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ORIGINAL ARTICLE

Neuro-Ophthalmologic MRI Findings in the Detection of Rhinorrhoea Aetiology

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ABSTRACT

The purpose of this study is to evaluate the importance of neuro-ophthalmological magnetic resonance imaging (MRI) findings in the identification of the aetiology of rhinorrhoea, and the differentiation of spontaneous rhinorrhoea from non-spontaneous rhinorrhoea.

MR images of 25 patients with spontaneous and 21 patients with non-spontaneous rhinorrhoea were evaluated for the presence of neuro-ophthalmological findings of intracranial hypertension (IHT). These include optic nerve vertical tortuosity, optic nerve sheath enlargement, flattening of the posterior sclera and optic nerve protrusion, as well as other MRI findings of ICH, such as partial empty sella, dilatation of Meckel's cave and the presence of arachnoid pits.

IHT findings were more common in the spontaneous group. Six criteria (optic nerve distention, optic nerve vertical tortuosity, posterior flattening of the sclera, partial empty sella, Meckel's cave dilatation and presence of arachnoid pits) differentiate between patient and control groups.

Patients with spontaneous cerebrospinal fluid (CSF) leaks should be evaluated for signs of IHT on MRI, as they are present in the majority of spontaneous CSF leaks and are representative of increased intracranial pressure.

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Intracranial hypertension; optic nerve distention; optic nerve vertical tortuosity; posterior flattening of the sclera; partial empty sella; rhinorrhoea

Introduction

Leakage of the cerebrospinal fluid (CSF) without trauma, tumour or iatrogenic causes is known as spontaneous rhinorrhoea. With the widespread use of the B2 transferrin test, which has a high diagnostic efficiency in detecting CSF leakage (sensitivity: 93% and specificity: 100%, respectively), spontaneous BOS leakage has become more easily detectable.[1] It is estimated that spontaneous rhinorrhoea constitutes 14–46% of all rhinorrhoea.[2]

The majority of spontaneous rhinorrhoea cases are thought to be secondary to intracranial hypertension (IHT).[3–5] Prolonged pulsatile pressure applied to cranium causes erosion and leads to CSF leaks in areas that are structurally weak.[6] Recognition of IHT in the preoperative period affects treatment and long-term results of the surgery.[6] Optic nerve vertical tortuosity, optic nerve sheath enlargement, flattening of the posterior sclera, and optic nerve protrusion are common neuro-ophthalmological magnetic resonance imaging (MRI) findings of IHT.[7] The purpose of this study is to evaluate the importance of neuro-ophthalmological MRI findings in the identification of the aetiology of rhinorrhoea, and the differentiation of spontaneous rhinorrhoea from non-spontaneous rhinorrhoea.

Materials and methods

This retrospective study is a case series of patients with CSF leaks treated at a single institution from 2011 to 2017. Institutional review board approval was obtained before initiation of this study.

The study included 24 spontaneous and 20 non-spontaneous rhinorrhoea patients proven with surgery, and one spontaneous and one non-spontaneous rhinorrhoea patient who did not undergo surgery but were positive for β2 transferrin. All had radiologically shown CSF leakage.

Electronic medical records were reviewed to obtain the following patient data: age, sex and clinical presentation.

All MRI examinations were acquired with a 3T MRI scanner (Siemens Verio, Siemens Medical Solutions, Erlangen, Germany) using a standard head coil with T2-weighted imaging in the coronal plane, three-dimensional (3D) constructive

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interference in steady state (3D-CISS) in the sagittal plane, and two-dimensional sampling perfection with application-optimised contrasts using different flip-angle evolution (2D-SPACE) in the sagittal plane. MR images were retrospectively interpreted by three radiologists (EP, DK, MK) with 13 years, 8 years and 7 years of experience, respectively, in consensus, who were blinded to the β2 transferrin results and operative findings regarding the existence and location of the CSF leak. Brain parenchyma or meningeal herniation through a bone defect was also noted and considered a sign of CSF leakage (Figure 1).

All MR images were evaluated for the presence of neuro-ophthalmological findings of ICH. These include optic nerve vertical tortuosity, optic nerve sheath enlargement, flattening of the posterior sclera, and optic nerve protrusion as well as other MRI findings of ICH, such as partial empty sella, dilatation of Meckel's cave and the presence of arachnoid pits.

