Significance of Transverse Sinus Stenosis in Idiopathic Intracranial Hypertension Patients Using Contrast Enhanced Magnetic resonance Venogram

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Abstract

Background : Incidence of IIH is among population in united states is 1/10000 in general population , increasing to 1.6- 3.5 per 1lakh population in females and further increasing to 8 to 20 per 1lakh population in females of reproductive age group and obese [4] . Quincke first described idiopathic intracranial hypertension in 1893. Later in 1937 diagnostic criteria was first put forth by Dandy which was further modified by Smith in 1985 as Modified Dandy criteria . With the advent of MRI , few MR features like partial empty sella, prominent perioptic subarachnoid space , tortuous optic nerve, flattening of posterior globe of eye and papillary optic nerve protrusions , small and pinched ventricles has a sensitivity around 50 to 75 % .The observation of narrowed transverse-sigmoid sinus conduit in IIH noted with high sensitivity and specificity.

Methods: In both cases and controls contrast enhanced MR venogram is done by time resolved method after acquiring routine MR sequences ,then by post processing, subsegmental MIP image [volume MIP image of posterior part of superior sagittal sinus ,bilateral transverse and sigmoid sinus] is derived. Then posterior part superior sagittal sinus diameter is compared with stenosed transverse sinus for percentage of stenosis and scoring is given . A score less than 5 out of 8 is considered positive for case

Results : Combined conduit scoring for transverse sinus narrowing is more sensitive[90%] than other MRI features[50%-75% ], whereas specificity is comparable between them [around 90%] 2D TOF MRI showed more false positivity due to signal loss in slow flow and narrowed sinuses

Conclusion: Combined conduit scoring for transverse sinus stenosis is more sensitive method compared to other MR features of IIH like partial empty sella, prominent perioptic subarachnoid space , tortuous optic nerve, flattening of posterior globe of eye and papillary optic nerve protrusions , pinched ventricles . Contrast enhanced MR venogram is more superior to 2DTOF MRI . Invasive procedure of Lumbar puncture for CSF manometry can be replaced by CCS scoring for transverse sinus stenosis and other MR features . CCS scoring can also be used for follow up of cases instead of repeat lumbar punctures

Keywords: MRI – Magnetic resonance imaging CEMRV – Contrast enhanced magnetic resonance venogram IIH - Idiopathic intracranial hypertension CCS- Combined conduit scoring 2D TOF MRV – 2 dimensional time of flight magnetic resonance venogram Subsegmental MIP image Partial empty sella. prominent perioptic subarachnoid space Tortuous optic nerve, Flattening of posterior globe of eye Papillary optic nerve protrusions ,Pinched ventricles

I. Introduction

IIH is fast emerging because of the increasing incidence of obesity and one of the cause of treatable blindness causing great morbidity .There are no acceptable and highly sensitive imaging criteria . Modified Dandy criteria has not been modified since 1985,after the emergence of MRI . Invasive procedure like csf opening pressure measurement is mandatory to confirm intracranial hypertension .A non invasive imaging criteria which is highly sensitive enough to replace invasive procedure is required . Previous Studies based on transverse sinus narrowing as the criteria for IIH has showed rewarding results. CEMRV is considered superior to 2D TOF MR venogram and phase contrast MRvenogram .

3 major theories proposed for etiology of IIH ,but most accepted theory is venous outflow obstruction [4] various secondary causes for intracranial hypertension are medical disorder,medications ,endocrine disturbances ,venous thrombosis [10] . A typical case of idiopathic intracranial hypertension is a obese women in the child bearing age group [10] . The classic symptoms are head ache, obscuration of vision, pulsatile tinnitus , double vision ,photopsia and rarely blindness. Signs of IIH include papilledema, preservation of central vision, diplopia commonly due to 6 th nerve palsy [6]
Modified Dandy criteria
1. Signs and symptoms of increased intracranial pressure
2. No localizing neurologic signs , with exception of unilateral or bilateral VI nerve paresis.
3. CSF can show increased pressure, without cytologic or chemical abnormalities .

2D TOF MR venogram is based on the intravascular flow producing signal, so artifacts results from slow intravascular flow in plane flow, complex blood flow patterns and post processing. Phase contrast MR venogram depends on velocity induced phase shifts on moving spins. It requires long imaging times and proper estimation of blood flow velocities to avoid signal loss due to turbulence and intravoxel dephasing [12]. Contrast enhanced 3D MR venogram is the best among imaging studies which shortens the T1 relaxation time and it is flow independent. The image acquisition time should be optimized for good opacification with power injectors and bolus tracking methods.

