Auditory and Somatosensory Evoked Potentials in Cerebrovascular Critical Care Patients: Early Prognosis and Outcome

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ABSTRACT

Background: the clinical assessment of neurocritical care patients is often limited by impaired consciousness because of either the primary disease or the use of drugs. Also, evoked potentials examinations are non invasive, easily repeated neurodiagnostic method and highly resistant to effects of medication. The aim this study was aimed to evaluate the prognostic value of somatosensory and auditory evoked potentials during the course of illness of patients suffering from cerebrovascular stroke (CVS) and its outcome. Methods: fifty two patients admitted to the neurocritical care unit of Ain Shams University Hospitals with cerebrovascular stroke were included (26 supratentorial infarctions, 18 supratentorial hemorrhages, and 8 infratentorial infarctions). To evaluate the clinical outcome guided by the Glasgow Coma Scale (GCS), median nerve evoked somatosensory (SEPs) and brainstem auditory evoked potentials (BAEPs), were conducted twice for all patients with two weeks interval. Results: Statistical correlations of the clinical outcome in 52 patient to the findings of SEPs and BAEPs revealed that SEPs correlated significantly with the outcome of the supratentorial group of patients with both hemorrhage and infarction, and the BAEPs inter-peak latency (I-III) results were correlated significantly with the outcome of the supratentorial group while the IPL (III-V) results of BAEP were significantly delayed in the supratentorial group of patients either with or without clinical neurological evidence of brainstem signs, but were of more significance in patients with brainstem signs. Conclusion: the SEPs and BAEPs results were of prognostic value in cerebrovascular stroke patients with supratentorial lesion while of less predictive prognostic value in patients with infratentorial lesion. (Egypt J. Neurol. Psychiat. Neurosurg., 2006, 43(1): 287-293)

INTRODUCTION

Evoked cerebral potentials median nerve evoked somatosensory and brainstem auditory evoked potentials have become a standard neurophysiologic method in intensive care patients and have proven to be reliable with respect to diagnostic and prognostic aspects of patients suffering from various forms of acute cerebral disease.

In the case of neurocritical patients, clinical assessment is often severely limited by impaired consciousness because of the primary disease process or the use of sedative drugs. Also, evoked potentials examinations are non invasive, easily repeated and highly resistant to effects of medication. They are also significantly correlated to the outcome as mentioned in previous studies. The improvement of wave form and latencies is usually parallel to clinical improvement, while deterioration should be a source of concern and prompts further evaluation. It was found that significant prolongation in wave (V) when intracranial pressure (ICP) exceeded 30 mmHg so that BAEPs changes are correlated with clinical neurological deterioration. Therefore, our aim is to evaluate the prognostic value of evoked potentials in CVS patients early in the acute stage of the course of illness.

PATIENTS AND METHODS

Fifty two adult patients admitted to the neurocritical care unit of the Neurology
Department, Ain Shams University, and diagnosed as acute cerebrovascular disease (within the first 24 hours of the CVS onset) were included.

Clinical and neurological evaluations were performed for all patients at the admission time, including assessment of the conscious level, brainstem signs and reflexes. Follow-ups were performed within two weeks from the start of the study. Computed tomography (CT) studies were done to all patients twice; on admission and at the end of second week. According to the clinical and radiological data the patients were allocated to the following subgroups, supratentorial infarctions (n=26), supratentorial non traumatic hemorrhages (n=18), and infratentorial infarctions (n=8). Clinical status of all patients was documented on admission according to Glasgow Coma score scale and classified into two groups; the first is good outcome group (clinical improvement), and the second is poor outcome group (clinical deterioration and death).

All patients were treated with standard medical procedures for acute stroke patients. Artificial respiration was performed in the presence of insufficient respiratory function and sedatives were given according to the clinical criteria (provided that it would not interfere with the interpretation of SEPs or BAEPs results). Evoked potential testing including SEPs and BAEPs on admission and the end of second week was performed.