Partial empty sella was diagnosed when the presence of CSF in the pituitary fossa exceeded >50% (Figures 2 and 3).[8–11] Posterior flattening of the globe was defined as the flattening of normal convexity at the origin of the optic nerve.[12,13] Optic nerve protrusion was diagnosed when the convexity at the point of entry into globe is lost.[14,15] The presence of an 'S' shaped optic nerve in sagittal images was defined as optic nerve tortuosity (Figure 4).[8] The presence of a CSF distance of >2 mm around the optic nerve was diagnosed as optic nerve distention (Figures 5 and 6).[8]

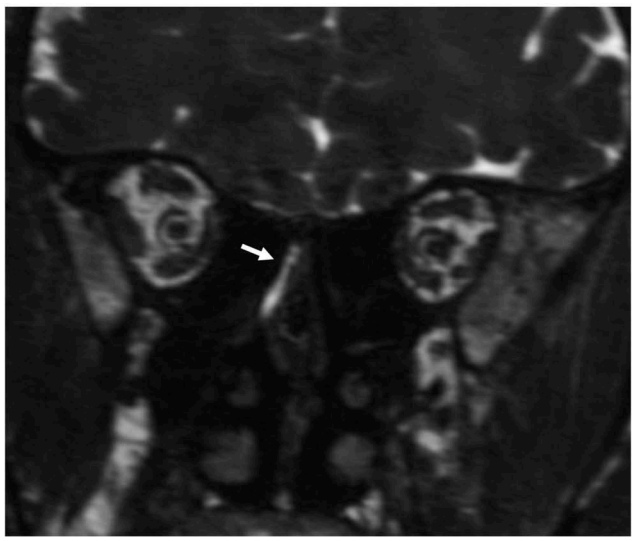

Figure 1. CSF leakage at the right cribriform plate on coronal CISS image.

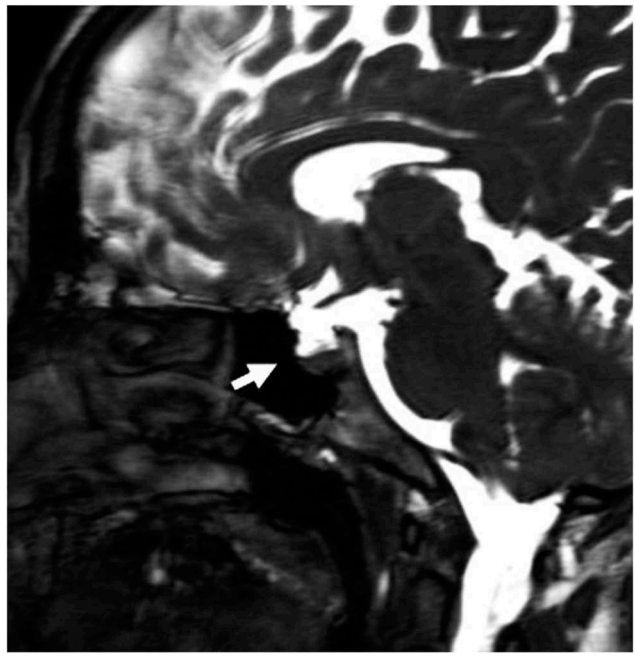

Figure 2. Patient with non-spontaneous CSF leakage. Sagittal T2 weighted image shows normal sized pituitary gland (arrow).

