Research Paper

Role of Brain Magnetic Resonance Imaging/ Magnetic Resonance Venography in the Diagnosis of Idiopathic Intracranial Hypertension

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ABSTRACT:

BACKGROUND:

Idiopathic intracranial hypertension (IIH) is an idiopathic condition. MRI is essential to exclude elevated cerebrospinal fluid pressure due to other causes such as brain tumour, dural sinus thrombosis, hydrocephalus, etc.

OBJECTIVE:

To determine the role of brain magnetic resonance imaging and venography in the diagnosis of idiopathic intracranial hypertension and to determine the sensitivity and specificity of each single radiological sign and in combination.

PATIENTS AND METHOD:

A prospective case control study was done in Al- Imamain Al-Kadhmain medical city between September 2021 and November 2022. A random selection of 40 patients (3 males and 37 females) with clinical features, neurological examination, brain MRI/ MRV and confirmed diagnosis of IIH. Forty controls were also randomly selected. A total of 10 brains MRI/MRV signs were evaluated.

RESULTS:

There is significant difference of the 10 MRI signs between patient group and control group. Regarding the sensitivity and specificity of each MRI sign: empty sella (97% sensitive, 77% specific), flat sclera (82%, 95%), Perioptic nerve sheath distension (90%, 95%), Intraocular protrusion (22%, 100%), vertical tortouisity f the optic nerve (35%, 95%), enlarged meckel's cave (82%, 92%), posterior displacement of the stalk (67%, 75%), slit like ventricle (55%, 97%), meningoceles (15%, 97%) and cerebral venous sinus stenosis (70%, 92%). Combination of MRI signs increases the sensitivity and specificity with combination of 3 signs and above would reach 100% specificity.

CONCLUSION:

Five MRI signs have the highest sensitivity and specificity (flat sclera, perioptic nerve sheath distension, empty sella, large meckel's cave, and cerebral venous sinus stenosis). Combination of MRI signs especially (optic nerve tortuosity/ optic nerve distension) and (flat sclera/ optic nerve distension) has significantly increased the sensitivity and specificity. Presence of 3 signs or more has the highest specificity.

KEYWORDS: magnetic resonance imaging, idiopathic intracranial hypertension

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INTRODUCTION:

Idiopathic intracranial hypertension (IIH) is a syndrome with signs and symptoms of increased intracranial pressure but where a causative mass or hydrocephalus is not identified (1). Elevated CSF pressure can lead to symptoms such as headache, vision disturbance, pulsatile tinnitus and nausea (2). This syndrome was grouped under the name pseudotumor cerebri and described by the German neurologist Max Nonne in 1904 (3). It demonstrates a strong female predominance, with a female/male ratio of 8:1 (4). Higher levels of weight gain and BMI are associated with greater risk of IIH. Even non-obese patients (BMI <30) are at greater risk for IIH in moderate weight gain (5). Body mass index had a small but clinically insignificant influence on CSF opening pressure [6]. Physiologically, intracranial pressure in healthy adults is 50–150 mm H2O [7]. According to modified dandy criteria for IIH diagnosis, CSF opening pressure should be more than 250mm H_2O in adults and 280 mm in children [8].

Imaging of the brain with CT and MRI is essential in patients with suspected IIH, to exclude other causes such as brain tumour, dural sinus thrombosis, hydrocephalus, etc [1]. Magnetic resonance venography (MRV) is a widely accepted modality for the diagnosis of venous sinus stenosis in patients with IIH [9]. The evaluation of dural venous sinuses on MRV is predominantly subjective based on the reader's impression in a descriptive method with no established quantitative method [10]. The prevalence of unilateral transverse sinus stenosis or hypoplasia was 33%, the prevalence of bilateral transverse sinus stenosis was 5%, and the prevalence of unilateral stenosis with contralateral hypoplasia was 1% [11].

AIM OF THE STUDY:

To determine the role of brain MRI, MRV in the diagnosis of IIH and to determine the sensitivity and specificity of each single radiological sign and in combination.

PATIENTS AND METHODS:

Study design: a prospective case control study was done in Al-Imamain Al-Kadhmain medical city between September 2021 and November 2022. A random selection of 40 patients (37 females and 3 males) with clinical features, brain MRI/ MRV and confirmed diagnosis of IIH. The age ranged from 18-53 years (mean age 33±9.9 years). Forty controls were also randomly selected.

