Visual Evoked Potentials and SPIR-FLAIR MRI in Acute Optic Neuropathies

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Abstract

The aim of the present study was to determine the role of the visual evoked potentials and SPIR-FLAIR (Selective partial inversion recovery-fluid attenuation inversion recovery) MRI technique in differentiating between non arteritic ischemic optic neuropathy (NAION) from acute isolated optic neuritis (ON).

Thirty patients with acute optic neuropathy and 20 normal volunteers matched for age and sex were included. Optic neuropathy was classified as NAION and acute isolated ON according to the characteristic symptoms and signs. Visual evoked potentials (VEPs) were performed for patients and control groups. Fat and water suppression MRI examination of the optic nerve and MRI brain were done.

P100 latency and amplitude of VEPs in studied patients were significantly affected compared to control group. The 22 patients diagnosed clinically as acute isolated ON had significantly delayed P100 latency and higher amplitude in comparison to those diagnosed clinically as NAION. MRI of the optic nerve with abnormal signal diagnosed as acute isolated ON. In the two patients with history of head trauma, one of them had kinked optic nerve and the second one had carotid cavernous fistula compressing the optic nerve and they diagnosed as NAION.

VEPs can differentiate acute isolated ON from NAION. Fat and water suppression MRI technique of the optic nerve was positive in all patients with acute isolated optic neuritis and posttraumatic optic neuritis.

Key Words: Visual evoked potentials – SPIR – FLAIR – MRI – Acute optic neuropathies.

Introduction

OPTIC neuropathy is a frequent cause of vision loss encountered by ophthalmologist. The diagnosis is made on clinical grounds. The history and clinical signs often points to the possible etiology of optic neuropathy. But they were not sufficient, as disc swelling occurs in non arteritic ischemic optic neuropathy, in none demyelinating and in 35% of demyelinating type [1]. Visual evoked potentials (VEPs) and neuro-imaging of the brain and orbit is essential in many optic neuropathies [2]. VEPs are widely recognized as a sensitive measure of optic nerve demyelination and it has been shown to be more sensitive to resolve optic neuritis (ON) than magnetic resonance imaging (MRI). Also it is useful for the diagnosis of subclinical demyelination of the optic nerve but can not determine the length of the affected segment or the etiology of optic neuropathy [3].

Detecting such lesions on MRI offers a unique opportunity to explore pathology. Using conventional T1- and T2-weighted sequence is characterized by little success in detecting small intrinsic lesions of optic nerve due to the dominant high signal from surrounding orbital fat [2]. The combination of T2-SPIR and SPIR-FLAIR sequences to suppress the fat and perineural CSF were shown to be the most sensitive technique in the detection of abnormal optic nerve. SPIR-FLAIR sequence increases the ratio of signal intensities between neurotic and non neurotic segment, and allow more clear delineation of the optic nerve due to absence of signal from perineural cerebrospinal fluids [4].

However, VEPs and MRI are not performed routinely in clinical settings. In the present study we aimed to determining the role of the VEPs and T2-SPIR and SPIR-FLAIR MRI sequences in differentiating non arteritic ischemic optic neuropathy from acute isolated optic neuritis based on clinical assessment.

Material and Methods

Thirty patients with acute optic nerve affection within 4 weeks of onset were enrolled in this study. Their age ranged from 20 to 60 years with a mean age was 40±20, seventeen (56.7%) were females and thirteen males (43.3%). They admitted in Neurology Department, Assiut University Hospital.
Monocular signs presented in 24 (80%), 46.7% of them affect the right side. The diagnosis of optic neuropathy was based on the presence of characteristic symptoms (rapid reduction of visual acuity lasting more than a few days, defective color vision, pain on movement of the eye etc.) and signs (disc swelling, relative afferent papillary defect) [8]. Patients with NAION are usually over 50 years old and have systemic vascular risk factors such as diabetes, hypertension, and smoking. Severe disc edema or disc swelling was observed, recovery of vision was minimal, visual acuity was normal or severely affected and a variety of visual field defects were combined [6,7]. On the other hand, optic neuritis is more common in females with a peak age of onset between 30-40 years [8]. It is characterized by acute or subacute visual loss with central scotoma, the optic disc is normal in 65% of cases (retrobulbar neuritis) [9]. Patients with symptoms or signs suggesting other etiologies were excluded. Also patients with neurological, psychiatric or ophthalmic diseases must be excluded. Twenty healthy volunteers matched for age and sex as a control group was studied for VEPs. The study was done from January 2010 to March 2012.