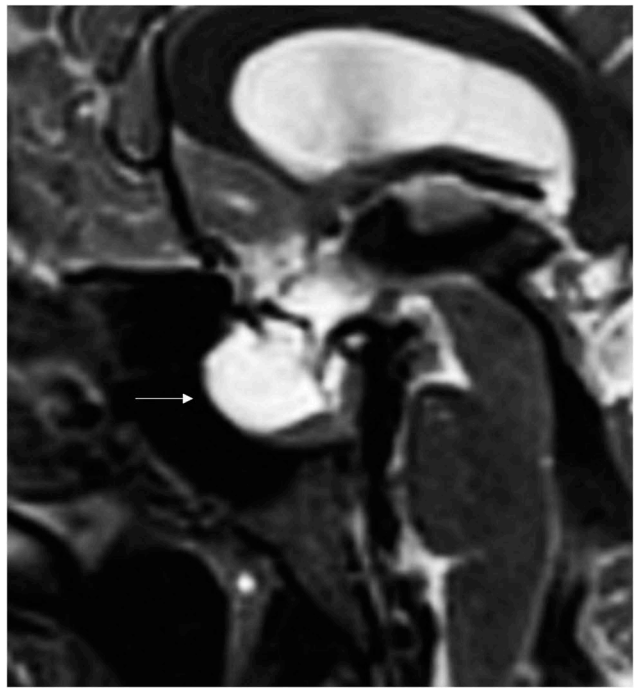

Figure 3. Patient with spontaneous CSF leakage. Partial empty sella on sagittal T2 weighted image (arrow).

The imaging findings were confirmed with a β2 transferrin test and surgical findings.

Frequency (percent) for categorical variables and mean ± standard deviation [median (minimum–maximum)] for metric variables are

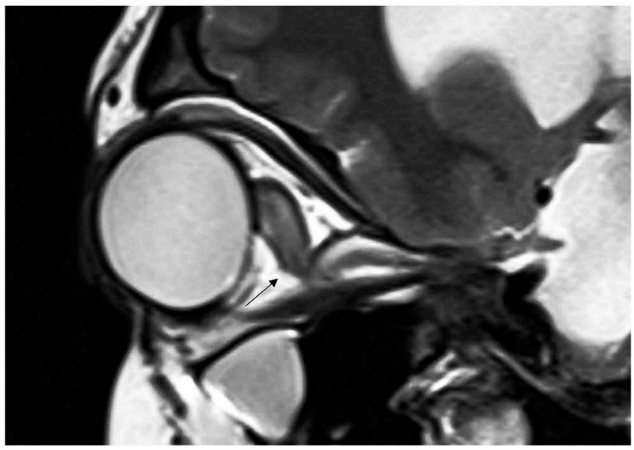

Figure 4. Vertical tortuosity of the optic nerve on sagittal T2 weighted image.

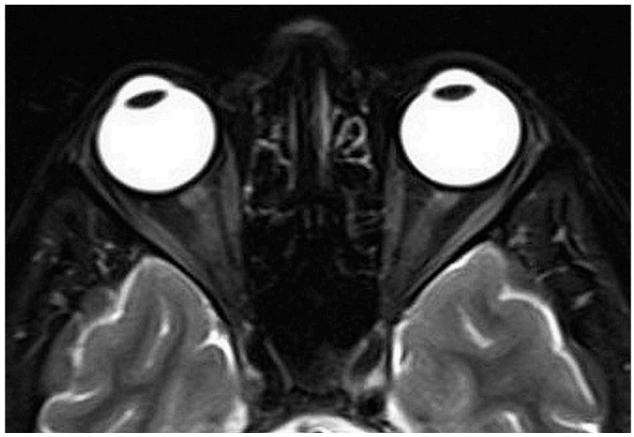

Figure 5. Patient with non-spontaneous CSF leakage. Axial T2 weighted image shows no distention of the optic nerve sheaths.

given as descriptive statistics. While the Mann–Whitney *U* test was used to compare the two independent groups in terms of metric variables, a chi-square test was performed to compare the two independent groups in terms of categorical variables. The area under the ROC curve (AUC) gives an estimate of the overall accuracy of each finding. AUC of 0.50 implies that the variable adds no information. In order to define risk factors of outcome variables (being in the spontaneous CSF leakage group) multivariable logistic regression analysis was used. $p < 0.05$ was accepted as statistically significant.

Results

The study included 25 patients with spontaneous rhinorrhoea and 21 patients with non-spontaneous rhinorrhoea. Non-spontaneous group consisted of