Inclusion criteria: any patient with clinical features, neurological examination, MRI/MRV findings suggestive of IIH with a subsequent confirmed diagnosis by LP manometry. **Exclusion criteria:** patients with a secondary cause of elevated intracranial pressure such as brain tumor, cerebral venous thrombosis, patients with hydrocephalus, patients with previous cranial surgery, patients with MRI/MRV findings suggestive of IIH and normal manometry, patients refuse to do LP puncture and general contraindications to MRI examination.

Controls: 40 control subjects who were age and sex compatible were randomly selected that are reported normal by a specialized radiologist. **Ethical consideration:** the study was approved by the scientific committee of the Iraqi Board of diagnostic radiology. Verbal informed consent was obtained from all patients included in the study.

MRI protocol: all patients were examined by 3T MR scanner (Acheiva medical system, Philips healthcare, Netherland) using standard head-coil (8-channel). All the patients were examined with the fallowing imaging sequences: Axial T2 weighted spine echo (TR3509ms, TE80ms), slice thickness 4mm and gap 1mm. Axial T1 weighted spine echo (TR254, TE4.6), slice thickness 5mm and gap 1mm. Coronal T2 FLAIR (TR 11000, TE 120), slice thickness 4mm and gap 1mm. DWI (TR 3996, TE 91), slice thickness 4mm and gap 1mm. TOF MRV (TR 16, TE 3.3), slice thickness 4mm and gap 1mm with maximum intensity projection (MIP) images were evaluated.

Image interpretation: was done by an experienced radiologist on an extended workstation. A total of 10 brains MRI/MRV signs were evaluated and including:

1. Flat posterior sclera: was evaluated in axial T2, diagnosis when there is flattening or loss of convexity of posterior globe at junction of globe and optic nerve
2. Prominent perioptic nerve subarachnoid space (optic nerve distension (OND)), diameter measured in axial T2 perpendicular to the optic nerve 3mm and 8mm posterior to globe and it considered dilated when measured more than 6.2mm and 5.8mm respectively.
3. Intraocular optic nerve protrusion also referred to as 'reversal of the optic nerve'. This is a more extreme version of posterior globe flattening, when the normal outwards convexity of the sclera is not only straightened but even concave towards the globe at the area of attachment to the optic nerve
4. Optic nerve tortuosity (ONT) was evaluated in axial T2; it was diagnosed when there is optic nerve twisting in horizontal plane.
5. Empty/ partially empty sella: when the vast majority of the pituitary fossa was filled with CSF.
6. Large Meckels' cave.
7. Posterior displacement of pituitary stalk.
8. Slit like ventricles coapted walls of the lateral ventricles that would not be expected in the normal adult population.
9. Prominent arachnoid pits (granulations).
10. MRV to check for unilateral or bilateral transverse cerebral venous sinus stenosis, the patency of each transverse sinus (left and right) was evaluated relative to the diameter of the lumen of the distal superior sagittal sinus and graded as: 0 (aplastic or discontinuous) 1 =severe (>75%

stenosis); 2= moderate (50-75% stenosis); 3 = mild (25-50% stenosis); and 4 = (normal or very mild).

Confirmation of the diagnosis: for all the patients included in this study was done by elevated CSF opening pressure by LP (above 250 mmH2O).

Statistical analysis: continuous variables were expressed as means and standard deviations. Categorical variables were expressed as frequency and percentages. The Welch's t-test (for normally distributed variables) was performed to test the difference in means. The difference between categorical variables was investigated using either the χ^2 test or Fisher's exact test, depending on the context. Univariate logistic regression was used to calculate logarithm of odds ratio for the risk of high intracranial pressure. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated according to the standard formula. An "OR" and an "AND" Boolean operator was used when analysing a combination of MRI findings. A P value less than 0.05 was considered statistically significant.

RESULTS:

Forty patients were included in the study with confirmed diagnosis of IIH, 37 (92.5%) of them were females and 3 (7.5%) males with a female to male ratio is 8.1. The patients age range from (18-53) years old with a mean of 33.0 ± 9.9years. Forty control group were also included in the study, 29(72.5%) of them were females and 11(27.5%) were males with mean age of 36.0±7.4 years.

