostaglandin D synthetase and is mainly produced by meningoepithelial cells (2, 3). Beta-trace protein shows a slightly higher concentration in the lumbar CSF compared to ventricular CSF in the normal population (2). Unilateral disc swelling is a common feature of ischemic and demyelinating optic neuropathy while disc

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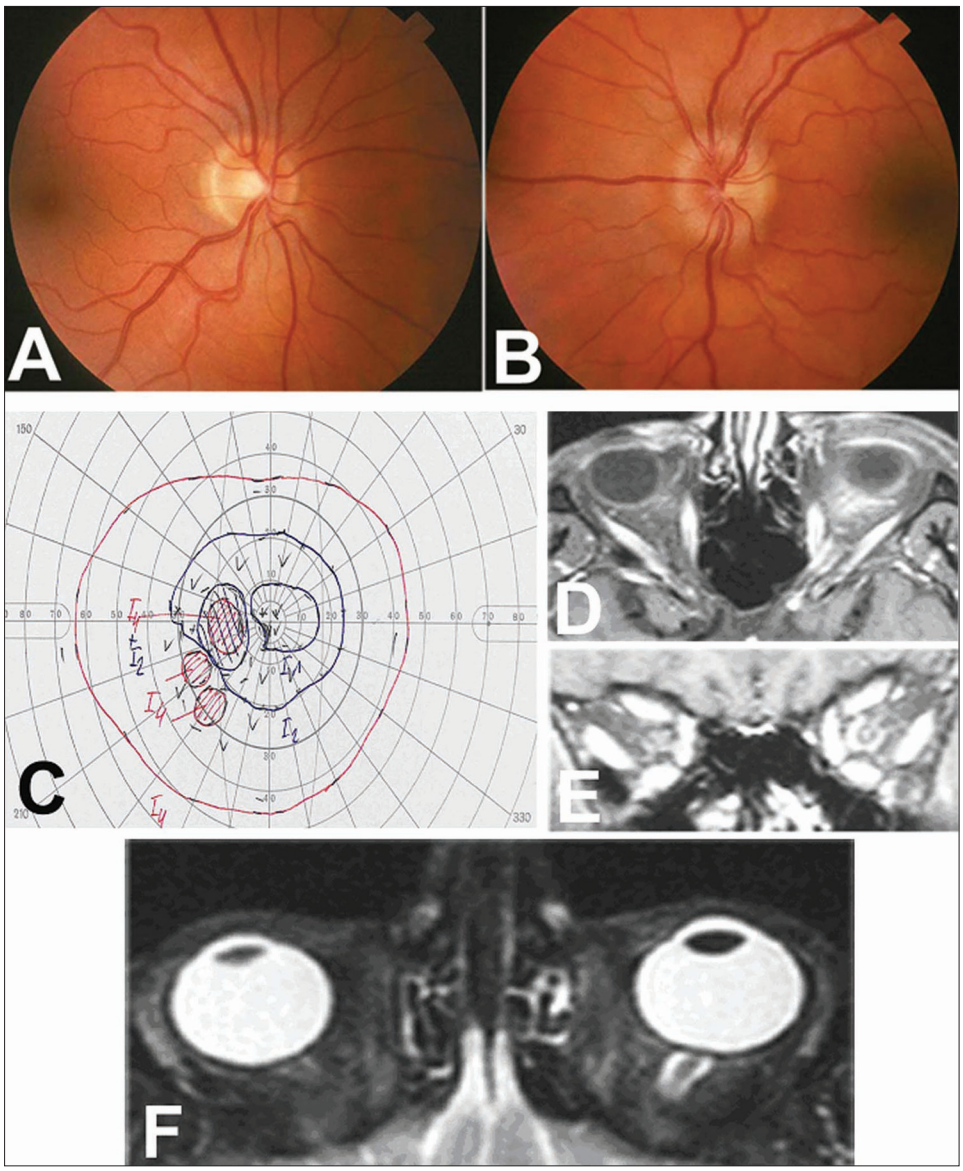

