Variation of P-100 latency measurements in clinical VEP with the effect of rate of stimulation

N. Sivanandan, Assistant Professor, Dept of Electronics, PSG CAS, Coimbatore, India.

Abstract

It is important to check the variability of a number of parameters for reliable interpretation of transient VEP. The pattern reversal frequency if increased from 1 Hz to 4 Hz, the P-100 latency increase by 4.8 m sec. At a faster rate, the waveforms become less distinct and stimulation above 8-10 Hz results in a steady state VEP. The VEP is the measure of cortically evoked electrical activity that provides information about the integrity of the optic nerve and the primary visual cortex. The optic nerve joins the retina with the brain. On giving pattern or flash stimulation, not only there is increased metabolism in primary visual area, but also in the visual association areas. The VEP studies in patients with well defined cortical lesions provide additional details about its generator sources. It is important that the infant or child does fix on the stimulus. For the children below five years, the pattern reversal is first carried out; if the potentials are un-recordable then a flash VEP should be undertaken. The pattern reversal is useful as these assess the visual acuity whereas the flash VEP determines the presence or absence of light perception.

Introduction

It is important to check the variability of a number of above mentioned parameters for reliable interpretation of VEP. The P-100 latency increases with the decrease of luminance. The reduction of contrast between black and white squares results in

increased latency and decreased amplitude of P-100. Usually black and white checks or gratings are employed in clinical practice. The pattern reversal frequency if increased from 1Hz to 4Hz , the P-100 latency increases by 4.8 m sec.

Experimental procedure

The clinical use of VEP is mainly based on the peak amplitude and latency of P-100. In general, the stimulation rate used for the recording is 1Hz. But it requires minimum of 50-60 trials for calculating P-100 value. Usually, it takes minimum of 30 minutes for completing the entire procedure and the fatigue condition affects the procedure. Higher rate of stimulation is preferred to reduce the procedure time and also to reduce fatigue levels in patients. But at higher rate of stimulation, identification of P-100 peaks becomes very difficult and also there is an increase in the latency compared to that of the latency obtained using the 1Hz stimulation rate. Figure (6.5) showed different rate of stimulation verses P-100 latency measurement.

Table (1.1) One Hertz stimulation

Montage	**N-75 (ms)**	**P-100 (ms)**	**N-145 (ms)**
Oz-Fz	**71.9**	**93.8**	**122.5**

Table (1.2) Two Hertz stimulation

Montage	**N-75 (ms)**	**P-100 (ms)**	**N-145 (ms)**
Oz-Fz	**70.6**	**94.4**	**122.5**

Table (1.3) Three Hertz stimulation Table

Montage	**N-75 (ms)**	**P-100 (ms)**	**N-145 (ms)**

Oz-Fz	**71.9**	**95.6**	**122.5**

Table (1.4) Four Hertz stimulation

Montage	**N-75 (ms)**	**P-100 (ms)**	**N-145 (ms)**
Oz-Fz	**71.9**	**97.5**	**122.5**

The VEP recordings were performed in a dark and sound attenuated room in a laboratory. Subject was asked to sit comfortably in front of the checker board pattern at an eye screen distance of 100 cm. The preferred stimulus for clinical investigation of the visual pathways is a reversal of a black and white checker board pattern, as it tends to evoke larger and clear responses than other patterns. The stimulus pattern was a black and white checkerboard displayed on a computer screen. The checks alternate from black/white and white/black at a rate approximately of twice per second.

The subject was instructed to gaze at a colored dot on the center of the checkerboard pattern. Every time when the pattern alternates, the patient visual system generates an electrical response and was recorded using electrodes. Signal acquisition and stimulus presentation was synchronized using software program. The starting point of VEP waveform is stimulus onset. The VEP waveform recording is done over a period of 250 m sec. More than 100 epochs were averaged to ensure a clear VEP waveform.

The primary results show that as the rate of effective stimulation increases, the P-100 moves towards higher value. For 1Hz stimulation rate (Table 1.1), P-100 value has been observed at 93.8 m sec and for 2Hz stimulation rate (Table 1.2), it has been found that the P-100 value increased to 94.4 m sec . For 3Hz stimulation rate (Table 1.3), P-100 value has been observed at 95.6 m sec and for 4Hz stimulation rate (Table 1.4), it has been observed at 97.5 m sec .The results show that as the of stimulation increases, the P-100 peak value moves towards higher value. Up to 4 Hz stimulation rate, the P-100 latency value has been clearly observed and after 4 Hz stimulation, P-100 peak completely disappears from the waveform and almost the waveform becomes sinusoidal. It has been found that there was a strong positive correlation between rate stimulation and P-100 latency value .The Table 1.5 showed P-100 latency value at different rate of stimulations, Table 1.6 showed dominant spectral component value verse rate of stimulations and Table 1.7 showed phase periodicity measure verse rate of stimulations.