MRI findings: the 10 MRI signs in the 40 patients and 40 controls were assessed. There is significant difference of those signs between patient group and control group, flat sclera (82.5% in patients vs 5% in controls), perioptic nerve sheath distension (90% vs 5%), intraocular protrusion of the optic nerve (22.5% in patients, 0% in controls), tortuosity of the optic nerve (35% in patients and 5% in controls), empty/ partially empty sella (97.5% vs 22.5%), large Meckel's cave (80% vs 7.5%), posterior displacement of the stalk (67.5% vs 25%), slit like ventricle (55% vs 2.5%), meningoceles (15% vs 2.5%), cerebral venous sinuses stenosis on MRV 70 % vs 7.5%). As illustrated in **table 1**.

A univariate logistic regression model was conducted to study the likelihood of IIH. It was found that flat sclera was 4.5 times more likely to predict intracranial hypertension, perioptic nerve sheath distension 5.1, intraocular protrusion 18, vertical tortouisty of the optic nerve 2.3, empty sella 4.9, large Meckel's cave 3.9, slit like ventricles 3.9 and cerebral venous sinus stenosis 3.4. All signs included in this study can predict the disease except for the presence of meningoceles and posterior displacement of the stalk as illustrated in table 2.

Table 1: Description of brain imaging signs and the statistical difference between patients and controls and Sensitivity, specificity, PPV and NPV in patients group.

Characteristics	Cases (40)	Control (40)	P-value	Sensitivity	Specificity	PPV	NPV
Flat sclera	33(82.5%)	2 (5%)	<0.001	82%	95%	94%	84%
PON sheath distension	36(90%)	2 (5%)	<0.001	90%	95%	94%	90%
Intraocular protrusion	9(22.5%)	0 (0%)	0.002	22%	100%	100%	56%
Tortuosity of the ON	14(35%)	2 (5%)	<0.001	35%	95%	87%	59%
Empty Sella	39(97.5%)	9 (22.5%)	<0.001	97%	77%	81%	96%
Large Meckel's cave	32(80%)	3 (7.5%)	<0.001	80%	92%	91%	82%
Post. displacement of stalk	27(67.5%)	10 (25%)	<0.001	67%	75%	72%	69%
Slit like ventricles	22(55%)	1 (2.5%)	<0.001	55%	97%	95%	68%
Meningoceles	6(15%)	1 (2.5%)	0.11	15%	97%	85%	53%
Cerebral venous sinus stenosis on MRV	28(70%)	3 (7.5%)	<0.001	70%	92%	90%	75%

Table 2: The odds of IIH utilizing unadjusted logistic regression model.

Characteristics	Log(OR)[1]	95% CI[1]	P-value[1]
Flat sclera	4.5	3.1, 6.5	<0.001
Perioptic nerve sheath distension	5.1	3.6, 7.2	<0.001
Intraocular protrusion	18	-88, NA	<0.001
Tortuosity of the ON	2.3	0.95, 4.2	0.004
Empty Sella	4.9	3.2, 7.8	<0.001
Large Meckel's cave	3.9	2.6, 5.5	<0.001
Posterior displacement of stalk	1.8	0.88, 2.8	<0.001
Slit like ventricles	3.9	2.2, 6.8	<0.001
Meningoceles	1.9	0.10, 4.9	0.081
Cerebral venous sinus stenosis on MRV	3.4	2.1, 4.9	<0.001

[1]OR = Odds Ratio, CI = Confidence Interval

The combination of MRI signs was also significantly more prevalent in the patient group than the control group with P value < 0.001 as illustrated in table 3.

Table 3: Description of the combined signs of IIH in both patientsand controls and Sensitivity, specificity, PPV, NPV of combined signs in the patients group.