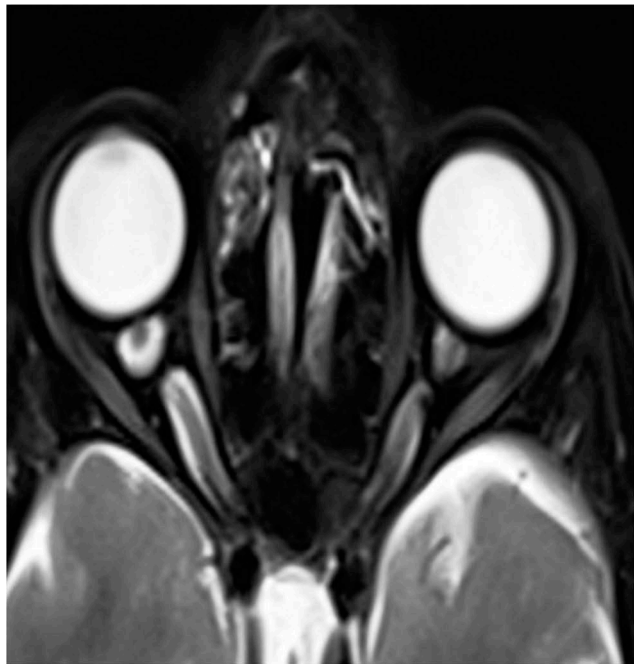

Figure 6. Patient with spontaneous CSF leakage. Distension of the optic nerve sheath on axial T2 weighted image.

one patient with tumour in the cavernous sinus, 16 patients with a history of trauma, four patients with a history of previous surgery.

Average age of presentation was 46 ± 11 years (23–68 years) for the spontaneous group, and 41 ± 11 years (21–63 years) for the non-spontaneous group. The difference was not statistically significant ($p = 0.111$).

Of the spontaneous group 72% ($n = 18$) and 28% ($n = 7$) of the non-spontaneous group were female. This difference was statistically significant ($p = 0.003$).

No headache was found in any patient in the non-spontaneous group, and headache was observed in 20% of the group with spontaneous CSF leakage.

For the spontaneous group the most common defect was lateral sphenoid sinus ($n = 10$, 41.6%), followed by cribriform plate (olfactory bulb) ($n = 10$, 41.6%), ethmoid roof ($n = 6$, 25%), frontal sinus ($n = 3$, 12.5%), central sphenoid sinus ($n = 1$, 4.1%), sella ($n = 1$, 4.1%), and nasal cavity ($n = 1$, 4.1%). Multiple defects were observed in seven patients (Table 1).

IHT findings were more common in the spontaneous group (median: 4 vs. 0). Optic nerve sheath distention, optic nerve tortuosity, optic nerve protrusion, partial empty sella, Meckel's cave dilatation and the presence of arachnoid pits

Table 1. Distribution of leak localisations in spontaneous and non-spontaneous CSF leaks.

	Spontaneous % (*n*)	Non-spontaneous % (*n*)
Lateral sphenoid sinus	41.6 (10)	0
Cribriform plate	41.6 (10)	10 (2)
Ethmoid roof	25 (6)	30 (6)
Frontal sinus	12.5 (3)	25 (5)
Central sphenoid sinus	4.1 (1)	10 (2)
Sella	4.1 (1)	15 (3)
Nasal cavity	4.1 (1)	5 (1)
Cavernous sinus	0	5 (1)

were more frequent in the spontaneous group than non-spontaneous CSF leakage group ($p < 0.05$). Optic nerve protrusion was seen in only one patient with spontaneous CSF leakage (Table 2).

Six criteria (optic nerve distention, optic nerve vertical tortuosity, posterior flattening of the sclera, partial empty sella, Meckel's cave dilatation and presence of arachnoid pits) differentiate between patient and control groups (AUC: 0.789, $p = 0.001$; AUC: 0.740, $p = 0.005$; AUC: 0.700, $p = 0.021$; AUC: 0.741, $p = 0.005$; AUC: 0.700, $p = 0.021$; and AUC: 0.832, $p = 0.000$, consecutively). Optic nerve protrusion was not discriminative between the two groups (AUC: 0.520, $p = 0.817$). Optic nerve sheath distention yielded the highest AUC (0.789) among the neuro-ophthalmologic findings and the presence of arachnoid pits showed the highest AUC (0.832) among all findings (Table 3). Eighteen patients had partial empty sella (sensitivity: 72%; specificity: 76%); 18 patients had optic nerve sheath distention (sensitivity: 72%; specificity: 85%); 12 patients had vertical tortuosity of the optic nerve (sensitivity: 48%; specificity: 100%); 10 patients had posterior flattening of the globe (sensitivity: 40%; specificity: 100%); 10 patients had Meckel's cave dilatation (sensitivity: 40%; specificity: 100%); and 19 patients had arachnoid pits (Figure 7) (sensitivity: 76%; specificity: 90%) (Table 3).

