Normative data of Electroretinogram and Visual Evoked Potential in Thai Population

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ABSTRACT

Objective: To define normal values of Electroretinogram [ERG] and Visual Evoked Potential [VEP] in different age groups using Viking Select Master Software V7.1.

Methods: ERG and VEP values were measured using Viking Select Master Software V7.1 in selected subjects without history of ocular and/or systemic diseases that affect ERG and VEP values. Results were studied in three groups of age: less than 10 years old, 11 to 40 years old and over 40 years old.

Results: There were 26 eyes in the first group with age range from 6-10 years old [mean 7.8 ± 1.52 years old]. In ERG: the normal values of photopic amplitude of a-wave was ≥ 18.57 microvolt [μV] and b-wave was ≥ 23.82 μV, flickering amplitude of b-wave was ≥ 21.93 μV, scotopic amplitude of b-wave was ≥ 39.12 μV, mesopic amplitude of a-wave was ≥ 60.44 μV and b-wave was ≥ 96.84 μV. In VEP: transient flash amplitude was ≥ 20.58 μV and latency was ≤ 94.10 millisecond[ms], transient pattern size 2 amplitude was ≥ 8.61 μV and latency was ≤ 100.00 ms. There were 75 eyes in the second group with age range from 11-38 years old [mean 26.8 ± 7.35 years old]. The values of photopic amplitude of a-wave was ≥ 22.56 μV and b-wave was ≥ 20.14 μV, flickering amplitude of b-wave was ≥ 19.35 μV, scotopic amplitude of b-wave was ≥ 32.29 μV, mesopic amplitude of a-wave was ≥ 45.05 μV and b-wave was ≥ 78.97 μV, VEP- transient flash amplitude was ≥ 11.64 μV and latency was ≤ 96.78 ms, transient pattern size 2 amplitude was ≥ 4.82 μV and latency was ≤ 88.49 ms. There were 77 eyes in the third group with age range from 41-81 years old [mean 60.1 ± 11.54 years old]. The values of photopic amplitude of a-wave was ≥ 19.12 μV and b-wave was ≥ 24.59 μV, flickering amplitude of b-wave was ≥ 18.76 μV, scotopic amplitude of b-wave was ≥ 35.60 μV, mesopic amplitude of a-wave was ≥ 40.90 μV and b-wave was ≥ 94.09 μV, VEP- transient flash amplitude was ≥ 10.07 μV and latency was ≤ 102.10 ms, transient pattern size 2 amplitude was ≥ 5.34 μV and latency was ≤ 96.00 ms.

Conclusion: We established normal ERG and VEP values in different age group using Viking Select Master Software V7.1 at Siriraj Hospital to distinguish between normal and pathological patients. The values are affected in relation to machine and environmental setting in different laboratory. It is essential for individual laboratories to set their own normal values.

Keywords: Electroretinography; electroretinogram; normal values; visual evoked potential

Siriraj Med J 2007; 59: 131-134
E-journal: http://www.sirirajmedj.com

Visualization of the fundus has progressed from simple ophthalmoscopy to highly technological devices. But for all the wealth of detail received from such techniques, information regarding the functional status of a specific retinal layer, the optic nerve, or visual cortex is lacking. Using light to produce electrical signals from different regions of the visual system can produce data with a high degree of specificity.

Electrophysiologic tests are the tests which using light to produce electrical signals from different regions of the visual system. They can produce information regarding the functional status of a specific retinal layer, the optic nerve and visual cortex. The most important thing of these tests is that they are objective tests which are more reliable than other subjective tests1.

The standard electrophysiologic tests are composed of electrooculography [EOG], electroretinography [ERG] and visual evoked potential [VEP]. EOG represents electrical activity from retinal pigment epithelium. ERG [full-field or classical ERG] represents electrical activity from photoreceptor cells and mid-retinal layers [except ganglion cells]. VEP represents electrical activity from nerve fiber layer, optic nerve through visual cortex. The normal value of EOG is the standard value of Arden ratio [≥ 1.8]. The normal value of ERG and VEP are affected by many factors such as machine, environmental setting and techniques.