Time resolved contrast MR venogram is a technique wherein the acquisition is started immediately after bolus injection of contrast and the sequence is repeated multiple times [13,14,15].

Treatment options available are medical and surgical methods. Medical management includes weight reduction, oral acetazolamide and steroids in resistant cases. Surgical management is indicated in medical management resistant cases. Optic nerve fenestration is indicated in patients with severe papilledema and less ICT symptoms. Lumboperitoneal shunting is indicated in patients with severe ICT symptoms. Dural venous sinus stenting is indicated in transverse sinus stenosis with pressure gradient above 10mmHg [27][28].

Aim Of The Study
To evaluate prevalence of bilateral transverse sinus stenosis using dynamic contrast enhanced magnetic resonance venogram in idiopathic intracranial hypertension

II. Materials And Methods

Study Population - Our study included 64 persons. The cases and controls were referred from Neurology department. The observer is blinded about whether a case or control is referred for MR examination. A case of idiopathic intracranial hypertension is diagnosed based on CSF opening pressure more than 250mm of water in our study.

Type of study - Case control study

Case
Inclusion criteria :
- CSF opening pressure greater than 250mm of H2O with normal CSF constituents and normal imaging study;

Exclusion criteria
- Pregnant and breast feeding women
- Severe hypersensitivity or previous allergic reactions
- Critically ill patients
- Known cause of intracranial hypertension identified like drugs, systemic disorders
- Known case of intracranial space occupying lesion, as every case or control screened with CT brain
- Previous history of sinus thrombosis

Two cases is excluded from our study as they showed sagittal and distal transverse sinus thrombosis using MRI and dynamic contrast Enhanced MR venogram.

One case excluded because post contrast study showed diffuse enhancement of leptomeninges suggestive of meningitis.

One case is excluded from the study as the patient taking steroids irregularly for rheumatoid arthritis.

Controls
- Patients with clinical symptoms of IIH like headache, tinnitus, blurring of vision for whom CSF pressure is less than 250cms of water
- Patients who was fixed for MRI brain with contrast for some other reasons for whom CSF manometry is done after consent and found csf pressure within limits.

Blinding
Cases and controls were referred from the department of Neurology, Madras medical college. The Neurologist performing CSF pressure is blinded of the MRI features of the patient, only the neurologist knows whether a referred person is case or control. Radiologist interpreting the MR images were blinded of the clinical information and CSF pressure. After completing the study, the results were discussed by radiologist and neurologist together on case by case basis and results were tabulated.

**Age Range**
- Cases – Age ranged from 17 years to 55 years
- Controls- Age ranged from 22 years to 60 years

**Sex**
- Cases - 28 females and 2 males
- Controls- 23 females and 7 males

**Materials**
- 1.5 tesla super conducting Magnetom Siemens
- Standard head coil
- Gadolinium dimeglumine 10 ml, saline bolus 20 ml

**Methods**
1. Initially MRI routine sequences of brain is obtained.
2. 2D TOF MR venogram acquired in axial plane with following parameters TR- 30, TE-6.5, FOV 145X145, 256X256, BW – 292, Flipangle -60
3. Contrast enhanced magnetic resonance venogram done using SPGR sequence, the sequence parameters are TR 3.6, TE- 1.4, slice thickness 2.5mm, fov- 292x360, 187x 256, BW-348. Coronal precontrast and post contrast SPGR sequence are obtained after 10ml of gadolinium with 20 ml saline chase. Post contrast sequence is acquired repeatedly for 4-5 times, then the best post contrast image is subtracted with the pre contrast image and then mipped to get 3D MIP image, then unnecessary part of the sinus are removed leaving behind the posterior half of superior sagittal sinus, transverse sinus and sigmoid sinus [subsegmental MIP image] for proper assessment of the stenosis.

**Combined conduit score using subsegmental MIP image**
In our study the distal sagittal sinus diameter is measured and compared with narrowed part of the sigmoid and transverse sinus conduit.
- If there is a flow gap in the sigmoid transverse conduit, then the score is 0.
- If the narrowed transverse diameter is between 1-25% of the distal sagittal sinus then the score is 1.
- If the narrowed diameter is between 26%-50% then a score is 2.
- If the narrowed diameter is between 51% - 75% then the score is 3.
- If the narrowed diameter of the transverse sinus is between 76% - 100% then the score is 4 and it is considered normal.