Fig. 1 - *Fundus photography with normal optic disc in the right eye* **(A)**, *swollen optic disc on the left* **(B)**. *Kinetic perimetry (Goldmann) left visual field demonstrating blind spot enlargement and two scotomas inferior to the blind spot* **(C)**. *Magnetic resonance imaging with axial gadolinium-enhanced T1-weighted image demonstrating hyperintense signal and dilated subarachnoid space in the retrobulbar portion of left optic nerve* **(D)** *and coronal gadolinium-enhanced T1-weighted image at the level of precanalicular portion shows increased signal intensity of left optic nerve sheath, conceiving optic nerve sheath meningioma* **(E)**. *Axial T2-weighted image shows dilated left optic nerve subarachnoid space with discrete protruding of optic disc into the posterior aspect of globe* **(F)**.

swelling due to raised intracranial pressure (papilledema) is symmetric in the majority of cases.
There are, however, reports about patients with unilateral or asymmetric optic disc swelling and raised intracranial pressure (papilledema) (4, 5). Magnetic resonance imaging (MRI) in such patients demonstrates dilation of the subarachnoid space (SAS) and flattening of the posterior sclera (6).

Case report

A 39-year-old woman presented with foggy vision in the left eye that was first noticed 4 months before admission. On examination visual acuity measured 20/15 in the right and 20/20 in the left eye. Anterior segment examination was normal in both eyes. Both pupils were of equal size. A relative afferent pupillary deficit (RAPD) was present in the left eye. On funduscopy the right disc was normal (Fig. 1A) while the left was swollen, displaying features of papilledema (Fig. 1B). Fifteen out of 15 Ishihara plates were identified with the right eye and 13 out of 15 with the left eye. The Goldmann visual field (kinetic perimetry) was normal on the right while the left visual field demonstrated enlargement of the blind spot and two scotomas inferior to the blind spot (Fig. 1C). Extensive

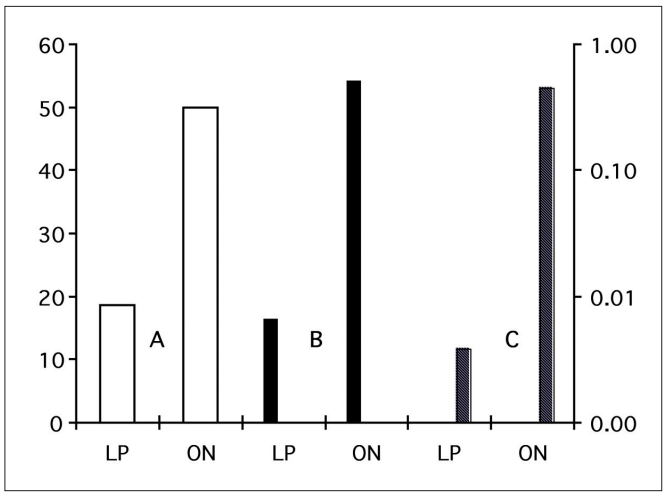

Fig. 2 - *Cerebrospinal fluid (CSF) analysis.* **(A)** *Beta trace (light bars) in mg/L. CSF/serum ratio of* **(B)** *albumin (dark bars) and of* **(C)** *IgG (hatched bars) logarithmic obtained by spinal tap (LP) and puncture of the subarachnoid space of the optic nerve (ON).*

laboratory studies including red and white blood count, sedimentation rate, serologies for infectious agents, and parameters for collagen vascular disorders were all within normal range. MRI of the brain and orbits demonstrated enhanced meninges on gadolinium in the precanalicular region of the left optic nerve (ON) and a markedly distended SAS most prominent in the bulbar portion behind the globe (Fig. 1, D–F). Based on the MRI findings the diagnosis of an ON sheath meningioma in the precanalicular region was made. Neurologic examination was found to be normal, including normal laboratory workup for CSF from the spinal canal (cell count, glucose and protein concentrations; beta-trace protein 18.6 [mg/L]). Opening pressure on lumbar puncture measured 19 (cm H_2O).

The morphologic feature of the left optic disc in funduscopy and the distended SAS in the retrobulbar portion of the ON on the orbital MRI suggested increased local CSF pressure due to regional stasis of CSF. Because of progressive foggy vision on the left, radiation therapy was offered to the patient, but was refused. One month later visual function deteriorated slightly on the left, in spite of the attempt of pharmacologic treatment with acetazolamide. In order to stop further deterioration of visual function (color vision) and to release the fluid volume and the possible volume depending pressure in the ON, optic nerve sheath fenestration (ONSF) was performed. CSF was locally collected after incision of the nerve sheath and analyzed. Albumin measured 20,800 mg/L (normal <350 mg/L), IgG measured 3430 mg/L (normal <34 mg/L), beta-trace measured 49.9 mg/L (lumbar beta-trace at the same day measured 18.6 mg/L) (Fig. 2).

