Principles and Practice of Clinical Electrophysiology of Vision

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Intraoperative and Intensive Care Unit Monitoring With Visual Evoked Potentials and Electroretinography

G. F. A. Harding

The use of visual evoked potential (VEP) monitoring in the operating theater has been relatively restricted for two reasons. In the first place, the VEP is a cortical response and affected by anesthetic agents. Halothane anesthetic significantly alters the VEP by increasing its latency and reducing its amplitude.[18] In the second place, normal methods of visual stimulation are inappropriate or inconvenient, particularly during neuro-ophthalmic surgery, although more freedom is available during intracranial surgery. Pattern-reversal stimulation has not been successfully applied to the unconscious patient, so flash stimulation has always been utilized. Diffuse flash stimulation using a stroboscope cannot normally be used during surgery due to its inconvenience. Although the stimulus is intense enough (up to 10,000 cd/m^2), the stimulator is large and cannot be placed in front of the patient's face without interfering with the surgeon's freedom of movement or his vision. Some studies have used flashing goggles, usually with an array of light-emitting diodes (LEDs) that overcome some of these limitations, but they are large and bulky and require a headband to hold them in place over the eyes. However, the size of the goggles precludes orbital surgery and restricts intracranial surgery to a nonanterior approach. An LED stimulator fitted within a scleral shell has been developed by Feinsod et al.,[6] but the VEPs produced by such a stimulus were of low amplitude and poorly formed. In addition, positioning the stimulator over the pupil was difficult. Wright et al.[22] reported on the development of a modified haptic contact lens in which a fiber-optic cable was inserted along the axis. The distal end of the fiber-optic cable was attached to a standard stroboscope. The technique was to be used to monitor optic nerve compression during orbital surgery. However, no report of this technique was forthcoming. Presumably the axially mounted fiber optic would produce torsional effects making location over the pupil difficult to maintain and would certainly interfere with the surgeon's freedom of movement.

Harding et al.[11] described an improved contact lens stimulator in which a haptic contact lens was fitted with a small plastic prism that had a socket into which a fiber-optic cable was inserted at 90 degrees to the axis of the contact lens (Fig 79–1). The cable had a small keyway that clipped into a retainer within the prism. Both the prism and the contact lens were clear with no silvering or tinting, thus ensuring a clear view through the lens and allowing accurate placement over the dilated pupil. Since the position of the fiber optic (at right angles to the axis of the lens and lying down the cheek) put no torsion on the lens and did not interfere with the surgeon's freedom of movement, even orbital surgery could be performed. Flash stimulation provided by a specially modified stroboscope[11] was provided at the distal end of the fiber-optic cable and produced flashes that would elicit electroretinograms (ERGs) of comparable amplitude to those produced by a normal stroboscope.[12]

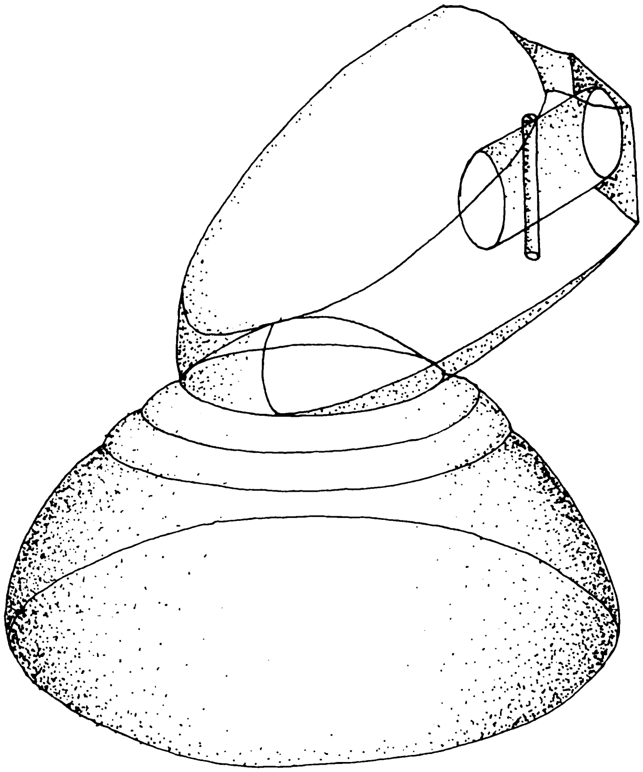

FIG 79–1.
Construction of a haptic contact lens stimulator. The lens is fitted with a 45-degree prism on its axis, and at right angles to the axis there is a 5-mm socket for a fiber-optic cable used to transfer the flashes from a stroboscope into the lens. Since the fiber-optic cable is at 90 degrees to the axis of the lens and since the prism contains no silvering, the surgeon has a clear view of the dilated pupil. The lateral position of the fiber-optic cable also exerts no torsion on the eye because it lies down the cheek of the patient.

