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The Role of Visual Evoked Potentials in the Diagnosis of Optic Nerve Injury as a Result of Mild Head Trauma

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A B S T R A C T

The curve of visual evoked potentials was observed and compared with changes of visual acuity and visual field during a 24-month period in a group of 39 patients with optic nerve injury as a result of mild cerebral trauma. Results of the study showed great improvement of visual acuity and visual field after treatment, and slower and continuous improvement of visual evoked potentials. The main abnormality of visual evoked potentials is the shortening of amplitude, which is recorded to gradually recede after treatment in half of the patients. Authors conclude that the shortening of amplitude can be partially explained by the edema and the compression of fibers in the optic canal. Also, they emphasize that in this type of optic nerve injury visual acuity testing is the best indicator of the promptness and scope of the injury, while visual field research presents the best method for following later delicate changes of visual function.

Introduction

Term cerebral trauma, or craniocerebral lesion, includes variety of injuries of different cerebral structures and compositions. Often, external head lesions and cranial lesions do not correspond to internal lesions of the brain and its capsule, of cranial nerves and circulatory system.

In recent years, owing to modern diagnosis, epidemiological and pathological researches, as well as new treatment approaches, we've learned much about severe craniocerebral lesions and its surgical treatment and nonsurgical methods of treating these types of lesions in all phases of the disease. As opposed to that, mild head lesion was traditionally given less attention, even though it presents a great problem to neurosurgeons, sur-

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geons, neurologists, psychiatrists, and recently to neuroophthalmologists[1].

Great number of patients with mild cerebral trauma develops firm uniform symptoms, most often the subtle neurophysiological and neuropsychological deficit, resulting in illness. This illness is a great psychological factor which complicates practitioners' work in the sense of evaluation, precise diagnosis, treatment selection, and, especially, in the field of legal medicine qualification of the injury and patient's strains to return to normal life. It is well known that blunt cerebral lesion, causing in appearance trivial damages of the head, can lead to visual deterioration or even loss of vision, as a result of the optic nerve damage[2].

According to the nature of the optic nerve damage and often legal aspect of the case, the aim of this study was to show the importance of visual evoked potentials (VEP) in the diagnosis and treatment of optic nerve damages in cases of mild cerebral trauma, in comparison with the changes of visual acuity and visual field.

Patients and Method

The research included following diagnostic procedures: visual acuity determination, determination of visual field and visual evoked potentials.

Visual acuity of each patient in the control group was determined, as well as of every patient with optic nerve injury in every phase of treatment, by subjective method and monocular approach, with and without correction glass, by means of standard 6-m Snellen's test types[3]. Visual field tests were conducted on standard Goldmann projection perimeter by kinetic perimetry in photopia.

When VEP was detected, we used chessboard stimulus, which is believed to be of greater clinical help giving more reliable curve generated by this stimulus. Here, instead of bright flashes of light we have rotation of repetitive sample of bright and dark chessboard fields in 1.1-Hz phases.

We used chessboard field of 16 × 12 angle minutes at a distance of 110 cm. Patient's pupils were not dilated. As a stimulant we used visual control stimulator with its computer, and chessboard field rotation. The sum of applied light was constant enabling the recording of contrast response.

VEP tests were carried out at the Clinic for Neurology of Zagreb Medical faculty, in neurophysiological laboratory for sensorimotor functions and computer analysis of neurophysiological data. Tests were conducted on BIO-LOGIC BRAIN ATLAS unit.

In the study we present the results of the research conducted on 39 patients with indirect optic nerve injury achieved by observing visual acuity, visual field and VEPs at three different periods: during clinical treatment, 6 months after treatment, and 18–24 months after treat-

TABLE 1
LABORATORY STANDARDS

	WF latency	WF amplitude	HF latency	HF amplitude
Mean value	103.481	12.2037	103.870	9.2870
SD	4.330	3.8724	4.705	3.1357
Mean value –2.5 SD	92.658	3.5227	92.109	1.4477
Mean value +2.5 SD	114.305	22.8847	115.632	17.1263

WF-whole field, HF-half field

ment. The research did not include patients with refraction bigger than 2 D and patients suffering from other ophthalmic and general pathological states, which could affect the analysis of this study[49–51].