VEPs assessment:

VEPs of the 30 patients and 20 controls were done. The filter frequency was 1-100 Hz, analysis time 300 ms. Responses to 100 stimuli were averaged and repeated 2-3 times to assess the trial to trial reliability. P100 was performed with best-corrected vision, and monocular stimulation of each eye was used. Pattern reversal stimuli were presented by means of a checkerboard displayed on a television screen. Subjects were instructed to fixate on a marker at the center of the screen. Fixation was monitored closely by the examiner throughout the entire testing period. The checkerboard reversed at 1/s, flash stimuli were delivered by photo stimulator held just in front of the patient eyes in 3 patients with severe visual affection. White light flashes of high intensity, at 1 Hz in a dimly illuminated room were used. Electrodes were attached with sticky conductive paste to the posterior scalp at Oz location according to the international 10/20 electrode placement system and referred to ears. The skin resistance under the electrodes was reduced with abrasive paste (Skin Pure) applied with cotton wool buds.

The following waves were analyzed in Oz location: The latency of the P100 wave and the amplitude (peak to peak from the preceding N75 wave). P100 latency and amplitude were compared to control group.

**Magnetic Resonance Imaging of the optic nerve and brain**

MRI was performed on a 1.5 T Philips units (Gyro scan). MRI was performed within 4 weeks of clinically fulfilled criteria of optic neuropathy, in Radiology Department of Assuit University Hospital. The coronal plane was chosen to minimize partial-volume effects. MRI protocol included: Axial T1 WI and sagittal T2 WI, axial and sagittal T2 SPIR, axial & sagittal SPIR-FLAIR sequences and axial FLAIR sequence of the brain. In all cases, T2-SPIR sequence (TR 2600 ms/TE 125 ms, 26 cm rectangular FOV, matrix 256 x 256, 3 mm interleaved contiguous slices). SPIR-FLAIR sequence (TR 10000 ms/TE 100 ms, 1 excitation (NEX), slice thickness 3 mm, gap 0.5 mm, FOV 24 cm, matrix 256 x 256, 2 acquisitions, 13 min imaging time). Both sequences provided coverage of the optic nerve from the globe to the chiasm. Intrinsic optic nerve lesions were classified by their longitudinal extent (number of slices), site (orbit, optic canal, intracranial optic nerve, optic chiasm).

**Data analysis**

All data were analyzed with the aid of SPSS program for windows version 16. The results were expressed as frequencies and mean ± SD. Independent samples test was used for comparison of means of patients and control groups also between patients with NAION and ON groups. p-value of <0.05 was considered significant for all statistical analysis.

**Results**

Demographic and clinical data were presented in Table (1). According to the clinical symptoms and signs, patients were classified into non arteritic optic neuropathy in 6 patients (20%) and optic neuritis in 22 (73.3%). Two (6.6%) patients had history of head trauma followed by progressive decrease in visual acuity; they aged eleven and 36 years old. Disc swelling in NAION present in 3 of 6 patients, pupillary reaction was abnormal in 5 patients and dyschromatopsia in all patients. Patients diagnosed clinically as acute isolated ON type showed disc swelling in 10 from 22 patients. Bilateral nerve affection occurred in 6, abnormal pupillary reaction in 18 patients. The 2 patients with history of head trauma had disc swelling, abnormal pupillary reaction and dyschromatopsia. VEPs of studied patients and control as described in Table (2). MRI pattern of the brain and optic nerve with T2 SPIR and SPIR FLAIR MRI showed that 24 (80%) patients had thickening and hyper-intense segment in optic nerve. The two patients
that had a history of head trauma, one had kinked optic nerve and the other had carotid-cavernous fistula. So they diagnosed as NAION after T2 SPIR and SPIR FLAIR MRI of the optic nerve. Three from the 6 patients diagnosed on clinical bases as NAION had small lacunars ischemic infarction in the white matter of per ventricular area and the remaining 3 patients showed no evidence of abnormalities in the optic nerve or brain. Out of 22 patients diagnosed by clinical presentation and

Table (1): Distribution according clinical presentation of the studied patients.

