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Oleksandr O. Zhukovskyi,
MD, associate professor;

Olena O. Filipets,
MD, assistant professor,
Bukovinian State Medical University

The Role of Evoked Brain Potentials in Dynamic Follow-Up in Patients with Mild Traumatic Brain Injury

Key words*: Mild traumatic brain injury, evoked potentials.*

Annotation: *The thesis presents the results of visual, brainstem auditory and cognitive evoked potentials testing in patients with brain concussion and mild brain contusion in the first 24 hours after head trauma and in dynamic follow-up on the 5th and the 10th day after mild traumatic brain injury.*

Background. Traumatic brain injury (TBI) is one of the most actual problems in neurology and neurosurgery. The estimated annual incidence of TBI in different regions of Ukraine varies from 1.6 to 4.0 per 1000 population. The most frequent type of head trauma is mild TBI which accounts for 70-80% of all TBI cases. For a long period of time mild TBI had been underestimated as it remained in the shadow of more dramatic severe head injury. However the high prevalence of not only mild TBI but also of its consequences turns it into independent medical and social problem requiring special attention.

Brain concussion and mild brain contusion are the mild forms of TBI which are characterized by short-term reversible impairment of neurological functions, so objective diagnostic methods for mild TBI need further study and improvement.

One of the possible pathophysiological mechanisms of traumatic brain damage is diffuse axonal injury. Head trauma is followed by brain motion in cranial cavity and acceleration/deceleration or rotational injuries of axons. More mobile cerebral hemispheres move ("twist") against relatively fixated brain stem. This leads to stretching and torsion of long axons which connect brain cortex and subcortical structures with brain stem. It immediately violates the function of ascending activating reticular formation and results in loss of consciousness. In case of mild TBI this process is restricted to invertible disturbance of axonal function.

Taking into consideration that there are particularly no signs of organic lesion in mild TBI, it is important to diagnose this pathology with the method that characterizes the functional state of neuronal pathways and allows for more precise localization of traumatic damage. Thus, evoked potentials (EPs), or evoked responses can help in assessment of higher cortical functions impairment in patients with mild TBI.

The aim of research. In our study we aimed to determine the dynamics of visual, brainstem auditory and cognitive EPs in patients with brain concussion and mild brain contusion.

Materials and methods. We have examined 37 patients with mild TBI aged 19-45 years, including 8 women and 29 men. 25 patients were diagnosed with brain concussion and 12 patients had mild brain contusion. The causes of trauma in most cases were intentional injuries and motor vehicle collisions. All patients were examined thrice: during the first 24 hours after head trauma, on the 5^{th} day after trauma, and after treatment period (on the average the 10^{th} day after injury). The fifth day was chosen according to the current concepts of pathogenesis of mild TBI which state that metabolic changes in the brain are critical in this period. The basic therapy of TBI included standard prescription of analgesics, sedatives, nootropic drugs, and diuretics.

The results of patients with trauma were compared to the control group which comprised 15 practically healthy individuals comparable by age and sex.

EP testing was performed on multifunctional computerized complex "Neuro-MVP". Visual EPs were tested with flash stimulation (1 Hz stimulus rate) and checkerboard pattern with rectangle shape of stimulus. Brainstem auditory EPs were recorded in a 2-channel montage with a sound signal of 85 dB. For cognitive EPs examination we used "significant" stimuli, e.g. signals with frequency rate 2000 Hz and probability of delivery up to 30%, as well as non-significant stimuli with frequency rate 1000 Hz and probability of delivery from 70%. Electrodes were placed according to international scheme "10-20". All components of EPs were separated and marked according to standard criteria accepted in neurophysiology. The results were assessed by the shape of the curve, the presence of all components, indexes of latent periods and the amplitudes of potential components. The data were evaluated statistically with Student's t-test (significance level α=0.05).

Results and discussion.

The results from the analyses of visual EPs in response to flash of light the first 24 hours after head trauma have shown statistically significant elongation of the approximate peak latency of the late component in patients with brain concussion and mild brain contusion ($p<0.05$). The existing data suggest that the late components of visual EPs are generated by the afferent inflow from reticular formation, thalamic nuclei, mediobasal parts of limbic cortex of temporal and frontal lobes. The late components of visual EPs with approximate peak latency more than 100 ms comprise non-specific component of response. Taking into account their high sensitivity to alterations of consciousness, attention, emotional state, functional activity of brain, we may conclude that our patients with mild TBI had changes in limbic-reticular system of brain. The shape of the curve of visual EPs was characterized by confluence of the late components N2, P3, N3 into one continuous negative wave. The P4 and N4 components were not taken into consideration because of their inconstancy and optionality in visual EPs examination. No disturbances of latent periods and amplitude changes of early and middle components (they reflect visual nerves conductivity) were found.