Characteristics	Cases (40)	Control (40)	P-value	Sensitivity	Specificity	PPV	NPV
At least one sign is positive	40(100%)	28(70%)	<0.001	100%	30%	58%	100%
Two combined signs							
Empty Sella- flat sclera	40(100%)	11(27.5%)	<0.001	100%	72%	78%	100%
Empty Sella- ON tortuosity	40(100%)	11(27.5%)	<0.001	100%	72%	78%	100%
ON tortuosity–ON distension	36(90%)	4(10%)	<0.001	100%	72%	78%	86%
Empty sells–ON distension	40(100%)	11(27.5%)	<0.001	90%	90%	90%	90%
Flat sclera - ON distension	37(92.5%)	4(10%)	<0.001	92%	90%	90%	92%
Flat sclera –ON tortuosity	34(85%)	4(10%)	<0.001	85%	90%	89%	85%
Three signs	9(22.5%)	0(0%)	0.002	22%	100%	100%	56%
Four signs	13(32.5%)	0(0%)	<0.001	32%	100%	100%	59%
Five signs	10(25.0%)	0(0%)	<0.001	25%	100%	100%	57%

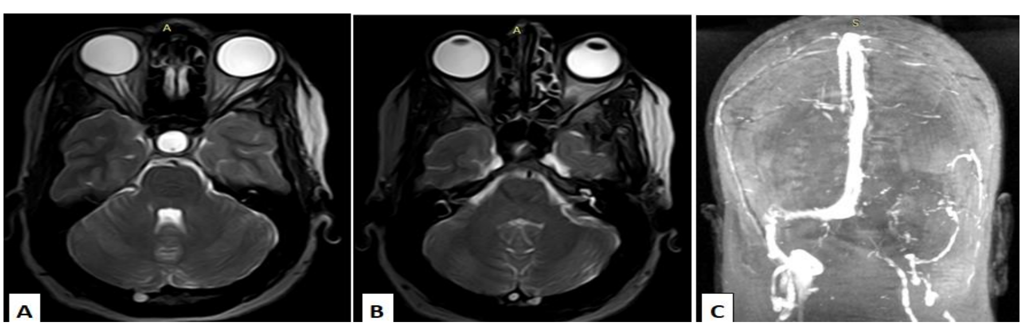

Figure (1 A, B, C): 36 years old female presented with severe headache and visual disturbance A) axial T2 image shows dilated perioptic nerve sheath complexes, empty sella turcica and posterior displacement of

pituitary stalk (white arrow) B) axial T2 image at another level shows prominent posterior fossa arachnoid granulations (white arrow) C) MRV MIP image shows left and lateral part of right transverse sinuses stenosis, the patient was diagnosed with IIH, lumber puncture CSF opening pressure was 290 mmHg.

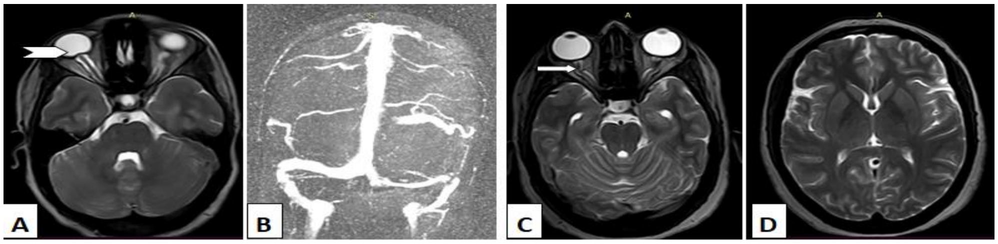

Figure (2 A, B): 23 years old female patient presented with severe headache and tinnitus A)axial T2 image shows dilated PON sheath complexes with intraocular protrusion of the optic nerve (white arrow), B) MRV – MIP image shows narrowing of the lateral part of left transverse sinus, IIH was diagnosed by lumber puncture.Figure (2 C, D): 30 years old female patient presented with severe headache A) axial T2 WI shows flattening of the posterior globe, PON distension, transverse tortuosity of the optic nerve (white arrow) C) the same sequence but at upper level showing slit like ventricles (white arrow), IIH was confirmed by lumber puncture.

DISCUSSION:

Several MRI signs are studied in the literature that can predict the diagnosis of IIH. The main aim of this study was to identify the sensitivity and specificity of each MRI sign and the accuracy of combined signs in the diagnosis of patients with this disease.

In this study, most of the patients were females (92.5%) with a mean age of 33.0+ 9.9 years. These results were identical with those of previous study done by Agid et al [12].