<table>
<thead>
<tr>
<th>Clinical presentation</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (Male/female)</td>
<td>13/17</td>
<td>43.3/56.7</td>
</tr>
<tr>
<td>Affected optic nerve right/left/bilateral</td>
<td>14/10/6</td>
<td>46.7/33.3/20</td>
</tr>
<tr>
<td>Non-arteritic optic neuropathy</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Post head trauma optic neuritis</td>
<td>2</td>
<td>6.6</td>
</tr>
<tr>
<td>Acute isolated optic neuritis</td>
<td>22</td>
<td>73.3</td>
</tr>
<tr>
<td>Visual acuity (normal/mild/severe)</td>
<td>2/18/10</td>
<td>6.6/60/33.3</td>
</tr>
<tr>
<td>Abnormal Visual field</td>
<td>18</td>
<td>60</td>
</tr>
<tr>
<td>Disc edema</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>Abnormal Color vision</td>
<td>16</td>
<td>53.3</td>
</tr>
<tr>
<td>Abnormal pupillary reaction</td>
<td>25</td>
<td>83.3</td>
</tr>
</tbody>
</table>

Table (2): VEPs of the studied patients and control.

<table>
<thead>
<tr>
<th>Visual evoked potentials</th>
<th>P100 Latency</th>
<th>P100 amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total patients (30)</td>
<td>133.5±18.3</td>
<td>5.2±1.6</td>
</tr>
<tr>
<td>Control group (20)</td>
<td>88.8±4.3</td>
<td>11.6±3.7</td>
</tr>
<tr>
<td>p-value</td>
<td>0.0001</td>
<td>0.002</td>
</tr>
<tr>
<td>Affected eye (3 6)</td>
<td>131.4±18.9</td>
<td>5.1±1.8</td>
</tr>
<tr>
<td>Non affected eye (24)</td>
<td>98.4±3.3</td>
<td>11.4±1.5</td>
</tr>
<tr>
<td>p-value</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>NAION &amp; post traumatic ON (8)</td>
<td>112±4.0</td>
<td>5.0±1.6</td>
</tr>
<tr>
<td>Optic neuritis (22)</td>
<td>138±18.5</td>
<td>7.5±1.4</td>
</tr>
<tr>
<td>p-value</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

P100 as acute isolated ON, 4 had scattered multiple sclerotic plaque in the brain. Optic nerve was thickened and hyperintense signals in 22 (73.3%), 3 (13.6%) out of them in the intracranial segment, 13 (59.1%) of them in the intra-orbital (Fig. 1), RT sided unilateral retrobulbar neurotic segment in 55 years old female patient and (Fig. 2), LT sided unilateral retrobulbar neurotic segment in 30 years old male patient and six (27.3%) in the intracanalicular portion.

Fig. (1-A.B.C.D):
- (A,B): Axial and sagittal T2 SPIR images revealed retrobulbar swollen neurotic segment exhibits hyperintense signal.
- (B,C): Axial and Sagittal SPIR-FLAIR images revealed retrobulbar neurotic segment exhibits hyperintense signal.
Discussion