Our aim is to report the normative values of the Electroretinogram [ERG] and the Visual evoked potential [VEP] of Thai population in our laboratory at Siriraj hospital using Viking Select Master Software V7.1.
TABLE 1. Normal values of ERG and VEP in group 1.

| Group I ERG | Photopic | a wave amplitude[^1] [μV] | ≥18.57 |
|            |         | b wave amplitude[^1] [μV] | ≥23.82 |
| Flickering | b wave amplitude[^1] [μV] | ≥21.93 |
| Scotopic   | b wave amplitude[^1] [μV] | ≥39.12 |
| Mesopic    | a wave amplitude[^1] [μV] | ≥60.44 |
|            | b wave amplitude[^1] [μV] | ≥96.84 |

OP* op1 amplitude[^1] [μV] ≥0.87
op2 amplitude[^1] [μV] ≥1.51
op3 amplitude[^1] [μV] ≥0.73
op4 amplitude[^1] [μV] ≥0.68

VEP Transient amplitude[^2] [μV] ≥20.58
latency[^3] [ms] ≤94.10

Pattern size 2 amplitude[^1] [μV] ≥8.61
latency[^4] [ms] ≤100.00

* OP = oscillatory potentials
1 = ≥ Mean - 1.645 SD
2 = ≥ Percentile 5
3 = ≤ Mean - 1.645 SD
4 = ≤ Percentile 5

TABLE 2. Normal values of ERG and VEP in group 2.

| Group II ERG | Scotopic | a wave amplitude[^1] [μV] | ≥22.56 |
|              | b wave amplitude[^1] [μV] | ≥20.14 |
| Flickering   | b wave amplitude[^1] [μV] | ≥19.35 |
| Scotopic     | b wave amplitude[^1] [μV] | ≥32.29 |

OP* op1 amplitude[^1] [μV] ≥45.05
op2 amplitude[^1] [μV] ≥78.97

VEP Transient amplitude[^2] [μV] ≥11.64
latency[^3] [ms] ≤96.78

Pattern size 2 amplitude[^2] [μV] ≥4.82
latency[^3] [ms] ≤88.49

* OP = oscillatory potentials
1 = ≥ Mean - 1.645 SD
2 = ≥ Percentile 5
3 = ≤ Mean - 1.645 SD

The full-field flash ERG testing has five recommended international standard responses that established by the International Society for Clinical Electrophysiology of Vision [ISCEV]. We performed the full-field flash ERG in our study according to the ISCEV. It composed of:

1. Rod single-flash response after dark adaptation with flash 2.5 log unit dimmer than standard flash
2. Maximal combined rod and cone single-flash response after dark adaptation
3. Oscillatory potentials with standard flash
4. Cone single-flash response after light adaptation with standard flash
5. Cone 30-Hz flicker response after light adaptation with standard flash

VEP was performed according to standard VEP recording which also established by the ISCEV. We used 2 types of stimulus for VEP response: flash stimulus and pattern stimulus [checkerboard size 2].

The results were classified by age into three groups [group 1: ≤ 10 years old, group 2: 11-40 years old and group 3: > 40 years old]. For normal distribution data, we use mean-1.645 SD for calculation the normal values and percentile 5 for non normal distribution data. Because there is no upper limit of amplitude of both ERG and VEP, so the normal values are the ones that greater than or equal to the aforesaid calculated values except the VEP latency that the normal values are lesser than or equal to them. The study protocol was approved by the research ethics committee of Siriraj Hospital, Mahidol University.

RESULTS

There were 26 eyes in the first group which the mean age ± SD was 7.8 ± 1.52 years old [range from 6-10 years old]. Normal values of the ERG and VEP in this group are shown in Table 1. In the second group 75 eyes were enrolled in our study. The mean age ± SD of the participants was 26.8 ± 7.35 years old [range from 11-38 years old] and the normal values of the ERG and VEP in this group are shown in Table 2. There were 77 eyes in the third group, which the mean age ± SD was 60.1 ± 11.54 years old [range from 41-81 years old]. Normal values of the ERG and VEP in this group are shown in Table 3.

DISCUSSION

The full-field electroretinogram [ERG] records the electrical responses from the retina stimulated by a flash stimulus. It measures the overall rod- and cone- generated responses. It is the only electrophysiologic test that assesses rod-generated activity. Numerous diseases including Leber congenital amaurosis, achromatopsia, congenital stationary night blindness and others abnormalities of photoreceptor cells use the ERG in conjunction with an ocular examination in diagnosis. The ERG waveform represents overall activities of all cells in the retina except from ganglion cells. So any localized defected or isolated macular lesion is not affected the full-field ERG response. In such cases, testing with focal or multifocal ERG is helpful.