Control group included 35 healthy people without ophthalmic disturbances. They all had visual acuity of 1.0 or 6/6 without correction or with correction smaller than 2 D. We tested their visual fields and they were all normal, e.g. according to anticipated modalities they were marked 0. In neurophysiological laboratory at the Clinic for neurology of Medical faculty, they were subjected to VEP tests and the achieved results corresponded to laboratory standards.

To get statistical values, we analyzed the results of the diagnostic research according to few variables. We compared visual acuity results before treatment (phase A), 6 months after treatment (phase B), and 18–24 months after treatment (phase C). At the same time we compared visual field and VEP results. We used two comparisons. First, we compared parameters (for example, arithmetic mean, standard deviation, median, grade, interquartile grade, inferior and superior quartile) of each group of patients. Then, we determined the impact of visual acuity and visual field on visual evoked potentials by means of multivariate studies. This is how we determined how visual acuity (independent variable) and visual filed (independent variable) influence visual evoked potentials (dependent variable). This research was done by the method of the smallest squares. Calculations were done using statistic package Statgraphic. Estimations were done in each research phase. Types of defects of the visual field are presented in numbers in Table 2, and disturbances of VEP detection in Table 3.

TABLE 2
VARIATIONS OF VISUAL FIELD ACCORDING TO GOLDMANN

0	findings within the physiologic range
1	initial downward isopter depression
2	initial downward isopter depression below 40°
3	initial reduction of all isopters and of I^1 below 10°
4	as in 3 with downward isopter depression of <30°
5	as in 4 with contraction of I_1 isopter below 5°, blind spot strarts to extend
6	major concentric reduction of all isopters within 30°, blind spot extended
7	as in 6, I_1 hardly registers with pronounced depression nasally and temporally, extended blind spot
8	as in 7 with central scotoma and/or absence of I_1 and I_2
9	visual field cannot be tested due to amaurosis or light perception

TABLE 3
MODALITIES OF DEVIATIONS IN VEP DETECTION

0	normal findings
1	shorter amplitude, other components normal
2	longer latency, other components normal
3	shorter amplitude, longer latency
4	as in 1 and/or 2, morphology of the wave changed

Results

The results of the research, presented in Table 4, show relevant clinical data of 39 patients with optic nerve injury. Tables 5, 6 and 7 show some statistical indicators of dynamics of changes of visual acuity, visual field and VEP in three observed periods (A,B,C).

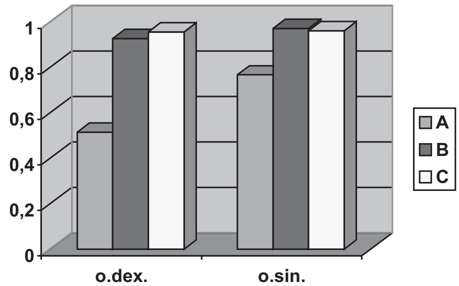

Fig. 1. Parallel test of mean values of visual acuity in right and left eye in three observed periods (n=39).

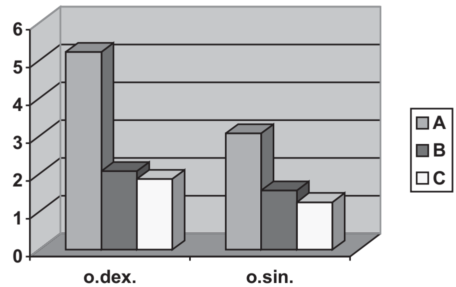

Fig. 2. Parallel test of mean values of visual field in right and left eye in three observed periods (n=39).

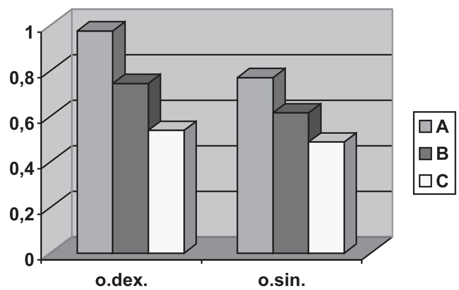

Fig. 3. Dynamics of the mean value of VEP in three observed periods (A,B,C) in the group of patients with optic nerve injury (n=39).

