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ORIGINAL ARTICLE **CME**

Magnetic Resonance Imaging Measurements of Optic Sheath to Optic Nerve Diameter Ratio for the Diagnosis of Idiopathic Intracranial Hypertension

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ABSTRACT

Objective: *To evaluate the usefulness of optic sheath–optic nerve diameter ratio for the diagnosis of idiopathic intracranial hypertension.*

Methods: *This study included 45 patients with idiopathic intracranial hypertension and 19 healthy volunteers as a control population. Magnetic resonance imaging of the orbits was performed in a 1.5T magnetic resonance imaging system using a standard non-enhanced magnetic resonance imaging orbital protocol, including 3-mm axial, sagittal, and coronal T1- and T2-weighted images, with and without fat-saturation using a conventional coil. The optic sheath and optic nerve diameters were measured using the outer diameter of the subarachnoid space and nerve at the point of maximum optic sheath distension. Correlation with the respective lumbar puncture opening pressure was made for the patient population.*

Results: *Among the control group, 88.6% had optic sheath–optic nerve diameter ratios of <2:1 and 11.4% had optic sheath–optic nerve ratios ≥2.5:1. All patients with idiopathic intracranial hypertension had optic sheath–optic nerve ratios ≥2.5:1.*

Conclusions: *Optic sheath–optic nerve diameter ratio is useful for the diagnosis of idiopathic intracranial hypertension. Ratios ≥2.5:1 have a high correlation with increased intracranial pressure.*

Key Words: *Magnetic resonance imaging; Optic nerve; Pseudotumor cerebri*

中文摘要

磁共振成像測量視神經鞘直徑與視神經直徑比值應用於診斷原發性顱內高壓

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目的：探討視神經鞘直徑與視神經直徑比值在診斷原發性顱內高壓的價值。

方法：研究納入45例原發性顱內高壓患者，以及19例健康志願者作為對照組。所有研究對象均在1.5T核磁掃描儀上行標准眼眶序列檢查；包括T1加權和T2加權成像，均含軸位，矢狀位及冠狀位；序列檢查含脂肪抑制及無脂肪抑制技術；所有檢查均使用普通線圈，均未注射造影劑。在神經鞘直徑最大處分別測量視神經鞘外蛛網膜下腔的直徑和視神經直徑。對每個研究對象的視神經鞘與視神經直徑比值和腰穿測得的壓力進行相關性分析。

結果：在對照組，88.6%的研究對象視神經鞘與視神經直徑比值為2:1或更小，11.4%研究對象比值大

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於2.5:1。所有原發性顱內高壓患者此比值均大於或等於2.5:1。
結論：視神經鞘與視神經直徑比值在診斷原發性顱內高壓方面有應用價值。該值大於或等於2.5:1與的顱內壓增高程度具有較高的相關性。

INTRODUCTION

Idiopathic intracranial hypertension (IIH), also known as pseudotumour cerebri, is a disorder of elevated intracranial pressure of unknown cause. Patients present with headache, pulse-synchronous tinnitus, transient visual obscurations, papilloedema with associated visual loss, and diplopia from sixth nerve paresis. Clinical diagnosis of IIH is based on clinical and biochemical criteria known as the modified Dandy criteria (Table 1).[1,2] Possible contributing causes of IIH should be identified and excluded. The clinical diagnosis is usually made by neurological examination and cross-sectional imaging of the brain to exclude any possible causes of intracranial hypertension. Biochemical analysis of the cerebrospinal fluid (CSF) obtained via lumbar puncture should be normal in all patients with IIH.[2]

The aim of this study was to evaluate the usefulness of optic sheath–optic nerve (OS-ON) diameter ratio for the diagnosis of IIH and to reduce the need for lumbar puncture as a diagnostic tool.

METHODS

This study included 45 patients (29 women and 16 men) with IIH and 19 age-matched healthy volunteers (10 women and 9 men) to act as a control population. The mean age of the patient population was 32 years and that of the controls was 29.5 years . Modified Dandy criteria for IIH (Table 1) were satisfied for all patients. All patients had headaches and visual disturbances. Fundoscopy was performed for all patients, and the presence of papilloedema was documented but not graded. No evidence of any other neurological derangement was detected. Lateral decubitus lumbar puncture opening pressure was elevated in all patients, with a mean pressure of 360 mm CSF (range, 250-530 mm CSF). The CSF chemistry was normal for all patients. All patients underwent magnetic resonance imaging (MRI) of the head and the orbits prior to the lumbar puncture.