According to the ISCEV, there are 5 types of ERG recordings as mention above. We can isolate the information of both photoreceptor cells which are rod cells and cone cells by using specific stimulations. To assess rod-generated activity, we used single-flash 2.5 log unit dimmer than standard flash [dim blue light] after dark adaptation which is called scotopic ERG. Cone cells function can be assessed...
by 2 types of responses that are photopic ERG and Flickering ERG. Photopic ERG is the response by using standard white flash stimulation and flickering ERG is the response by using 30-Hz flicker stimulation after light adaptation. The maximal combined rod and cone response is elicited by a single bright flash stimulation after dark adaptation which is called mesopic ERG. It is the biggest response generated by both rod and cone cells across the entire retina. The oscillatory potentials [OP] usually consist of three larger waves followed by a smaller one during the ascending phase of the b wave in mesopic ERG. They can be isolated or designated in order of occurrence as OP1, OP2, OP3 and OP4. The oscillatory potentials represent inner retinal circulation. Normal values should be established by each laboratory for specific ERG responses, because the difference in recording equipment and techniques such as electrode type.

Visual Evoked Potential [VEP] is the signal elicited by visual stimuli which are recorded with cutaneous electrodes placed on the scalp in the occipital region. It is the only electrophysiologic test that assesses visual cortical activity, and standard for VEP recording has been established by the ISCEV. In clinical usage, VEP is commonly performed to detect visual pathway deficits or unexplained visual loss. An impaired VEP can be produced by a deficit anywhere along the visual pathway including the retina, optic nerve and brain. Therefore, an impaired VEP is anatomically non-specific unless it is used in combination with a complete ocular examination and other clinical investigations such as visual field, ERG and neuroimaging. VEP should not perform in place of a comprehensive ophthalmic examination or neuroimaging. Impaired VEP responses may be produced in some normal persons by poor fixation, defocusing or conscious suppression. There are three standard responses in clinical VEP testing: Pattern reversal VEP [by using checkerboard stimulation], Pattern onset/offset VEP, and Flash VEP. The normal values should be established by each laboratory like the normal values of ERG.

In our laboratory we used skin electrodes in both ERG and VEP recordings. The machine with software name Viking Select Master Software V7.1 that has Ganzfeld stimulation was used in this study. To obtain reproducible responses, the stimulus and background light should be homogeneous and cover the entire retina, so all of the receptors are stimulated or adapted in a relatively homogeneous manner. The Ganzfeld stimulator represents such a stimulus and has been recommended by the ISCEV. We performed the stimulation for VEP [Pattern reversal VEP and Flash VEP] with miodilated pupil, and then ERG was done with fully dilated pupil by using standard specific stimulations as mention above. We collected the values from the normal eye of patient as the normal values as well as values from normal participants.

As the maturation and aging are influenced on electrophysiologic responses, we analyzed normal values for three different age groups; group 1: ≤ 10 years old, group 2: 11-40 years old, group 3: > 40 years old. More than 50 percents of participants in the first group were more than 6 years old because children under 6 years old could not cooperate with the tests. This is the limitation for using these normal values in infants and very young children. The number of participants in group 1 is less than group 2 and group 3. This due to the small amount of cases in children below 10 years old and no normal volunteer in this group. In this study, we found that almost the amplitudes of waves from group 1 were larger than ones from group 2 and group 3 [as shown in Table 1, 2 and 3]. The amplitudes of waves from children are bigger because the cells in young age group are fully developed and still healthy.

In conclusion, these electrophysiologic responses are variable among persons, group of age, difference laboratory and techniques. Each laboratory should obtain their normal values and age-related normative values for each electrophysiologic test to facilitate clinical interpretation. These tests will help or support the diagnosis for the clinician only when correlate with complete ocular examination. Slit-lamp biomicroscopy and ophthalmoscopy are important parts of the clinical routine, but without support from functional findings it can be a less accurate indicator. We encourage each laboratory of electrophysiologic tests of vision to establish normal values of their own.

**REFERENCES**

ถ้าหากคุณต้องการแปลส่วนหนึ่งของข้อความจากภาษาไทย ให้ใช้ฟังก์ชันการแปลภาษาในอินเทอร์เน็ต หรือบริการแปลภาษาอัตโนมัติเพื่อแปลส่วนของข้อความที่ต้องการแปลได้