Discussion and Conclusion

It is not rare to have a patient complaining of sudden loss of vision, while fundus check gives normal vision. The diagnosis would be the optic nerve affection. In order to evaluate the optic nerve condition it is important to check visual function. Testing techniques can be divided into two categories. There are quite simple procedures that can be performed at clinics or in outpatient departments. These are: tests for visual acuity color vision, and pupil reaction to light. Besides these procedures, there are more complicated methods that require more time, knowledge, and sophisticated apparatus. These methods include, for example, visual field testing by quantitative light perimetry on hemispheric perimeter and visual evoked potentials. Simple methods used for early neuroophthalmologic evaluation of the optic nerve function are sometimes inadequate for determination of the delicate, unrecognizable vision disturbances.

There have been several methodical researches dealing with the results of possible correlation between individual procedures determining the function of the optic nerve, as visual acuity, color vision, pupils' reactions, appearance of the optic nerve papilla and sensibility to brightness[4–6]. In some researches, visual acuity and visual evoked potentials were proportional, especially in children[56,57], while in other researches in proportion were visual field and visual evoked potentials[7,8].

Some believe that visual evoked potentials present the useful method of con-

TABLE 4
CLINICAL DATA OF PATIENTS WITH OPTIC NERVE INJURY (NO., AGE, SEX)

			A						B						C					
			o.dex			*o.sin*			*o.dex*			*o.sin*			*o.dex*			*o.sin*		
No.	age	sex	Var1	Fvar1	Vepr1	Vas1	Fvas1	Veps1	Var2	Fvar2	Vepr2	Vas2	Fvas2	Veps2	Var3	Fvar3	Vepr3	Vas3	Fvas3	Veps3
1	41	m	0.2	7	1	1	1	0	1	2	0	1	0	0	1	2	0	1	0	0
2	32	m	0.1	8	1	1	1	0	0.8	2	1	1	0	0	1	2	0	1	0	0
3	23	m	0.3	7	3	1	2	1	1	1	1	1	0	0	1	1	1	1	0	0
4	19	f	0.5	6	1	1	1	0	1	0	1	1	0	0	1	1	0	1	0	0
5	28	m	0.3	7	3	1	0	0	0.8	2	1	1	0	0	0.8	2	1	1	0	0
6	19	m	0.2	7	1	1	0	0	1	2	1	1	0	0	1	1	0	1	0	0
7	41	m	0.6	6	1	1	1	0	1	1	0	1	0	0	1	1	0	1	0	0
8	45	m	0.5	6	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	1
9	38	f	0.1	7	1	1	1	1	1	2	1	1	0	1	1	2	1	1	0	1
10	26	f	0.05	8	1	1	0	1	0.8	3	1	1	0	1	0.8	3	1	1	0	1
11	29	m	0.01	9	1	1	0	1	0.5	4	1	1	0	1	0.4	4	1	1	0	1
12	33	m	0.4	6	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0
13	28	m	0.8	5	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0
14	30	f	1	0	0	0.6	5	1	1	0	0	1	2	0	1	0	0	1	3	0
15	34	m	1	0	0	0.2	7	1	1	0	0	0.8	3	1	1	0	0	1	1	1
16	48	f	1	0	0	0.1	7	1	1	0	0	0.8	2	0	1	0	0	0.8	2	0
17	51	m	1	2	1	0.05	7	1	1	1	1	0.4	4	1	1	1	1	0.6	2	1
18	40	m	0.4	7	1	0.5	6	1	1	2	1	1	1	1	1	2	1	1	2	1
19	32	m	0.1	7	1	1	0	1	0.8	3	1	1	0	1	0.8	3	1	1	0	1
20	27	m	0.2	7	1	1	1	1	0.8	3	1	1	1	1	1	2	0	1	1	0
21	32	m	0.2	7	1	0.4	6	1	0.8	4	1	1	3	1	0.8	3	0	1	1	0
22	22	f	0.1	7	1	1	3	1	0.8	4	1	1	2	1	0.8	4	1	1	2	1
23	18	f	1	2	1	0.6	4	1	1	2	1	1	3	1	1	2	1	1	2	1
24	28	m	1	3	1	0.4	5	1	1	2	1	1	3	1	1	2	1	1	2	1
25	43	m	1	2	1	0.4	7	1	1	1	1	1	3	1	1	1	0	1	3	0
26	19	f	1	2	1	0.1	8	1	1	1	1	0.8	4	1	1	1	0	1	2	0
27	26	m	0.2	7	1	1	2	1	0.8	4	1	1	2	1	1	2	1	1	1	1
28	24	m	0.1	8	1	1	3	1	1	4	1	1	2	1	1	3	1	1	2	1
29	51	m	0.05	8	1	1	1	1	0.6	3	1	1	1	1	0.8	3	1	1	1	1
30	32	f	0.6	6	1	1	2	0	1	3	0	1	2	0	1	3	0	0	1	0
31	29	m	1	2	0	0.8	5	1	1	1	0	1	3	0	1	1	0	1	3	0
32	40	m	1	2	1	0.2	7	1	1	1	0	1	3	0	1	1	0	1	3	0
33	35	m	1	2	1	0.1	8	1	1	2	1	1	4	1	1	2	1	1	3	1
34	23	m	0.4	7	1	1	2	1	1	3	1	1	1	1	1	3	1	1	1	1
35	21	f	0.2	8	1	1	2	1	0.8	4	1	1	2	1	1	3	1	1	2	1
36	18	f	1	2	1	0.6	5	1	1	2	1	1	3	1	1	2	1	1	3	1
37	27	m	1	2	1	0.8	5	1	1	2	1	1	3	1	1	2	1	1	3	1
38	33	m	0.3	7	1	1	2	1	1	3	0	1	1	0	1	2	0	1	1	0
39	28	m	0.1	8	1	1	2	1	0.8	4	1	1	2	1	1	3	0	1	1	0