On the 5^{th} day after brain concussion the visual EPs patterns have demonstrated gradual decrease of duration of the latent period. After the course of treatment the latency of the late components of visual EPs approximated to the normal levels ($p>0.05$). However in 10% patients with brain concussion substantial improvement was not observed.

Patients with mild brain contusion have shown similar tendencies but the regress of latency indexes of the late EPs components was slower. We consider the decrease of latency duration of the late EPs components as a sign of reversibility of diffuse axonal injury process in mild TBI.

The results of visual EPs assessment are presented in Table 1.

Table 1

Peak latency of the late components of visual evoked potentials after mild traumatic brain injury (ms)

	1st day		**5th day**		**After treatment (10th day)**		**Control group**
Component	BC	MBC	BC	MBC	BC	MBC	
N2	153.4±2.9 p<0.05	165.4±2.4 p<0.05	143.3±3.7 p<0.05	161.7±4.1 p<0.05	135.4 ±3.6 p>0.05	146.4 ±3.6 p<0.05	128.5±3.4
P3	179.3±3.3 p<0.05	185.3±3.6 p<0.05	175.3±3.6 p<0.05	181.3±3.3 p_1<0.05	165.3±3.7 p>0.05	174.3±4.1 p<0.01	162.7±2.8
N3	189.5±2.8 p<0.05	196.7± 4.1 p<0.05	183.4±3.3 p>0.05	188.2±4.3 p<0.05	179.9±3.5 p>0.05	184.9±3.6 p<0.01	174.3±3.2

BC – patients with brain concussion; MBC – patients with mild brain contusion; p – significance of differences in comparison with control group.

For evaluation of the functional state of the brain stem we have used the method of brainstem acoustic EPs. Normal acoustic EPs consist of 5-7 peaks. The first two peaks are peripheral and they reflect the condition of distal and proximal parts of acoustic nerve. The rest of components are generated by brainstem structures. Examination of brainstem acoustic EPs in patients with mild TBI has not revealed any statistically significant differences in latent periods of components in comparison to the corresponding indexes in healthy individuals (p>0.05). The analysis of data in dynamic observation has not shown any pathological deviations in patients with brain concussion and mild brain contusion.

The results of our study are not contrary to the current opinion about pathogenesis of mild TBI, and particularly of the theory of diffuse axonal injury when the pathological changes involve only long axons and do not affect fixated brain stem. It should be also considered that brainstem acoustic EPs reflect the function of conducting sound on a rather limited area. Lesions of the other levels of brain stem may not substantially influence the values that are measured in the present study.

In clinical presentation of mild TBI cognitive impairment is one of the leading manifestations. However, the presence and the level of severity of cognitive impairment are rather hard to determine.

Aiming to assess the state of higher cerebral functions we used the method of detection of cognitive EPs which are related to thinking. This technique is based on the appearance of the late component P300 with approximate peak latency about 300 ms. This component on the potential curve is connected with recognition, memorization and estimation of stimuli.

The analysis of cognitive EPs in the first 24 hours of head trauma in patients with brain concussion and mild brain contusion has demonstrated statistically significant elongation of P300 latency (p<0.05). These changes indicate disturbances of higher cerebral functions id

patients with TBI. We consider elongation of P300 latency and decrease of it's amplitude as a sensitive indicator of cognitive impairment in patients with mild neurotrauma. The changes of cognitive EPs is related to difficulties in differentiation and recognition of signals, violation of the mechanisms of operative memory, directed attention and increased patient distraction.

Table 2

P300 latency after mild traumatic brain injury (ms)

	1st day		**5th day**		**After treatment (10th day)**		**Control group**
Component	BC	MBC	BC	MBC	BC	MBC	
P300	325.6±2.3 p<0.05	334.8±2.6 p<0.05	332.3±3.6 p<0.05	342.5±2.8 p<0.05	318.4±3.4 p<0.05	146.4±3.6 p<0.05	328.1±4.6 p<0.05

BC – patients with brain concussion; MBC – patients with mild brain contusion; p – significance of differences in comparison with control group.

On the 5th day after head trauma in patients with brain concussion and mild brain contusion we have observed an increment of P300 latency. In our opinion the underlying cause of these changes is a gradual destructive process in nervous tissue resulting from trauma. After the course of treatment on the 10th day of mild TBI the P300 latency has shown the tendency to decrease. Despite the positive dynamics in these groups, P300 values after treatment were higher in comparison to control group ($p<0.05$). The indexes of P300 latency can be considered as the objective criterion of treatment efficacy of cognitive impairment.

Conclusions. 1. Evaluation of visual EPs in the first 24 hours of mild TBI has shown statistically significant elongation of the latency of late components of visual EPs with the further regress of these values.

2. Assessment of the brainstem acoustic EPs in patients with mild TBI has not shown any changes in EPs pattern.

3. According to the results of cognitive EPs testing the most pronounced impairment of higher cerebral functions in patients with brain concussion and mild brain contusion was observed on the 5th day after head injury.