So the total score is 8 which is called combined conduit score.
In our study we considered a score less than 5 as significant.

CSF opening pressure is measured in lateral decubitus position using lumbar puncture 20-22 g spinal needle and a score more than 250cms of water is considered as positive.

**III. Results**
Statistical analysis for sensitivity, specificity, test for significance was done for the acquired data. Out of 30 cases, 27 cases had significant bilateral stenosis with a combined conduit score less than 5, whereas in controls only 4 persons had combined conduit score less than 5. Hence sensitivity and specificity of is 90% and 86% respectively. The positive and negative predictive value of the test is 87% and 89%.

<table>
<thead>
<tr>
<th></th>
<th>cases</th>
<th>controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ccs&lt; 5</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td>Ccs&gt;or= 5</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>total</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Sensitivity - 90%
Specificity - 86%
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PPV - 87%
NPV - 89%

Test of significance using chi square test was done using combined conduit score in control and cases. There is significant correlation between CSF pressure and combined conduit score and the scoring using contrast enhanced venogram is correlating well with p value less than 0.001. On comparison of CCS score with other MRI features using chi-square test, p value of 0.014 is obtained with less than 5% significance suggesting statistically significant degree of correlation in which the combined conduit score has more statistically more useful than other MRI features.

### Comparison of various MR features in idiopathic intracranial hypertension

<table>
<thead>
<tr>
<th>MRI features</th>
<th>cases</th>
<th>Sensitivity%</th>
<th>controls</th>
<th>Specificity%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ccs &lt;5</td>
<td>27</td>
<td>90</td>
<td>4</td>
<td>86.67</td>
</tr>
<tr>
<td>Patulous optic nerve sheath</td>
<td>20</td>
<td>66</td>
<td>3</td>
<td>90</td>
</tr>
<tr>
<td>Small symmetrical ventricles</td>
<td>15</td>
<td>50</td>
<td>2</td>
<td>93.33</td>
</tr>
<tr>
<td>Flattening of the posterior sclera</td>
<td>18</td>
<td>60</td>
<td>2</td>
<td>93.33</td>
</tr>
<tr>
<td>Partially empty sella</td>
<td>22</td>
<td>73</td>
<td>3</td>
<td>90</td>
</tr>
</tbody>
</table>

From the above data it is clear that the sensitivity of combined conduit score is 90% and it is more than the sensitivities of other MR features. The specificity of various MR features in the diagnosis of IIH is around 90% for all features. Chi-square test comparing between MR venogram and 2D TOF venogram in cases and control showed a P value of 0.22 suggesting significant difference between CEMRV and 2D TOF.

### IV. Discussion

From the results it obvious that combined conduit scoring of bilateral sigmoid and transverse sinus stenosis using contrast enhanced MR venogram is highly sensitive test in diagnosing idiopathic intracranial hypertension. Three cases which showed combined conduit score of 5 were in the borderline stage and showed false negative values and all such cases had borderline elevation in pressure between 250 to 300 mms of water. The possibilities for false negatives may be because of imaging error or CSF pressure monitoring error.

The specificity of the test is 86% with four of the patients has higher combined conduit score. Again in all four cases the CCS score is borderline with a score of 4 in all four cases. In all these 4 controls only one side is involved and medial transverse sinus is involved whereas in cases, both transverse sinus either symmetrically or asymmetrically and lateral aspect of the transverse sinus is involved.

In our study using 2D TOF MRV, we observed significant false positive values in controls with 14 out of 30 controls showing score less than 5 possibly due to due to in-plane flow error, slow flow. In nearly all the cases which showed signal gaps, contrast enhanced venogram showed some flow.

Out of 30 cases, 3 cases showed pressure more than 400 mms of water. In those cases, 2 cases showed a score of 2/8 and one case showed a score of 3/8. From this it is clear that as CCS score decreases as the CSF pressure increases and hence can be used for follow up.

Other known MRI features of IIH had sensitivities between 50 to 75%, whereas CCS scoring is highly sensitive about 90%.

The specificity of various MRI features and CCS is comparable and above 90%

We found papillary optic nerve protrusion has very low sensitivity[13.3%] and high specificity [100%].

In our study obesity is correlated well with idiopathic intracranial hypertension with 27 out of 30 cases had BMI more than or equal to 28.