Parameters for visual function (visual acuity, perimetry, color vision) remained stable after ONSF for 18 months follow-up.

DISCUSSION

Foggy vision in the left eye was the presenting symptom in a 39-year-old woman with unilateral optic disc swelling on funduscopy. Although the opening pressure on lumbar puncture was normal, the morphologic features of the left disc as well as the orbital MRI findings were compatible with the typical criteria of papilledema (6). In most patients with raised intracranial pressure optic disc swelling presents bilaterally (papilledema). Asymmetric and unilateral optic disc swelling in patients with or without raised intracranial pressure (papilledema), however, is described in the literature (4, 5, 7).

Various theories have been proposed to explain unilateral and asymmetric optic disc swelling in patients with raised intracranial pressure (papilledema), such as acquired and congenital abnormalities of the ON sheath, occlusion of the communication between the SAS of the ON and the intracranial cavity, as well as alteration of the microscopic anatomy of the trabecular network in the SAS of the ON (4, 8, 9). Cisternographic studies using a contrast agent demonstrated an impaired flow of contrast loaded CSF from the chiasmal cistern to the SAS of the ON in patients with idiopathic intracranial hypertension pointing to the concept of an ON compartment (10).

CSF enters the SAS of the ON via the chiasmal cistern. Due to the volume gradient of CSF pointing from intracranial toward the SAS of the ON it is difficult to understand how CSF would change direction of flow from this cul de sac compartment back to the site of absorption, i.e., the arachnoid villi (11). In addition to the arachnoid villi, lymphatic CSF absorption has recently been demonstrated in an animal model and lymphatics are now considered to play a major role in CSF absorption (12-17). The recent finding of lymphatic clefts in the dura of the optic nerve sheath fits

well into this concept of lymphatic CSF absorption (11).

The funduscopic aspect of the optic disc in our patient resembled strikingly the disc morphology in patients with unilateral papilledema. Unlike such patients, however, the etiology for disc swelling in our patient was not an elevated intracranial pressure but a morphologic alteration of the ON dura due to a meningioma leading to compartmentation of the SAS of the ON. The accumulation of CSF in the SAS of the ON displays features of a perioptic cyst (18). Whether the fluid accumulation occurs because of an impaired outflow of CSF via lymphatics or is produced by a local overproduction of CSF components with a high molecular weight and an osmotic activity is not clear.

The marked concentration gradient of the meningoepithelial cell derived beta-trace protein with its high end in the SAS of the ON suggests for the diagnosis of CSF space compartmentation, precisely an ON sheath compartmentation. The mechanism leading to the concentration gradient is not understood. In our patient a surplus production of local beta-trace protein by meningoepithelial cells would offer a possible hypothesis. The increase of albumin and IgG could be explained by disruption of the CSF-blood barrier or by the surgical procedure. Both mechanisms, however, do not explain the significant elevation of beta-trace protein (19). Marked differences in the concentration of beta-trace protein between the lumbar CSF and the CSF in the SAS in patients with ON disease have recently been reported (20). Based on this case study we conclude that the development to an ON compartment syndrome could be one of many reasons for visual function deterioration in patients with ON sheath meningioma.

We are aware that ONSF is not a standard procedure for patients with ON sheath meningioma and disc swelling. The rational for ONSF in this patient who refused radiation therapy, however, was to release CSF volume and probably volume depending pressure from the local SAS in order to prevent further deterioration of the visual function. The marked dilation of the retrobulbar portion of the SAS of the left ON in the orbital MRI was highly suggestive for impaired communication of the CSF between the chiasmal cistern and the SAS of the ON in such a way that volume built up locally. The disc swelling that strongly resembled papilledema could therefore partly be explained by impaired axoplasmic flow. Releasing volume and probably pressure might have resulted in improved axoplasmic flow and clearance of local CSF since stagnation of CSF is considered to be a pathophysiologic factor in neurodegenerative disease (21, 22).