Table 1. Modified Dandy criteria for diagnosis of idiopathic intracranial hypertension.[1,2]

1.	High-pressure headache and papilloedema
2.	Cerebrospinal fluid opening pressure of >25 mm Hg
3.	Awake and alert patient
4.	No localising signs other than lateral rectus paresis
5.	Normal cerebrospinal fluid constituents
6.	Normal brain imaging with no evidence of venous obstruction
7.	Benign clinical course apart from visual deterioration
8.	No other cause of raised intracranial pressure

All MRI examinations were performed on a 1.5T system (Signa GE, Milwaukee, USA), using a standard neurovascular head coil and a standard protocol for the brain, including sagittal T1 spin-echo and axial dual-echo using a slice thickness of 5 mm. Two-dimensional phase-contrast MR venography was performed for all patients. MRI of the orbits was performed for all patients and controls using a standard non-enhanced MRI orbital protocol, including 3-mm axial oblique parasagittal (parallel to the optic nerve) and coronal T1- and T2-weighted images, with and without application of fat-saturation pulse sequence. A 20-cm field of view was used.

The MRI scans of the brain were assessed for the presence or absence of parenchymal abnormalities, masses, and dural sinus thrombosis. The ventricles, sulci, and basal cisterns were visually assessed for signs of effacement or enlargement. The presence of partial or complete empty sella was recorded. The MRI scans of the orbits were assessed for abnormalities of the globe, optic nerve, extraocular muscles, and intra-/extra-conal abnormalities. The OS-ON diameters were measured using the outer diameter of the subarachnoid space and the nerve at the point of maximum OS distension, as depicted from the fat-saturated T2-weighted images. All measurements were performed by the author on the coronal T2 fat-saturated sequence. Correlation with the respective lumbar puncture opening pressure was made for the patient population**.**

RESULTS

Seventeen controls (88.6%) had an OS-ON ratio of <2:1. Only 2 controls (11.4%) had an OS-ON ratio measuring ≥2.5:1. All patients with IIH (100%) had an OS-ON ratio ≥2.5:1. The age of the patients did not have an impact on the OS-ON ratio. Figures 1 and 2 show the OS-ON ratio in a patient with IIH and a healthy volunteer.

All lumbar punctures resulted in CSF opening pressure >30 mm Hg. The correlation of OS-ON ratio measurement and CSF opening pressure showed that OS-ON ratio had 100% sensitivity, 80% specificity, 90% positive predictive value, and 100% negative predictive value.

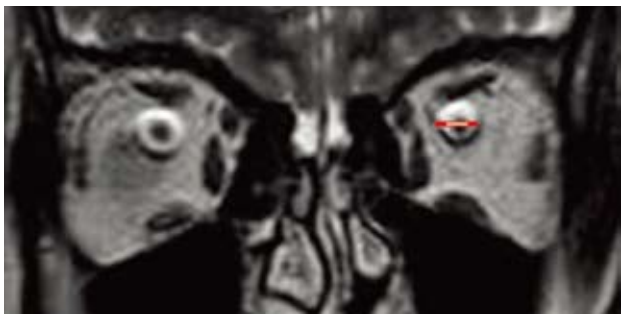

Figure 1. Coronal T2 fast spin echo image with fat saturation obtained at the point of maximum dilatation, demonstrating an optic sheath (red)–optic nerve (white) ratio >2.5:1* in a patient with idiopathic intracranial hypertension. The lumbar puncture opening pressure was 360 mm Hg.
* Optic sheath = 6.8 mm; optic nerve = 2.4 mm.

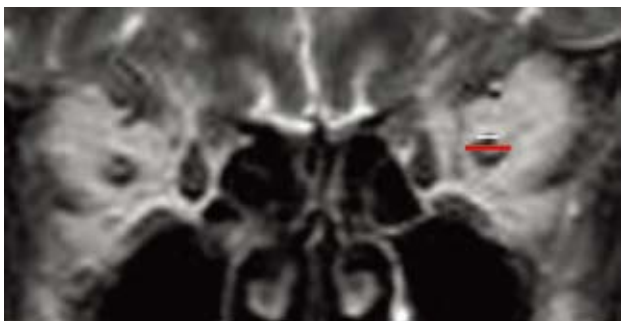

Figure 2. Coronal T2 fast spin echo image with fat saturation obtained at the point of maximum dilatation, demonstrating an optic sheath (red)–optic nerve (white) ratio <2:1* in a healthy volunteer.
* Optic sheath = 4.1 mm; optic nerve = 2.2 mm.