Spontaneous CSF leakage can be distinguished from non-spontaneous CSF leakage with an accuracy of 84.7% (95% CI: 71.1–93.6) if two or more of the IHT findings are positive. The accuracy rate increases to 86.9% (95% CI: 71.1–93.6) when partial empty sella is not included (Table 4).When the partial empty sella is excluded, 100% of the cases with two or more positive IHT findings were in the spontaneous group. 77% of the non-spontaneous group had less than two findings.

The logistic regression analysis showed that distention of the optic nerve sheath ($p = 0.014$, Exp(B): 9,358, 95% CI: 1,579–55,470) and arachnoid pit presence ($p = 0.002$, Exp(B) CI: 3,118–129,543) was significant. The model with partial empty sella was not significantly distinctive ($p = 0.288$).

Limitations

Our study has some limitations. First, this was a retrospective study with a relatively small sample size. Second, no lumber pressure data was available for the patients included in the study. The major

Table 2. The frequency of intracranial hypertension findings in spontaneous and non-spontaneous CSF leaks.

	Spontaneous $n = 24$	Non-Spontaneous $n = 21$	Significance ($p =$)
Optic nerve sheath distention	18 (72%)	3 (14.3%)	0.001
Optic nerve vertical tortuosity	12 (48%)	0	0.000
Optic nerve protrusion	1 (4%)	0	1.000
Flattening of the posterior sclera	10 (40%)	0	0.001
Partial empty sella, *n* (%)	18 (72%)	5 (23.8%)	0.005
Meckel's cave dilatation	10 (40%)	0	0.001
Presence of arachnoid pit	19 (76%)	2 (9.5%)	0.000
Median number of positive findings	4 (0–6)	0 (0–2)	

Table 3. Diagnostic value of MRI parameters.

	True positive	True negative	False positive	False negative	AUC (95%CI) [p =]	Sensitivity (95%CI)	Specificity (95%CI)
Optic nerve sheath distention	18/25	18/21	3/21	7/25	0.789 (0.652–0.925) [0.000]	72% (0.52–0.85)	85% (0.65–0.95)
Optic nerve vertical tortuosity	12/25	21/21	0/21	13/25	0.740 (0.596–0.884) [0.005]	48% (0.30–0.66)	100% (0.84–1.00)
Optic nerve protrusion	1/25	21/21	0/21	24/25	0.520 (0.351–0.689) [0.817]	4% (0.007–0.145)	100% (0.84–1.00)
Flattening of the posterior sclera	10/25	21/21	0/21	15/25	0.700 (0.549–0.851) [0.021]	40% (0.23–0.59)	100% (0.84–1.00)
Partial empty sella, *n* (%)	18/25	16/21	5/21	7/25	0.741 (0.593–0.889) [0.001]	72% (0.52–0.85)	76% (0.54–0.89)
Meckel's cave dilatation	10/25	21/21	0/21	15/25	0.700 (0.549–0.851) [0.021]	40% (0.23–0.59)	100% (0.84–1.00)
Presence of arachnoid pit	19/25	19/21	2/21	6/25	0.832 (0.709–0.957) [0.000]	76% (0.56–0.88)	90% (0.71–0.97)

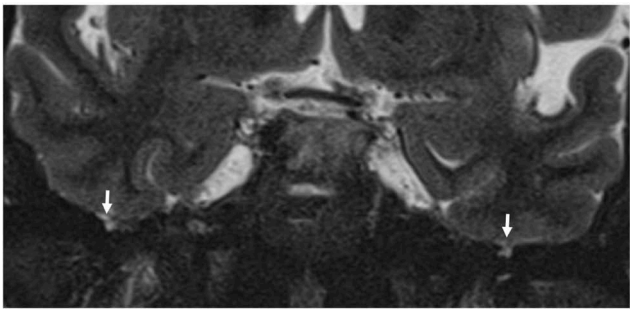

Figure 7. Bilateral arachnoid pits at the temporal region on coronal T2 weighted image.

limitation of this study is the absence of neurological evaluation including optic disc examination. Despite retrospective design of the study, it may still be possible to reach the neurological evaluation of the patients because of rhinorrhoea. The patients were operated in the early period and they were directed for neurological examination after the operation. As a result, neurological examination results were not obtained preoperatively.