**Methods:** BAEP testing was performed with recording electrodes placed as one active electrode placed at the scalp vertex (Cz), one reference placed at the ear lobe, and ground electrode placed on the middle of forehead. The impedance level was to be kept below 10 Kohm; click hearing threshold was pressured for both ears separately. Mononeural activity stimuli consisting of refraction clicks of 0.1 msec. Square wave pulses were delivered through the ear phones at a rate of 1 sec. the intensity clicks were adjusted to be 70 db above normal hearing threshold. Recording filters were 100-3000 Hz and 2000 stimuli were delivered. The response picked up by recording electrodes, summated and averaged, and displayed on the screen. The results were graded as: 1. Normal response, 2. unilateral or bilateral prolonged interpeak latencies between (I-III), and (III-V) waves beyond 2 standard deviations of the mean value of control group, 3. abnormal left-right ear differences beyond 2 standard deviations of the mean value of control group, 4. absent wave (III-V)³. SEPs from median nerve were recorded with surface electrodes placed along the elicited nerve pathway to the cortex. The nerve plexus, the spinal cord and scalp area. The recording electrodes were placed as: Two electrodes placed over both right-left Erb's point, one surface electrode placed at fifth spinous process, two surface scalp electrodes over ipsilateral and contralateral C3 and C4, and surface electrode over Fz (C3 – C4, Fz position of international 10-20 system), ground electrode placed on the forearm between the stimulator and recording electrode. The Erb's point potential N9 is the principal negative wave (Erb's ipsilateral is the active electrode, and Erb's contralateral is the reference electrode). N13 component is negative potential in the C5 spine and Fz channel (fifth spinous process is the active electrode, and Fz is the reference electrode). N20 is a negative component in the C-Fz channel (contralateral scalp electrode is the active electrode and F2 is the reference electrode). The impedance was to be kept below 10 Kohm to avoid undesired interferences. The median nerve stimulated at wrist, and the intensity of the stimulus was to be kept sufficient to elicit visible twitch of the intense muscle. Two hundred responses were averaged for each SEP measurement. The latencies of N13 and N20 and interpeak latencies of N13-N20 were measured. N13-N20 is the interpeak cervical potential (N13) to that of cortical potential (N20) was taken to be central conduction time.

**RESULTS**

Among the 52 patients included in this work, 24 were males, while 28 were females, with a
mean age of 55 years. They were classified according to clinical neurological and radiological assessment into three different clinical diagnoses. Data of clinical improvement and deterioration is summarized in Table (1).

The SEPs from the upper limbs were graded as: 1. normal response, 2. unilateral or bilateral prolonged N_{13}-N_{20} interpeak latency (IPL) beyond 2 standard deviations of the mean value of the control group, 3. abnormal left-right difference of the N_{13}-N_{20} IPL beyond 2 standard deviations of the mean value of the control group, 4. absence of cortical N_{20} peak (Figs. 1-3).

Significance is determined based on the p-value, where p<0.05 means that the correlation is significant.

The somatosensory results were significantly correlated with the supratentorial infarction and hemorrhage group of patients' outcome, while not significantly correlated with the infratentorial infarction group of patients' outcome (Table 2).

BAEP IPL (I-III) results significantly correlated with the supratentorial group of patients' outcome, and insignificantly correlated with the infratentorial group outcome, while the IPL (III-V) results insignificantly correlated with the outcome of all patient groups (Table 3).

IP Latency (III-V) was significantly more delayed in patients with supratentorial group with clinical brain stem signs (Table 4).

Table 1. Frequency of significant clinical deterioration diagnosis.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Total Number of Patients</th>
<th>Number of Patients with Clinical Improvement</th>
<th>Number of Patients with Clinical Deterioration and Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supratentorial infarction</td>
<td>26</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>Supratentorial hemorrhage</td>
<td>18</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Infratentorial infarction</td>
<td>8</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

Fig. (1): Normal latency and amplitude of brainstem auditory evoked potentials (BAEP) and somatosensory evoked potentials (SEP).
Fig. (2): Unilateral pathologic latency of brainstem auditory evoked potentials (BAEP) IPL III-V and unilateral prolonged N13-N20 interpeak latency of somatosensory evoked potentials (SEP).