Ischemia of the optic nerve can occur in different anatomical locations and can have a myriad of etiologies. It is helpful to classify these syndromes by location and etiology (if known). By definition, anterior ischemic optic neuropathy (AION) involves the 1mm segment of the optic nerve head, also known as the optic disc, and results in visible disc swelling. AION has two varieties. The first is non-arteritic (NAION) and the second is arteritic (AAION) and is almost always associated with giant cell arteritis. Posterior ischemic optic neuropathy (PION) encompasses those conditions that result in ischemia to any portion of the optic nerve posterior to the optic disc. By definition, PION will not cause disc edema. The vast majority of cases of NAION are idiopathic but some specific etiologies have been reported to be associated with NAION although in all of the cases, no causal relationship has been definitively established [9]. NAION presumed to result from a circulatory insufficiency, or infarct, within the retrolaminar portion of the optic nerve head that is supplied by the short posterior ciliary arteries (SPCA). Clinical and pathological evidence does not support arterial occlusion in NAION and they have theorized that NAION might result from venous insufficiency that occurs from closure of tributary venules receiving blood from optic nerve capillaries that drain into the central retinal vein posterior to the optic nerve head [10]. Patients with ON usually have a good visual prognosis but are at high risk for the development of multiple sclerosis. Patients with ischemic optic neuropathy have little prospect for improvement and have no risk for multiple sclerosis. Since therapy for each disorder differ, the differential diagnosis between the two conditions is very important. Most authors depend on clinical signs and symptoms in the differentiation. Ischemic optic neuropathy one of the easiest diagnoses to make in ophthalmology [11]. However symptoms and signs of the two disorders overlap sufficiently to blur their clinical distinction [12]. As in the present study, clinical examination showed disc swollen in only 3 out of 6 patients diagnosed as NAON. Also in the present study 10 (45.5%) from 22 patients diagnosed clinically as optic neuritis showed disc swelling. Also two patients diagnosed by MRI as NAON had history of head trauma and of young age with no history of hypertension or diabetes. Careful clinical evaluation is essential to rule in the diagnosis of optic neuropathy, but some additional tests particularly VEPs and neuro-imaging are very useful in the definite diagnosis [1].
Regarding P100 latencies and amplitude of VEPs in the present work, we founded that all patients had significant prolonged latency and lower amplitude in comparison to data of control group. Also there was significant prolonged latency and lower amplitude in affected eye in comparison to the non affected one. Patients diagnosed on clinical presentation as NAION including post traumatic patients (diagnosed as NAION in MRI) showed mild prolonged latency and lower amplitude with significant difference when compared to patients clinically diagnosed as ON, these finding reported by many authors as they recorded the same results [13]. Patients with a history of disseminated central nervous system disease had significantly longer VEPs latencies than the isolated ON cases when tested up to 4 weeks after the attack [14]. A marked reduction in the amplitude and small increases in the P100 peak latency in patients with ischemic optic neuropathy [15]. The combination of normal or mildly prolonged P100 latency was a possible indicator of ischemic optic neuropathy [16]. So most studies, reported a marked reduction of P100 amplitude that was greater in ION patients than in ON patients as presented in this work [17]. On the contrary, study reported that the amplitude of P100 showed no significant difference between ION and ON [18]. Visual evoked potentials were even more sensitive than MRI in detecting lesions and are still the investigation of choice in suspected demyelinating disease involving the optic nerve [2].

In the present study, T2-SPIR and SPIR-FLAIR MRI are a good diagnostic tool in patients diagnosed by clinical and VEPs as ON. As all patients had hyperintense segment in the optic nerve, four of them had silent multiple sclerotic plaques in the brain. Also it was important in the determining the length and anatomical site of the affected segment of the optic nerve. Hyperintense lesions were seen within all symptomatic nerves. Lesion length varied from one to 12 slices (3-36mm) [19]. High-resolution fat-suppressed technique is a useful new imaging in diagnosing optic neuritis and offers further improvement in localization of the symptomatic lesion [20]. So orbital fat suppression was effective, its sensitivity to lesions was better than that of conventional images, the increased resolution demonstrated potentially relevant anatomical detail and the area of tissue abnormality occasionally appeared more extensive, especially in the region of the intracanicular and intracranial segments, although it was evident that the inflammatory-demyelinating lesion in optic neuritis is most often found in the intraorbital portion. Regarding, MRI with fat suppressed technique role in the diagnosis of NAION, 8 patients in the present work diagnosed as NAION. One of them had kinked optic nerve and another one had carotid-cavernous fistula compressing the nerve, three patients had lacunars ischemic areas in the brain. So it is alone less efficient in the diagnosis of NAION. Optic nerve was abnormal in the clinically affected eye in 31 of the 32 ON patients but in only 5 of the 32 NAION patients [21]. Abnormal contrast enhancement of the optic nerve is a sensitive (94%) finding in acute optic neuritis and is absent in unaffected or previously affected optic nerves [22].

Conclusion:
From the present work we concluded that good clinical evaluation of symptoms and signs of optic nerve affection were important in the understanding of different types of optic neuropathy. VEPs were highly sensitive tool in diagnosis of optic neuropathy especially demyelinating type and can be used in differentiating acute isolated optic neuritis from NAION. T2-SPIR and SPIR-FLAIR MRI was sensitive technique for diagnosis of ON and determination of site and length of affected segment of the optic nerve and helping in diagnosis of some cases of NAION. So the combination of VEPs and T2-SPIR and SPIR-FLAIR MRI were good tools for differentiating between NAON and ON.

References


