Principles and Practice of Clinical Electrophysiology of Vision

Editors

John R. Heckenlively, M.D.
Professor of Ophthalmology
Jules Stein Eye Institute
Los Angeles, California

Geoffrey B. Arden, M.D., Ph.D.
Professor of Ophthalmology and Neurophysiology
Institute of Ophthalmology
Moorfields Eye Hospital
London, England

Associate Editors

Emiko Adachi-Usami, M.D.
Professor of Ophthalmology
Chiba University School of Medicine
Chiba, Japan

G.F.A. Harding, Ph.D.
Professor of Neurosciences
Department of Vision Sciences
Aston University
Birmingham, England

Sven Erik Nilsson, M.D., Ph.D.
Professor of Ophthalmology
University of Linköping
Linköping, Sweden

Richard G. Weleber, M.D.
Professor of Ophthalmology
University of Oregon Health Science Center
Portland, Oregon

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Flash Visual Evoked Cortical Potential in Developmental Delay

G. F. A. Harding

The majority of studies of the visual evoked potential (VEP) in preterm and full-term neonates has been carried out using flash stimulation. The first flash VEP was recorded in a full-term infant by Ellingson.[9] However, in his more extensive study in 1960,[8] he compared the VEPs of full-term and preterm infants. Despite considerable intersubject variability full-term infants showed a relatively simple VEP in which there was an initial brief positive wave followed by a high-amplitude negative wave of longer duration. The mean latencies of the initial positive component were as follows: 0 to 30 hours, 189 ms; 30 to 60 hours, 184 ms; 60 to 90 hours, 176 ms; and 90 to 120 hours, 178 ms. The presence of this initial positive wave was greater in the more mature infants, and the VEP in the preterm newborns often consisted of only a broad negative deflection that had a longer peak latency than did the negative wave seen in the full-term infant. Some preterm infants did show an initial positive wave, and of these infants, the youngest to show this response was 32 weeks' gestational age. At 34 to 35 weeks the latency of the positive wave was on average 219 ms; for 36 to 37 weeks, 209 ms; and for 38 to 39 weeks, 200 ms (Fig 75–1). The earliest age at which the flash VEP has been recorded from a human infant is at 24 weeks' gestational age.[23] In infants between 24 and 27 weeks of age the response consists only of a slow negative wave with an average latency of around 300 ms.[23] It is after 26 weeks' gestation that this negative wave divides to form the N_3 wave with a later positive P_3 component and an even later N_4 wave.[16] It is obviously between 30 and 35 weeks of gestational age that the N_3 wave becomes preceded by the initial positive P_2 component.[23]

Some authors have suggested that there is a linear negative relationship between VEP latency and gestational age.[16, 20, 24] However, other authors have suggested that no such relationship exists,[3, 23] but it should be noted that in both of these latter studies light-emitting diode (LED) goggles were used rather than the normal photostimulator. LED goggles make it impossible to tell whether or not the infants have their eyes open or closed, and in addition, the LED stimulator produces a red flash that may well prolong the latency of the VEP.[15] In addition, the goggle stimulator does not produce an unstructured field and may well be equivalent to a flashed-on pattern.

The amplitude of the flash VEP is much larger in neonates than in adults and may well be obvious following either a single stimulus or certainly no more than four stimuli.[8, 16] Because of this high amplitude, fewer averaging sweeps are necessary, and indeed it is common practice to only average approximately ten sweeps.[4, 10] Equally, the interstimulus interval should be kept fairly long, approximately 3 seconds, to prevent attenuation of the successive VEP signals.

Studies of the development of the flash VEP in full-term infants have shown that the negative N_3 component is the most prominent at birth and during the first month of life. The preceding positive wave (P_2) is always present at around 4 to 6 weeks, and by 6 to 8 weeks it is more prominent than the