Fig. (3): Unilateral loss of brainstem auditory evoked potentials (BAEP) and somatosensory evoked potentials (SEP).

Fig. (4): Bilateral loss of brainstem auditory evoked potentials (BAEP) and cortical somatosensory evoked potentials (SEP).
Table 2. Correlation of SEPs results, with the outcome of: supratentorial infarction, hemorrhage, and infratentorial group.

<table>
<thead>
<tr>
<th></th>
<th>IP latency (N\textsubscript{13}-N\textsubscript{20})</th>
<th>Cortical Latency (N\textsubscript{20})</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supratentorial infarction</td>
<td>P= 0.005</td>
<td>P=0.002</td>
<td>H.S</td>
</tr>
<tr>
<td>Supratentorial hemorrhage</td>
<td>P= 0.000</td>
<td>P=0.000</td>
<td>H.S</td>
</tr>
<tr>
<td>Infratentorial infarction</td>
<td>P= 0.100</td>
<td>P=0.400</td>
<td>N.S</td>
</tr>
</tbody>
</table>

Table 3. Correlation of brainstem results, with the outcome of: supratentorial infarction, hemorrhage, and infratentorial group.

<table>
<thead>
<tr>
<th></th>
<th>(I-III) ILP</th>
<th>Significance</th>
<th>(III-V) ILP</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supratentorial infarction</td>
<td>P= 0.010</td>
<td>H.S</td>
<td>P= 0.700</td>
<td>N.S</td>
</tr>
<tr>
<td>Supratentorial hemorrhage</td>
<td>P= 0.000</td>
<td>H.S</td>
<td>P= 0.600</td>
<td>N.S</td>
</tr>
<tr>
<td>Infratentorial infarction</td>
<td>P= 0.500</td>
<td>N.S</td>
<td>P= 0.080</td>
<td>N.S</td>
</tr>
</tbody>
</table>

Table 4. Comparison between the supratentorial group with no clinical brainstem signs and with clinical brainstem signs, using BAEP IPL (III-V).

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>IP Latency of Wave (III-V)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Supratentorial group without clinical brainstem signs</td>
<td>34</td>
<td>1.5</td>
</tr>
<tr>
<td>Supratentorial group with clinical brainstem signs</td>
<td>10</td>
<td>1.7</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The value of evoked potentials for assessment of functional impairment of afferent pathways has been documented in a large number of studies in patients suffering from non-traumatic cerebral disease\(^9\). It is generally held that SEPs and BAEPs are both reliable methods for the assessment of functional impairment of the respective afferent pathways and SEPs, are valuable indicators of supratentorial functional impairment while BAEPs are the indicative of the extent of infratentorial damage\(^10\,11\,13\).

The current study shows a significant correlation between SEP results of N\textsubscript{13}-N\textsubscript{20} IPL and the cortical N\textsubscript{20} latency during the first and second week follow up examination in the supratentorial group of patients with both hemorrhages and infarctions. This means that SEPs results have prognostic value regarding the clinical outcome in the supratentorial group, but not in the infratentorial group, table (2). Similar results were shown in earlier studies\(^12\,9\). They all reported that SEPs could be taken as a good marker of prognosis, and that the prognostic statement of the first SEP is most valuable to determine prognosis as soon as possible during the early course of the disease.

SSEPs did not correlate with the infratentorial group of patients’ outcome. These results while not in agreement with previous studies\(^12\,9\), who found significant correlation between SEPs and the infratentorial group outcome. But are in agreement with Shimbo et al.\(^13\), who reported that abnormal SEPs and BAEP were associated with lesions involving the pontine tegmentum, and that the abnormalities in wave (V) in BAEPs and N\textsubscript{20} in SEPs are associated with a
localized overlapping area in the pontine tegmentum contralateral to the stimulation and coincidence with the location of the lesion in medial lemniscus attribute.