Discussion

The association of spontaneous CSF leakage with IHT is well known[6] and have similar clinical presentations. As in our research, both IHT and spontaneous CSF leakage has been reported mainly in female patients.[3,6,16,17]

Leakage of CSF reduces CSF pressure by serving as an alternative drainage route for patients with IHT.[18] Symptoms may recur due to elimination of this alternative drainage pathway after surgical treatment.[19] For this reason, treatment to decrease CSF pressure should be performed before surgery in these patients. Recurrence has been reported in cases where IHT therapy cannot be performed effectively.[6] Determining the aetiology of CSF leakage and recognising these findings as related to IHT before surgery has a critical importance for appropriate treatment and reducing recurrence rates.

IHT is significantly associated with distention of the optic nerve sheath, optic nerve protrusion vertical tortuosity of the optic nerve, posterior flattening of the globe, partial empty sella, dilatation of Meckel's cave and the presence of arachnoid pits.[8,20–22] Evaluation of MRI findings of IHT in patients with rhinorrhoea is important for appropriate treatment. This study is focused on determining the diagnostic value of the presence of neuro-ophthalmologic IHT findings in patients with spontaneous CSF leakage and to differentiate between spontaneous and non-spontaneous CSF leakage. Our study has shown that optic nerve sheath distention, optic nerve tortuosity, partial empty sella, Meckel's cave dilatation and the presence of arachnoid pits are significantly more common in the spontaneous CSF leakage group than the non-spontaneous group. Spontaneous CSF leakage can be distinguished from non-spontaneous CSF leakage with high accuracy if two or more of the IHT findings are positive. Diagnostic efficiency is increased when partial empty sella is not included.

Because of increased CSF pressure after prolonged IHT, CSF leaks can be observed in sites that are structurally weak, such as the lateral wall of the excessive pneumatised sphenoid sinus, or adjacent to natural perforations such as the cribriform plate.[6,18] Similar to other literature, in our study spontaneous CSF leaks were most commonly seen in these regions.[3,6] In the non-spontaneous group, the leakage location varies according to the trauma, previous surgery or tumour site.

In conclusion, patients with spontaneous CSF leaks should be evaluated for signs of IHT on MRI, as they are present in the majority of spontaneous CSF leaks and are representative of increased intracranial pressure.

Disclosure statement

No potential conflict of interest was reported by the authors.

Table 4. Diagnostic efficacy in terms of detection of spontaneous CSF leakage in the presence of 2 or more intracranial hypertension.

	True positive	True negative	False positive	False negative	Sensitivity [95%CI]	Specificity [95%CI]	Positive predictive value [95%CI]	Negative predictive value [95%CI]	AUC [95%CI]	Accuracy [95%CI]
>1 findings positive	20	19	2	5	80% (20/25) [59.3–93.7]	90.4% (19/21) [69.6–98.8]	90.9% (20/22) [72.5–97.4]	79.1% (19/24) [63.1–89.3]	0.912 [0.826–0.999]	84.7% (39/46) [71.1–93.6]
>1 findings positive (except partial empty sella)	19	21	0	6	76% (19/25) [54.8–90.6]	100% (21/21) [83.8–100]	100% (19/19)	77.7% (21/27) [63.5–87.5]		86.9% (40/46) [73.7–95.6]