### V. Conclusion

- Contrast enhanced MR venogram with combined conduit score is more sensitive with sensitivity of about 90%, compared to other MRI features.
- Contrast MR venogram is superior to 2D TOF MR venogram by reducing False positives.
- Modified Dandy criteria which include pinched ventricle is less sensitive, hence the criteria should be modified with CCS scoring and other MR features.
- Invasive CSF manometry can be avoided and replaced by CCS scoring, at least in high risk patients and in follow up after treatment.

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Annexur Normal Anatomy Superior dural sinuses

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Contrast enhanced venogram in MIP format shows superior sagittal sinus in green, transverse sinus in blue, sigmoid sinus in yellow, jugular veins in light purple, straight sinus in dark purple, inferior sagittal sinus in light blue, torcula herophili in yellow colour.

Superficial draining veins

MR venographic image image after removing deep sinus
1- Frontopolar
2- Anterior frontal
3- Posterior frontal
4- Vein of trolard
5- anterior parietal vein
6 superficial middle cerebral vein
7 labbe vein

Deep venous system

1. Thalamostriate vein
2. septal vein
3. internal cerebral vein
4. basal vein of Rosenthal
5. vein of Galen
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Basal dural sinuses

1 Cavernous sinus
2 Superior petrosal sinus
3 Inferior petrosal sinus
4 Superficial middle cerebral vein
5 Emissary and occipital venous plexus complex

TECHNIQUE OF ACQUIRING CONTRAST MR VENOGRAM

2D TOF MR Venogram Vs Contrast MR Venogram
2D TOF MR venogram shows artifactual signal loss due to in-plane flow error. Slow flow, turbulent flow. Contrast enhanced venogram shows luminal diameter correctly as this is flow insensitive. The above example shows bilateral signal loss in both transverse sinus due to slow flow near the site of stenosis, whereas contrast MR venogram shows narrowed lumen as this is insensitive to slow flow.

**Combined Conduit Scoring**

Distal luminal diameter of superior sagittal sinus compared with diameter of narrowed part of sigmoid-transverse conduit.

**Grading**

0 - Discontinuity (gap) or aplastic segment;
1  Severe stenosis  [less than 25% patent lumen ]
2  Moderate stenosis (25–50% patent lumen )
3. Mild stenosis (50–75% patent lumen); and
4. No significant stenosis (75–100% patent lumen).

- Total score is 8.
- When the score is less than 5, we consider the score significant and positive for intracranial hypertension.

**Case -1**

38 years old female was referred for MR Venogram with the complaints of headache and blurring of vision. Fundoscopy showed bilateral papilledema. Her CSF opening pressure which was known later in the study is 330 mm of water.
Contrast MR Venogram

Left Oblique
Right Oblique

There is partial empty sella noted in T1 sagittal image, no obvious flattening of posterior sclera in T2 axial image, T2 coronal image shows prominent perioptic space, coronal FLAIR image shows partial empty sella. 2D TOF MR venogram shows bilateral transverse sinus signal gap with a score of 0/8. Contrast enhanced venogram shows there is some patent lumen bilaterally which was shown as a signal gap in 2D TOF MRV. The score using contrast MR venogram is 4/8 suggestive of significant stenosis.

Case 2

50 years old Lakshmi referred from department of neurology with complaints of chronic headache for 6 months and eye pain for 2 months and transient visual disturbances, she had bilateral papilledema. Her CSF opening pressure which was known later in the study was 310 mm of water.
Sagittal T1 image shows normal pituitary. Axial T2 shows flattening of posterior sclera and tortuous optic nerve sheath. Coronal T2 shows prominent perioptic space. Coronal FLAIR image shows normal pituitary. 2D TOF MR venogram shows bilateral signal gaps suggesting a score of 0/8. Contrast MR venogram shows patent flow in the signal gaps but with narrowing and with a score of 4/8, hence this case is a true positive case.
Flair Coronal  
2D TOF MR Venogram

Contrast MR Venogram

Contrast MR Venogram

37 years old female with complaints of chronic headache, no papilledema with csf pressure of 140mm of water known later in the study. MRI reveals no features of idiopathic intracranial hypertension. 2D TOF MRV shows bilateral significant narrowing with flow gap on right side with a score of 1, contrast enhanced MR venogram shows combined conduit score of 6 In this case 2D TOF MRV shows false positive value, whereas contrast enhanced MRV shows score more than 5 suggesting normal study.