Regarding the incidence of MRI signs between patient group and control group, the studied 10 signs were statistically significant between the 2 groups except for meningoceles. The incidence in patients group was (empty sellain 97.5%, flat sclera in 82.5%, PON distension in 90%, intraocular protrusion of optic nerve 22.5%, tortuosity of optic nerve in 35%, large meckel’s cave in 80%, posterior displacement of stalk 67.5%, slit like ventricles in 55%, meningoceles in 15% and cerebral venous sinus stenosis on MRV in 70%), These results were similar to Maralani et al [13] who found that 6 signs were more prevalent in IIH patients (partially empty sella, posterior displacement of the pituitary stalk, flattening of the posterior globe, ON protrusion, ON sheath distensionand ON tortouisity. Another study by MC brodosky et al [14] showedthat flattening of the posterior sclera in 80% of patients with IIH, empty sella in 70%, distension of the perioptic subarachnoid space in 45%, vertical tortuosity of the orbital optic nerve in 40%, and intraocular protrusion of the prelaminar optic nerve in 30%. Similar results were also noted in the study by Agid et al [12] regarding posterior globe flattening, ON sheath distension, ON tortuosity and empty sella turcica in patients with IIH.

Regarding cerebral venous sinus stenosis in IIH, the results of the current study were similar with that of Higgins et al [15] and Farb et al [9] studies.

The high incidence of enlarged meckel’s cave in this study was matched to a study by a kamali et al [16].

Although The presence of meningoceles in this study was not statistically significant but it occurs 15% in patient group versus 2.5% in control group which is in agreement to bailer et al [17] who included 79 IIH patients and 76 control subjects. Meningoceles were found in 11% of IIH patients and 0% of control.

In this study Slit like ventricles was seen in 55% of patients which was found to be an uncommon finding in previously reported study [4], this difference can be explained by the difference in demographic variables.

Regarding the sensitivity, specificity of each single MRI finding, this study showed that (flat sclera, PON distension, empty sella, large meckel’s cave, and cerebral venous sinus stenosis) has high both sensitivity and specificity with a sensitivity of (82%, 90%, 97% 80% and 70%) respectively and specificity of (95%, 95%, 95%, 92% and 92%) respectively, these results were similar to that of Maralani et al [13] study (53.5% sensitive and 100% specific) and Brodsky et al [14] study (flat sclerais 80% sensitive and 95% specific).

Agid et al [12], Maralani et al [13] and Brodsky et al [14] all found that PON distension has high specificity but relatively low sensitivity which was different from this study, the high sensitivity can be explained that the studies were done by 3T MRI and the difference in demographic variables in patient and control groups.

The results of this study regarding empty sella was similar to that of previously reported study [14] who found Empty sella to have 70% sensitivity and 95% specificity.

The high sensitivity and specificity of cerebral venous stenosis observed in this study is also in agreement with the Maralani et al [13] study.

In this study intraocular protrusion of ON has highest specificity (100%) but low sensitivity which is also similar to Agid et al [12] and Maralani et al [13] studies.

ON tortuosity found to have 35% sensitivity and 95% specificity which was in agreement to Agid et al [12] study who found 40% sensitivity and 91 specificity.

Slit like ventricles in this study has 55% sensitivity and 97% specificity which is fairly similar to the Brodsky et al [18] study who has 39% sensitivity and 79.1% specificity and Agid et al [12] who found a specificity of 100% but 3% sensitivity which is significantly lower than this study and this difference can be explained by differences in demographic variables in patients and control groups.

Posterior displacement of stalk 67% sensitivity and 75%specificity which is fairly similar to the Maralani et al [13] study sensitivity of 40% and specificity of 90%.

In this study the accuracy and reliability of different combinations of MRI signs were evaluated and shows that combination of MRI signs has significantly increased the specificity for diagnosing IIH. The highest sensitivity and specificity of two combined signs were (optic nerve tortuosity/ optic nerve distension) and (flat sclera/ optic nerve distension) which is in agreement to Firuze et al [19] who also found that combination of MRI findings would increase the diagnostic accuracy for diagnosing IIH.

CONCLUSION:

Five MRI signs has the highest sensitivity and specificity which are flat sclera, PON distension, empty sella, large meckel's cave, and cerebral venous sinus stenosis. Combination of MRI signs has significantly increased the sensitivity and specificity with highest combination being (optic nerve tortuosity/ optic nerve distension) and (flat sclera / optic nerve distension). Presence of 3 signs or more has the highest specificity for the diagnosis.

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