References

1. 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;351:169–176. doi:10.1016/j.cccn.2004.09.008.
2. Soler ZM, Schlosser RJ. Spontaneous cerebrospinal fluid leak and management of intracranial pressure. *Adv Otorhinolaryngol*. 2013;74:92:103.
3. Stevens SM, Rizk HG, Golnik K, Andaluz N, Samy RN, Meyer TA, Lambert PR. Idiopathic intracranial hypertension: contemporary review and implications for the otolarygologist. *Laryngoscope*. 2018;128:248–256.
4. Schlosser RJ, Wilensky EM, Grady MS, Bolger WE. Elevated intracranial pressures in spontaneous cerebrospinal fluid leaks. *Am J Rhinol*. 2003;17:191–195. doi:10.1177/194589240301700403.
5. Schlosser RJ, Woodworth BA, Wilensky EM, Grady MS, Bolger WE. Spontaneous cerebrospinal fluid leaks: a variant of benign intracranial hypertension. *Ann Otol Rhinol Laryngol*. 2006;115:495–500. doi:10.1177/000348940611500703.
6. Woodworth BA, Prince A, Chiu AG, Cohen NA, Schlosser RJ, Bolger WE, Kennedy DW, Palmer JN. Spontaneous CSF leaks: a paradigm for definitive repair and management of intracranial hypertension. *Otolaryngol Head Neck Surg*. 2008;138:715–720.
7. Ridha MA, Saindane A, Bruce BB, Riggeal BD, Kelly LP, Newman NJ, Biousse V. Magnetic resonance imaging findings of elevated intracranial pressure in cerebral venous thrombosis versus idiopathic intracranial hypertension with transverse sinus stenosis. *Neuroophthalmology*. 2013;37:1–6. doi:10.3109/01658107.2012.738759.
8. Brodsky MC, Vaphiades M. Magnetic resonance imaging in pseudotumor cerebri. *Ophthalmology*. 1998;105:1686–1693. doi:10.1016/S0161-6420(98)99039-X.
9. George AE. Idiopathic intracranial hypertension: pathogenesis and the role of MR imaging. *Radiology*. 1989;170:21–22. doi:10.1148/radiology.170.1.2909099.
10. Jacobson HG, Shapiro JH. Pseudotumor cerebri. *Radiology*. 1964;82:202–210. doi:10.1148/82.2.202.
11. Silbergleit R, Junck L, Gebarski SS, Hatfield MK. Idiopathic intracranial hypertension (pseudotumor cerebri): MR imaging. *Radiology*. 1989;170:207–209. doi:10.1148/radiology.170.1.2909098.
12. Agid R, Farb RI, Willinsky RA, Mikulis DJ, Tomlinson G. Idiopathic intracranial hypertension: the validity of cross-sectional neuroimaging signs. *Neuroradiology*. 2006;48:521–527. doi:10.1007/s00234-006-0095-y.
13. Brodsky MC. Flattening of the posterior sclera: hypotony or elevated intracranial pressure? *Am J Ophthalmol*. 2004;138:511–512. doi:10.1016/j.ajo.2004.05.020.
14. Gass A, Barker GJ, Riordan-Eva P, MacManus D, Sanders M, Tofts PS, McDonald WI, Moseley IF, Miller DH. MRI of the optic nerve in benign intracranial hypertension. *Neuroradiology*. 1996;38:769–773. doi:10.1007/s002340050344.
15. Jinkins JR, Athale S, Xiong L, Yuh WT, Rothman MI, Nquyen PT. MR of optic papilla protrusion in patients with high intracranial pressure. *AJNR Am J Neuroradiol*. 1996;17:665–668.
16. Wall M. Idiopathic intracranial hypertension (pseudotumor cerebri). *Curr Neurol Neurosci Rep*. 2008;8:87–93. doi:10.1007/s11910-008-0015-0.
17. Teachey W, Grayson J, Cho DY, Riley KO, Woodworth BA. Intervention of elevated intracranial pressure improves success rate after repair of spontaneous cerebrospinal fluid leaks. *Laryngoscope*. 2017;127:2011–2016. doi:10.1002/lary.26612.
18. Schuman TA, Senior BA. Long-term management and outcomes after repair of cerebrospinal fluid rhinorrhea related to idiopathic intracranial hypertension. *Curr Opin Otolaryngol Head Neck Surg*. 2018;26:46–51.
19. Perez MA, Bialer OY, Bruce BB, Newman NJ, Biousse V. Primary spontaneous cerebrospinal fluid leaks and idiopathic intracranial hypertension. *J Neuro-Ophthalmol*. 2013;33:330–337. doi:10.1097/WNO.0b013e318299c292.
20. Agid R, Farb RI. Neuroimaging in the diagnosis of idiopathic intracranial hypertension. *Minerva Med*. 2006;97:365–370.
21. Maralani PJ, Hassanlou M, Torres C, Chakraborty S, Kingstone M, Patel V, Zackon D, Bussiere M. Accuracy of brain imaging in the diagnosis of idiopathic intracranial hypertension. *Clin Radiol*. 2012;67:656–663. doi:10.1016/j.crad.2011.12.002.
22. Hansen HC, Helmke K, Kunze K. Optic nerve sheath enlargement in acute intracranial hypertension. *Neuroophthalmology*. 1994;6:345–354. doi:10.3109/01658109409024061.