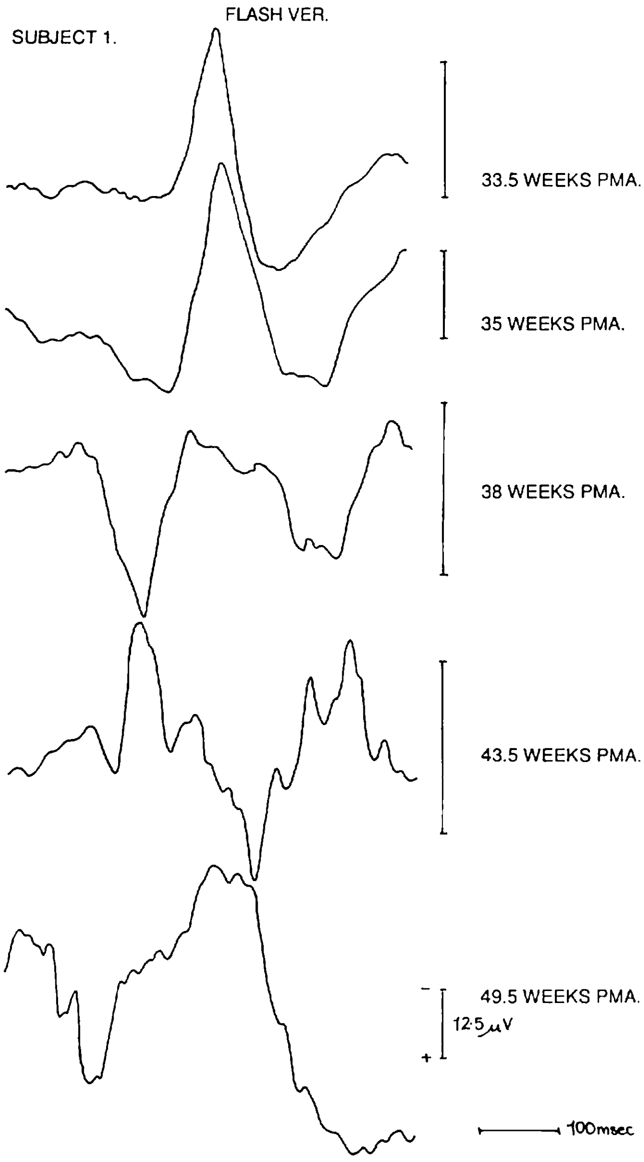

FIG 75–1.
Flash visual evoked response (VER) as recorded in premature babies. In young babies up to 35 weeks' postmenstrual age (PMA) the VEP frequently consists of a simple negative component N_1 around 250 ms. Above 35 weeks' postmenstrual age an earlier positive component (P_1) becomes apparent, and the peak latency of this component steadily reduces to equal the component frequently seen post-term.

N_3 component. It shortens in latency and reaches adult values by about 3 months of age.[11, 12] The waveform becomes more complex, with earlier components developing as the infant matures. The latencies of earlier components are also reported to decrease in latency during maturation.[1, 7] However, Blom et al.[2] reported that the early components of the flash VEP are often discernible at birth.

Pattern-reversal VEPs have been studied in full-term newborn infants. The pattern-reversal VEP consists of a single positive peak (P_1) that by 14 weeks is preceded by a negative peak (N_1).[18, 21] A later N_2 component also becomes apparent around 2 months of age.[18] In general the P_1 component is the most reliable, although Kurtzberg & Vaughan[17] found that its occurrence was inconsistent in some full-term neonates and found the later negative component around 250 ms to be more reliable. Usually the responses can only be elicited by large check sizes, usually in excess of 30 minutes of visual angle.[18, 19, 21] By 8 to 10 weeks of age it is usually possible to elicit a measurable VEP for checks of 15 minutes of visual angle, and by 14 weeks of age it is possible to record responses to check sizes of 7.5 minutes.[18, 21] The latency of the P_1 component shifts from around 265 ms at 3 days of age to about 220 ms at 50 days. By 16 weeks of age the P_1 component has a similar latency to the P100 component in adults.[21]

Although a comparison has been made of the pattern-reversal VEP in both full-term and preterm infants of the same postmenstrual age above 40 weeks, it has only recently been proved possible to record a pattern-reversal VEP in preterm infants. Harding et al.[14] and Grose et al.[13] have demonstrated that pattern-reversal VEPs can be recorded down to 31 weeks' gestational age. The VEP was of simple waveform and similar to that reported in full-term and preterm infants beyond 40 weeks and consisted of a simple major positivity (P_1). The pattern-reversal VEP became more complex as the infant grew older, the N_2 component emerging at about 46 weeks' gestational age and the N_1 component about 49 weeks' gestational age. There was little variability in the P_1 component in successive trials, but as the child became older, the latency became shorter, and there was an increase in amplitude. Both these relationships correlated with the gestational age at recording. The latency decreased from an average value of 334 ms at 30 weeks' gestational age to 240 ms at 40 weeks and 127 ms at 53 weeks' gestational age (Fig 75–2). These findings correlate well with those obtained by other authors in post-term babies. The authors point out that it is essential to use large checks of approximately 2 degrees of visual angle.