DISCUSSION

IIH is defined as a syndrome of signs and symptoms of increased intracranial pressure without causative lesions on MRI or computed tomography (CT). The terms pseudotumour cerebri and pseudotumour syndrome are also used, but the term benign intracranial hypertension is now obsolete, reflecting current awareness of the major risks to vision from papilloedema, including severe visual loss, that may complicate IIH.[1,2]

Several pathophysiological theories have been proposed as possible mechanisms for the development of IIH. A defect in the CSF absorption mechanism at the arachnoid granulations, increased CSF production, cerebral oedema, and increased intracranial venous pressure are among the widely accepted mechanisms.[3-8] Similarly, associations with several clinical conditions, including obesity, obstructive sleep apnoea, Behçet's disease, renal impairment, and systemic lupus erythematosus, have also been documented in the literature.[9-17]

The aims of treatment are to arrest progressive visual loss. Medical therapies include alleviation of associated systemic diseases, discontinuation of contributing medications, provision of carbonic anhydrase inhibitors, and the introduction of a reduced sodium weight-reduction program. Patients for whom medical therapy is unsuccessful may benefit from surgical fenestration of the optic nerve sheath and/or CSF shunting procedures.[3]

The ophthalmic hallmark of raised intracranial pressure is papilloedema. Conventionally, the term papilloedema is reserved for optic disc oedema when the swelling is due to raised intracranial pressure and does not arise from local optic nerve processes such as inflammation, extrinsic compression, or ischaemia.[18,19]

There are many publications reporting different orbital MR findings in patients with IIH, for example, flattening/elevation of the optic disc, distension of the optic sheath, and optic nerve kinking.[20-22] Brodsky and Vaphiades evaluated 20 patients with IIH and 20 controls.[20] MRI showed flattening of the posterior sclera in 80% of patients with pseudotumour cerebri, empty sella in 70%, distension of the perioptic subarachnoid space in 45%, enhancement of the prelaminar optic nerve in 50%, vertical tortuosity of the orbital optic nerve in 40%, and intraocular protrusion of the prelaminar optic nerve in 30%. Most of these signs were also detected in 5% of controls. Based on these MRI signs, the authors were able to predict the presence of elevated intracranial pressure in 90% of patients with pseudotumour cerebri and the absence of elevated intracranial pressure in all controls.

Agid et al, in 2 different studies, evaluated the accuracy of previously reported neuroimaging signs and MR venography for establishing or excluding the diagnosis of IIH.[21,22] All examinations were evaluated for the presence or absence of the traditional signs of IIH, including empty sella turcica, deformation of the pituitary, slit-like ventricles, tight subarachnoid spaces, flattening of the posterior globe, enhancement of the optic nerve head, distension of the optic nerve sheath, and vertical tortuosity of the optic nerve. These authors concluded that optic nerve enhancement, slit-like ventricles, and tight CSF spaces were not significantly associated with IIH; optic nerve sheath distension, optic nerve tortuosity, pituitary deformity, and empty sella turcica were significantly associated with IIH, but most of these are not helpful clinically; and posterior globe flattening was the only sign that, if present, strongly suggests a diagnosis of IIH.

A few publications have highlighted the value of observing the changes in the optic sheath diameter as part of the

evaluation of intracranial hypertension and response to treatment.[2,19,23-25] This study concurs with the previously reported studies[2,19,23-25] of using the OS-ON ratio as a marker for the diagnosis and follow-up of patients with IIH. However, none of the published literature used a specific ratio. Watanabe et al found that dilated OS was associated with IIH and was thought to reflect the increased intracranial pressure.[19] Twelve patients with chronic subdural haematoma underwent burr-hole craniotomy with continuous drainage. Orbital thin-slice fat-saturated MRI scans were obtained before and after surgery, and the OS diameters were measured just behind the optic disc. Subdural pressure was measured using a manometer before opening of the dura mater. A significant correlation was found between the OS diameter and the subdural pressure. The OS diameter before surgery was significantly reduced after surgery. In another study, Watanabe et al examined 3 patients with CSF hypovolaemia using coronal thin-slice fat-saturated T2-weighted MRI before and after treatment, and found that the subarachnoid space was decreased in patients with hypovolaemia.[24] Both studies had a small patient population and did not present an OS-ON diameter ratio.

This study found that 88.6% of the control population had an OS-ON diameter ratio of <2:1, with only 11.4% of the control population having OS-ON ratios ≥2.5:1. However, all patients with IIH had an OS-ON ratio ≥2.5:1, and the lumbar puncture showed CSF opening pressure >30 mm Hg. The overlap in the results of 11.4% of the controls and the patients with IIH should not be confused clinically, as none of the controls was symptomatic or fulfilled the modified Dandy criteria for IIH diagnosis. These results are in agreement with the concept of OS dilatation. However, as there are no published data on exact diameter ratios, the results need to be verified.

In conclusion, the results of this study highlight the usefulness of OS-ON diameter ratio measurements on orbital MRI for the diagnosis and follow-up of patients with IIH. A ratio ≥2.5:1 is highly suggestive of the diagnosis of IIH. Such measurements can be used as a non-invasive replacement of lumbar puncture for the diagnosis and follow-up of IIH.

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