VAR1 = visual acuity of the right eye in the first observed period; mark 2 stands for the same variable in the second observed period (B) and mark 3 for the same variable in the third observed period (C);
VAS1 = the same as VAR, but for the left eye;
FVAR1 = the same as for FVAR1, but for the left eye;
FVAS1 = the same as for FVAR1, but for the left eye;
VEPR1 = visual evoked potentials of the right eye in period A, while 2 and 3 stand for the same variable in periods B and C;
VEPS1 = the same as for VEPR1, but for the left eye;
O. DEX. = the right eye;
O. SIN. = the left eye.

TABLE 5
SOME INDICATORS OF STATISTIC ANALYSIS OF VISUAL ACUITY IN RIGHT AND LEFT EYE IN THREE OBSERVED PERIODS (A,B,C) IN THE GROUP OF PATIENTS WITH OPTIC NERVE INJURY (N=39)

	Right eye			Left eye		
	A	B	C	A	B	C
Mean value	0.51	0.93	0.95	0.77	0.97	0.96
Median	0.4	1	1	1	1	1
SD	0.39	0.13	0.12	0.34	0.11	0.17
Grade	0.99	0.5	0.6	0.95	0.6	1
Interquart. grade	0.8	0.2	0	0.5	0	0
Inferior quartile	0.2	0.8	1	0.5	1	1
Superior quartile	1	1	1	1	1	1

TABLE 6
SOME INDICATORS OF STATISTIC ANALYSIS OF VISUAL FIELD IN RIGHT AND LEFT EYE IN THREE OBSERVED PERIODS (A,B,C) IN THE GROUP OF PATIENTS WITH OPTIC NERVE INJURY (N=39)

	Right eye			Left eye		
	A	B	C	A	B	C
Mean value	5.23	2.08	1.87	3.08	1.56	1.26
Median	7	2	2	2	2	1
SD	2.74	1.26	1.03	2.67	1.37	1.12
Grade	9	4	4	8	4	3
Interquart. grade	5	2	2	4	3	2
Infererior quartile	2	1	1	1	0	0
Superior quartile	7	3	3	5	3	2

TABLE 7
SOME INDICATORS OF STATISTIC ANALYSIS OF VEP IN RIGHT AND LEFT EYES IN THREE OBSERVED PERIODS (A,B,C) IN THE GROUP OF PATIENTS WITH OPTIC NERVE INJURY (N=39)

	Right eye			Left eye		
	A	B	C	A	B	C
Mean value	0.97	0.74	0.54	0.77	0.62	0.49
Median	1	1	1	1	1	0
SD	0.58	0.44	0.51	0.43	0.50	0.51
Grade	3	1	1	1	1	1
Interquart grade	0	1	1	0	1	1
Inferior quartile	1	0	0	1	0	0
Superior quartile	1	1	1	1	1	1

ducting the so-called objective perimetry which does not require subject's co-operation[9].