With regards to BAEP, the results of (I-III) IPL were significantly delayed in patients with supratentorial lesions. This agrees with the findings of a previous study\(^9\), who reported that this finding implies that BAEPs are valuable for detection and localization of brainstem lesions but doesn't predict the outcome early in the disease. An earlier study\(^\text{14}\), reported that BAEPs changes are frequent and transient in origin and are mainly related to an increase in temperature and drugs, and could be reversible. Therefore, absence of BAEP abnormalities denotes sparing and integrity of the auditory pathways but doesn't exclude bad prognosis\(^\text{15}\).

The IPL of (III-V) results insignificantly correlated with the outcome of the three groups of patients, but were useful in follow up of patients with supratentorial lesions with or without clinical brainstem signs of compression; which means that BAEP results have prognostic value regarding the clinical outcome in the supratentorial group, but not in the infratentorial group, table (3). This is in agreement with the previous study\(^\text{16}\), who reported that BAEPs testing provides relevant prognostic information, since improvement of graded BAEPs. This indicates a favorable outcome and progressive deterioration showing irreversible damage. This is because the upper brainstem function in the acute phase of supratentorial mass lesion compression results in secondary vascular damage and consequent BAEPs deterioration during later clinical course. Therefore, BAEPs could be used as a valuable predictor before irreversible damage to brainstem occurs\(^\text{16}\).

Previous serial studies reported that the reversibility of BAEPs IPL (III-V) abnormalities suggest more topographic displacement of BAEP generators than ischemic induced extinctions. Therefore, BAEPs IPL (III-V) can be used to assess reversible brain damage and reliably monitor the effect of therapy\(^\text{17}\). Thus, we conclude from this study that SEPs and BAEPs results are independent of each other in their diagnostic and prognostic implications because they measure different functions of the brain, and that SEP and BAEP data together provide superior statements compared to these derived from each modality alone.

Our study confirms that both SEPs and BAEPs results are predictive to the prognosis and the outcome early in the acute stage of the CVS patients with supratentorial lesion but not with the infratentorial group of patients.

### REFERENCES


الملخص العربي

يحقق التقييم الكلييني لمرضى رعاية الأعصاب الحرجة ضعف وعيهم وذلك قد يكون بسبب حالتهم نفسها أو نتيجة استخدام بعض العناصر. تصل فحوصات الجد المستشار للمخ من وسائل التشخيص الغير مناعية كما يمكن تكرارها عددا من المرات ولا تتأثر بالعلاجات الطبية. يهدف هذا البحث إلى تقييم قدرة فحوصات الجد المستشار لتجزئة المخ ومسار الحس.

ت stron هذه الدراسة على 52 من مرضى السكتة الدماغية في رعاية الأعصاب الحرجة بجامعة عين شمس. وقد تم تقسيم هؤلاء المرضى إلى 26 مريض بحلقة ما فوق خيمة المخيخ و 18 مريض ينفي باسل خيمة المخيخ و8 مرضى بحلقة بما أسفل خيمة المخيخ. وقد تم تقسيم حالة هؤلاء المرضى كليينيًا باستخدام مؤشر جلاسجو للجهاز وفحوصات الجد المستشار للمسار الحس عن طريق العصب الأول وتلك لجذع المخ في مرتين بينهما أسبوعين.

نتائج البحث: أظهرت نتائج فحوصات الجد المستشار للمسار الدماغي أنها متوازنة مع مال مرضى السكتة الدماغية بنوعيا، وأن نتيجة الجد المستشار لجذع المخ (III-V) كانت مستقرة مع مال مرضى السكتة الدماغية ما على خيمة المخيخ وبينما أظهرت نتيجة الجد المستشار لجذع المخ (III-V) تأثيرها في بعض مرضى السكتة الدماغية ما على خيمة المخيخ بعد بعض المراحل وجود أو عدم وجود علامات كليوباتridية لإصابة جذع المخ. كانت هذه النتائج أوضح في مرضى السكتة الدماغية ما أسفل خيمة المخيخ.

المتسللين من هذا البحث أن استخدام كلا الفحصين للجد المستشار للتخيان في مرضى السكتة الدماغية ما أسفل خيمة المخيخ على خيمة المخيخ أكثر من فعالية في مرضى السكتة الدماغية ما أسفل خيمة المخيخ.