Pattern-onset-offset VEPs have also been studied in infants. The pattern needs to be presented for around 300 ms in order to ensure that there is no contamination of the pattern-onset response by the pattern-offset response.[5] Once again, the morphology of the pattern-onset response is found to be much simpler and even at 2 months of age consists of only a positive peak with a mean latency of

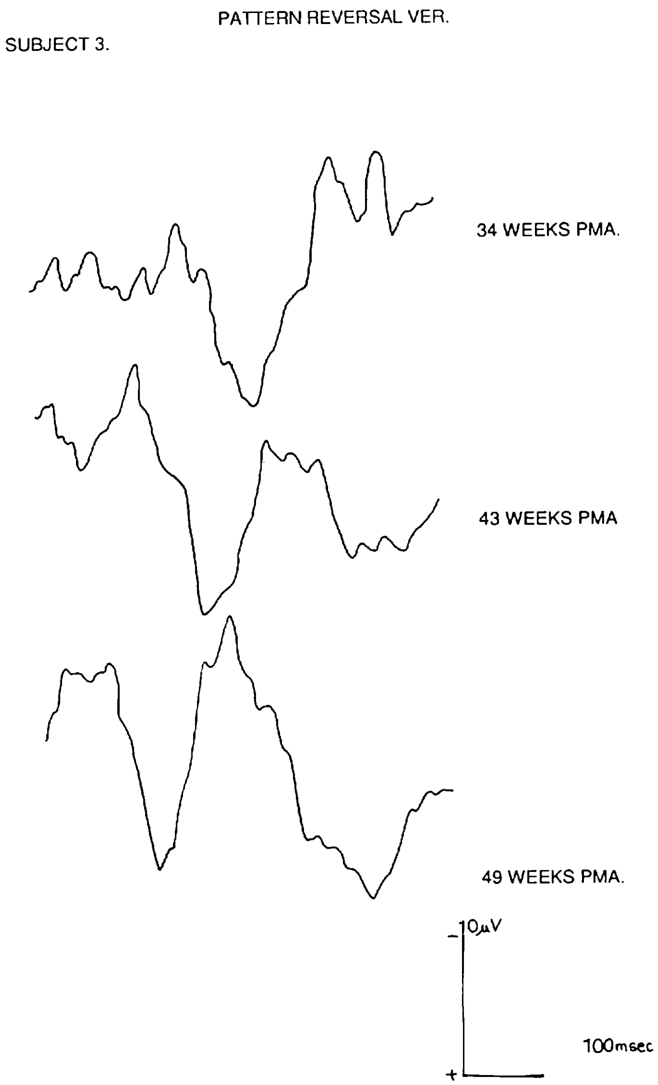

FIG 75–2.
Pattern-reversal VER in premature babies. Unlike the flash VER, the pattern-reversal response consists of only a major positivity that slowly reduces in peak latency from 32 weeks' postmenstrual age (PMA). This is the component reported by other authors post-term.

around 190 ms.[22] As the infant grows older, the latency of this positive component is reduced and reaches about 160 ms by 5 months of age. The contour-specific C_{II} component is only recordable at around 10 months of age and reaches 100% incidence by 100 months of age.[5]

The VEP has been used to assess neurological or neuro-ophthalmological damage occurring in young infants. Dubowitz et al.[6] found that 50% of infants with periventricular hemorrhages showed a delayed appearance of the P_2 wave. They pointed out, however, that flash VEPs of abnormal waveform could even be recorded in infants without an occipital cortex, which suggests that the flash VEP at this age may be subcortically mediated. Kurtzberg and Vaughan,[17] however, found good correlations between the flash VEP at term and the incidence of periventricular low-density masses. Normal flash VEPs consisting of P_2, N_3, and P_3 recordable from both cerebral hemispheres were found in 88% of very low birth weight infants with normal computed tomographic (CT) scans. All the infants who had immature VEPs, that is, components absent or of long latency, were found to have periventricular low-density masses, and 75% of the infants with asymmetrical VEPs were found to have the same abnormalities.

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