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REFERENCES

1. Dichiro G. Movement of the cerebrospinal fluid in human beings. Nature 1964; 204: 290-1.
2. Reiber H. Dynamics of brain-derived proteins in cerebrospinal fluid. Clin Chim Acta 2001; 310: 173-86.
3. Hoffmann A, Conradt HS, Gross G, Nimtz M, Lottspeich F, Wurster U. Purification and chemical characterization of beta-trace protein from human cerebrospinal fluid: its identification as prostaglandin D synthase. J Neurochem 1993; 61: 451-6.
4. Sedwick LA, Burde RM. Unilateral asymmetric optic disc swelling with intracranial abnormalities. Am J Ophthalmol 1983; 96: 484-7.
5. Killer HE, Flammer J. Unilateral papilledema in a patient with a fronto-parieto-occipital arachnoid cyst. Am J Ophthalmol 2001; 132: 589-91.
6. Brodsky M, Vaphiades M. Magnetic resonance imaging in pseudotumor cerebri. Ophthalmology 1998; 105: 1686-93.
7. Killer HE, Mironov A, Flammer J. Optic neuritis with marked distension of the optic nerve sheath due to fluid congestion. Br J Ophthalmol 2003; 87: 249.
8. Huna-Baron R, Landau K, Rosenberg M, Warren FA,

Kupersmith MJ. Unilateral swollen disc due to increased intracranial pressure. Neurology 2001; 56: 1588-90.
9. Killer HE, Laeng HR, Flammer J, Groscurth P. The arachnoid trabeculae and septae in the subarachnoid space of the human optic nerve: anatomy and clinical considerations. Br J Ophthalmol 2003; 87: 777-81.
10. Killer HE, Jaggi GP, Flammer J, Miller NR, Huber AR, Mironov A. Cerebrospinal fluid dynamics between the intracranial and the subarachnoid space of the optic nerve. Is it always bidirectional? Brain 2007; 130: 514-20.
11. Killer HE, Laeng HR, Groscurth P. Lymphatic capillaries in the meninges of the human optic nerve. J Neuro-Ophthalmol 1999; 19: 222-8.
12. Boulton M, Flessner M, Armstrong D, Hay J, Johnston M. Determination of volumetric cerebrospinal fluid absorption into extracranial lymphatics in sheep. Am J Physiol 1998; 274: 88-96.
13. Boulton M, Flessner M, Armstrong D, Mohamed R, Hay J, Johnston M. Contribution of extracranial lymphatics and arachnoid villi to the clearance of a CSF tracer in the rat. Am J Physiol 1999; 276: 818-23.
14. Johnston M. The importance of lymphatics in cerebrospinal fluid transport. Lymphat Res Biol 2003; 1: 41-4.
15. Boulton M, Armstrong D, Flessner M, Hay J, Szalai JP, Johnston M. Raised intracranial pressure increases CSF drainage through arachnoid villi and extracranial lymphatics. Am J Physiol 1998; 275: 889-96.
16. Bozanovic-Sosic R, Mollanji R, Johnston MG. Spinal and cranial contributions to total cerebrospinal fluid transport. Am J Physiol 2001; 281: 909-16.
17. Johnston M, Papaiconomou C. Cerebrospinal fluid transport: a lymphatic perspective. News Physiol Sci 2002; 17: 227-30.
18. Lindblom B, Norman D, Hoyt WF. Perioptic cyst distal to optic nerve meningioma: MR demonstration. Am J Neuroradiol 1992; 13: 1622-4.
19. Risch L, Lisec I, Jutzi M, Podvinec M, Landolt H, Huber AR. Rapid, accurate and non-invasive detection of cerebrospinal fluid leakage using combined determination of beta-trace protein in secretion and serum. Clin Chim Acta 2005; 351: 169-76.
20. Killer HE, Jaggi GP, Flammer J, Miller NR, Huber AR. The optic nerve: a new window into cerebrospinal fluid composition? Brain 2006; 29: 1027-30.
21. Rubenstein E. Relationship of senescence of cerebrospinal fluid circulatory system to dementias of the aged. Lancet 1998; 351: 283-85.
22. Silverberg GD, Mayo M, Saul T, Rubenstein E, McGuire D. Alzheimer's disease, normal-pressure hydrocephalus, and senescent changes in CSF circulatory physiology: a hypothesis. Lancet Neurol 2003; 2: 506-11.