The question of the role and importance of visual evoked potentials in the diagnosis and treatment of traumatic optic nerve injuries still remains. Is VEP really an objective type of perimetry? What is a correlation between visual field disturbances and pathologic deviation of one VEP wave component, and what is a correlation between VEP and visual acuity? Is it possible to use VEP to determine the optic nerve injury and its treatment, and also, are VEP findings, with or without comparison with other methods of visual function determination, enough to make clinical decisions?

Results of the research conducted on patients (39) with optic nerve injury, which were longitudinally followed at three different periods, in relation to the dynamics of changes of visual acuity show marked recovery as a response to the applied treatment, especially between phases A and B. This is best shown by mean values (0.53 to 0.93) and mean deviation from the average value (0.39 to 0.13). Similar recovery can be seen in the dynamics of visual field (5.23 in Phase A to 2.08 in phase B), while VEP recovery was slower and continuous. By multivariate analysis of mutual influence of these parameters we recorded stronger correlation between visual acuity and VEP than between visual field and VEP. In detection of VEP we mainly noticed the shortening of amplitude. In only three patients we marked longer latency, while five patients had normal VEPs. However, in phase C eighteen patients had normal VEPs (46%). This group of patients showed marked recovery of visual acuity and visual field. The most delicate test suitable for long-term following was visual field test.

Considering the results of the research and analyzing mean values of visual field and VEP variables, we cannot confirm the assumption that VEP could present the objective type of perimetry that does not require subject's co-operation. In other words, application of structural reaction in determination of field disturbances requires some patient's co-operation because of the fixation. Hemianopic patients do not require firm fixation. Field reaction tests conducted on healthy people do require fixation, as well as those conducted on people with concentric visual field narrowing, because great field of stimulation, which has to include all areas of preserved vision, produces by itself characteristic asymmetry in field damages. However, patient has to be prepared to co-operate by looking at the field of stimulation during the recording. Also, VEP cannot compete with quantitative light perimetry, because this method gives, in reasonably short period of time, precise information on shape and location of visual field injury, and records even small scotomata.

However, in some cases VEP can be of great diagnostic help and as an objective method it can help in deciding whether a type of injury is functional or organic. But here, too, we can use the existing methodological approach[10,11].

Pathophysiologic nature of described changes of VEP is only partially explained. We can assume that longer VEP latency is a result of the reduced currency of damaged fibers of the optic nerve, even though longer latency can also be a result of a delay in cortical or retinal layer.

Changes in amplitudes are probably result of the currency block in damaged tissues.

The main abnormality of VEP presented the shortening of amplitude which, after 18–24 months, receded. After this period 46% of patients presented with normal VEPs. The question is whether this tendency would continue with further longitudinal following? Longer latency was recorded in only 3 patients. These VEP abnormalities can be partially explained by the appearance of edema and compression of fibers in optic canal.

VEP findings can be useful in evaluation of the scope and type of lesion and, also, in the prognosis and following of the illness, after the clinician, by means of other standard methods, determines the right diagnosis. Visual acuity test can be best used for describing prompt changes of the lesion and recovery of visual function, while visual field test presents the best method for following delicate changes of visual function.

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ULOGA VIDNIH EVOCIRANIH POTENCIJALA U DIJAGNOSTICI OZLJEDE VIDNOG ŽIVCA KOD BLAGE TRAUME GLAVE

SAŽETAK

Autori u skupini 39 ispitanika s ozljedom vidnog živca kod blage traume glave praćenjem tijekom 24 mjeseca istražuju ponašanje krivulje vidnih evociranih potencijala u komparaciji s promjenama vidne oštrine i vidnog polja. Rezultati istraživanja pokazuju nakon provedenoga liječenja znakovit oporavak vidne oštrine, te vidnog polja dok je oporavak vidnih evociranih potencijala blaži i kontinuiran. Pretežita abnormalnost vidnih evociranih potencijala je sniženje amplitude što se nakon liječenja postupno povlači u polovice ispitanika. Autori zaključuju da se sniženje amplitude djelomično može objasniti edemom i kompresijom vlakana u optičkom kanalu. Također autori ističu da kod ovog tipa oštećenja vidnog živca testiranje vidne oštrine najbolje pokazuje promptnost i opseg oštećenja,dok je istraživanje vidnog polja najbolja metoda za praćenje kasnijih finih promjena vidne funkcije.