The VEP waveform was sampled at 1024Hz. The spectral components of the each pre-stimulus waveform and post-stimulus averaged waveform with a frequency resolution of 1Hz. Beyond 5Hz no major spectral components were obtained for of all the subjects, so the values on the frequency band 1 - 5 Hz were normalized according to the maximum value in that band. Specifically, the first two dominant peaks were extracted from the spectral plot along with the corresponding magnitude and frequency values. A program to extract the magnitude and frequency of the first two dominant spectral components values has been developed. The relations between the rate of stimulation and P-100 latency, rate of stimulation and spectral components have also been identified.

Table 1.5 P-100 latency values at different rate of stimulations

Rate of stimulation	1 Hz	2 Hz	3
P-100 Latency	93.8 m sec	94.4 m sec	9

of a signal f as a normalized difference of the sum of the power spectrum values at the highest amplitude frequency and its multiples and the sum of power spectrum values at the frequency half way between them i.e.,

Table 1.6 Rate of stimulation vs spectral component values.

S.No	Rate of stimulation	Spectral component values
1.	1Hz	2Hz
2.	2Hz	3Hz
3.	3Hz	4Hz
4.	4Hz	5Hz
5.	5Hz	5Hz

Table 1.7 Rate of stimulation vs Phase peroidicity

Rate of stimulation	Phase Periodicity
1 Hz	0.6 m sec
2 Hz	1.2 m sec
3 Hz	1.9 m sec

Conclusion

In time domain analysis, at higher rate of stimulation, it is very difficult to identify the exact P-100 values due to the irregular peaks. As the rate of stimulation increases, the visual system will not get time to come back to the original state before the next stimulation. The pattern reversal frequency if increased from 1 Hz to 4 Hz, the P-100 latency increase by 4.8 m sec. Because of this reason, the responses will overlap, thus making it difficult to measure the exact P-100 value. At the higher rate of stimulation, the transient PSVEP is almost similar to sinusoidal waveform. Up to 4Hz stimulation, the P-100 latency value has been clearly observed and after 4Hz stimulation P-100 peak completely disappears from the waveform and almost the waveform becomes sinusoidal. Beyond the 4Hz stimulation rate, it has been shown that the spectral component value observed is exactly at the stimulation rate.

References

1. Duke-Elder S, Scott GI. System of ophthalmology: The anatomy of the visual system. Henry kimpton, London 1971.
2. Courjon J, Mauguiere F and Revol M eds, Clinical applications of evoked potentials in Neurology. Raven press, New York 1982; 11.
3. Kuba M.Peregrin j, Vit F, Hanusova I. Visual evoked responses to reversal stimulation in the upper and lower half of central part of the visual field in man. Physiological Bohemoslova 1982; 31:503.
4. La Marche JA, Dobson WR, Cohn NB, Dustman RE. Amplitude of visually evoked potentials to pattern stimuli: age and sex comparisons. Electroencephalography Clinical Neurophysiology 1986; 65:81.
5. Matthews WB, Small DG. Small M, Poultney E. Pattern reversal visual evoked potential in the diagnosis of multiple sclerosis. J Neurology Neurosurgery Psychiatry 1977; 40:1009.
6. Oepen G.Doerr M.Thoden V.Visual (VEP) and somatosensory (SSEP) evoked potentials in Huntington's chorea. Electroencephalography Clinical Neurophysiology 1981; 51:666.
7. Oishi M. Yamada T, Dickins M. Kimura J. Visual evoked potentials by different check sizes in patients with multiple sclerosis, Neurology 1985; 35:1461.
8. Oken BJ, Chiappa KH, and Gill E. Normal temporal variability of the P-100 Electroencephalography Clinical Neurophysiology 1987; 68:153.
9. Regan D. Human visual evoked potentials In: Picton TW ed. Handbook of Electroencephalography and clinical neurophysiology Vol-3. Elsevier, Amsterdam 1988; 159.
10. Sokol S. Visual evoked potentials In: Aminioff MJ (Ed) Electro diagnosis in Clinical Neurology. Churchill Livingstone, New York 1986; 441.
11. Stockard JJ, Hughes JR, SharVough FW. Visual evoked potentials to electronics pattern reversal; latency variations with gender, age and technical factors. Am J EWEG Technology 1979, 19:171.

12. Aso K, Watanabe K, Negoro T, *et al.* Developmental changes of pattern reversal visual evoked potentials. Brain Dev 1988; 10:154–9.
13. Misra.J.K. and Kalith (1999) ' Clinical Neurophysiology ', I. Churchill Livingstone private Ltd, New Delhi.
14. Sivakumar R. and Ravindran G. (2002) 'Effect of rate of stimulation on pattern shift visual evoked potential spectral components', Proc. Of IEEE EMBS UK & RI Postgraduate Conference on Biomedical Engineering and Medical Physics, Aston University, Aston, U.K., pp. 15.
15. G G, Daly RR. Visual electroencephalographic computer analysis (VECA). Neurology 1977; 27:637.

Author Profile

N.Sivanandan, Assistant professor, Department of Electronics, PSG CAS, Coimbatore, India.