The most comprehensive study of VEP monitoring during surgery was that of Harding et al.[12] Forty cases of orbital surgery were mentioned, 29 being for dysthyroid exophthalmos, 9 for intraorbital tumors, and 2 for intraorbital foreign bodies. Orbital surgery unfortunately causes a risk of unexpected damage to the optic nerve either due to surgical manipulation or in the immediate postoperative period. During surgery torsional or tractional forces exerted on the orbital contents may jeopardize the vascular supply of the optic nerve. If the surgeon is dependent on feedback provided at the conclusion of the operation, he is unable to identify the event that caused the unacceptable outcome. In this study, therefore, continuous VEP monitoring was provided, the eye undergoing surgery being constantly compared with the fellow eye. The latency of the P_2 wave of the flash VEP varied slightly in a manner unrelated to surgical procedure and probably reflected cortical conditions. Similar changes were seen in the fellow eye. Persistent delays of over 50 ms were sometimes seen during surgical manipulation, but a more consistent finding was a marked reduction in amplitude of the P_2 wave. It appeared that a temporary abolition of the VEP could be observed but did not indicate irrevocable changes to the optic nerve unless the absence persisted for more than 4 minutes (Fig 79–2). Simple procedures such as the use of retractors to move the globe across the orbit could have a marked effect on the VEP, and the surgical technique was adapted to al-

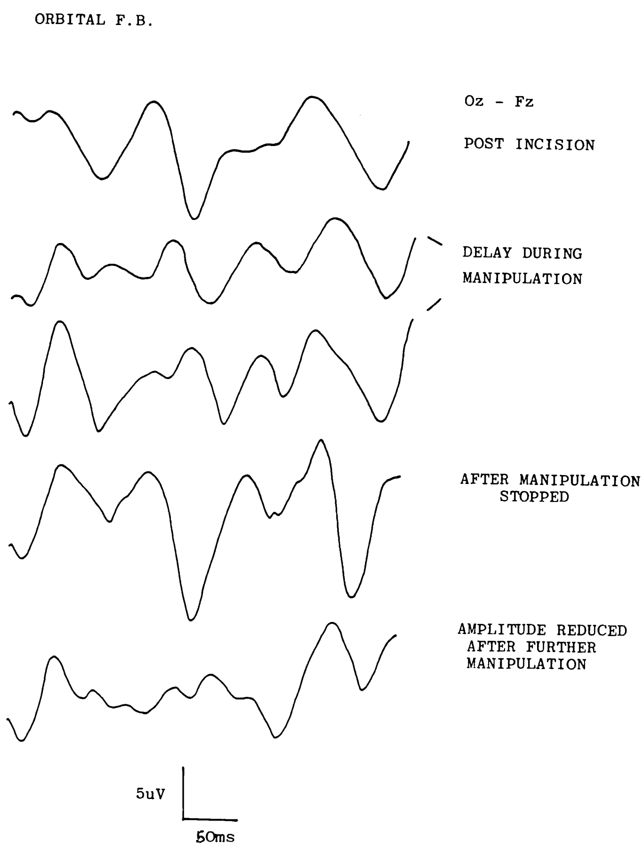

FIG 79–2.
VEP obtained during surgery. Postincision the major positive component can be seen around 155 ms as the second positive wave in the first trace. During manipulation to remove an orbital foreign body lying against the optic nerve the VEP became reduced in amplitude and also delayed, but after manipulation was stopped, the positive component returned to its previous latency and high amplitude. Unfortunately, since the foreign body was still in place, further manipulation had to be undertaken, and the visual evoked response almost disappeared and did not return to its normal amplitude during the subsequent 30 minutes of the operation. Postoperatively the VEP was grossly delayed and reduced and vision did not improve beyond "counts fingers."

low the setting of the retractors to be monitored by VEP amplitude (Fig 79–3).

Similar findings have been reported with both optic nerve and chiasmal surgery,[4] although in this small series LED goggle stimulators were used. Cedzick et al.,[3] however, used goggle stimulators and reported that the intrinsic variation due to anesthesia invalidated the technique of VEP monitoring. This dichotomy exemplifies the literature on the use of flash VEP for intraoperative monitoring. Many of the reports involve small numbers of patients and in general are optimistic.[1, 6, 9, 21]

In studies of larger series of patients the two opposing views prevail. Some authors[1, 3, 10, 16] maintain that the changes in VEP latencies and amplitude were due to spontaneous variability, were unrelated to surgical procedure, and equally were unrelated to postoperative outcome. Other authors[5, 11, 12, 18, 20] claim consistent responses that change predictably with surgical interference and show a correlation between intraoperative VEP changes and postoperative vision. With the exception of Harding et al.,[11, 12] who used a fiber-optic contact lens stimulator, and Albright and Sclabassi,[1] who used a conventional stroboscope, all other authors used an LED-type stimulator.

There is an almost complete absence of the use of VEP monitoring in intensive care. Although there is frequent use of brain stem auditory evoked potentials and even somatosensory potential monitoring, the VEP is only utilized if there is a question as to whether the visual system is functioning. However, in the newborn at risk, flash VEPs are frequently used to indicate possible neurological damage. Hrbeck et al.[13] showed that VEPs were often abnormal for gestational age in high-risk infants, and these findings have been confirmed by Gambi et al.,[7] Watnabe et al.,[19, 20] and Crutchfield et al.[5] Most studies suggest that long-latency, low-amplitude VEPs or VEPs in which components normally present at a particular gestational age are absent are associated with poor clinical development. In addition, VEPs in which the latency of the component does not shorten with increasing development indicate a poor prognosis.[5] However, some studies report abnormal VEPs in which no evidence of neurological deficit can be established.

Studies of respiratory distress syndrome (RDS) in young babies were carried out by a number of authors. Graziani et al.[8] found that during periods of extreme hypoxemia the VEP was absent. If, however, resuscitation was performed before brain damage had occurred, the VEP would revert to normal.

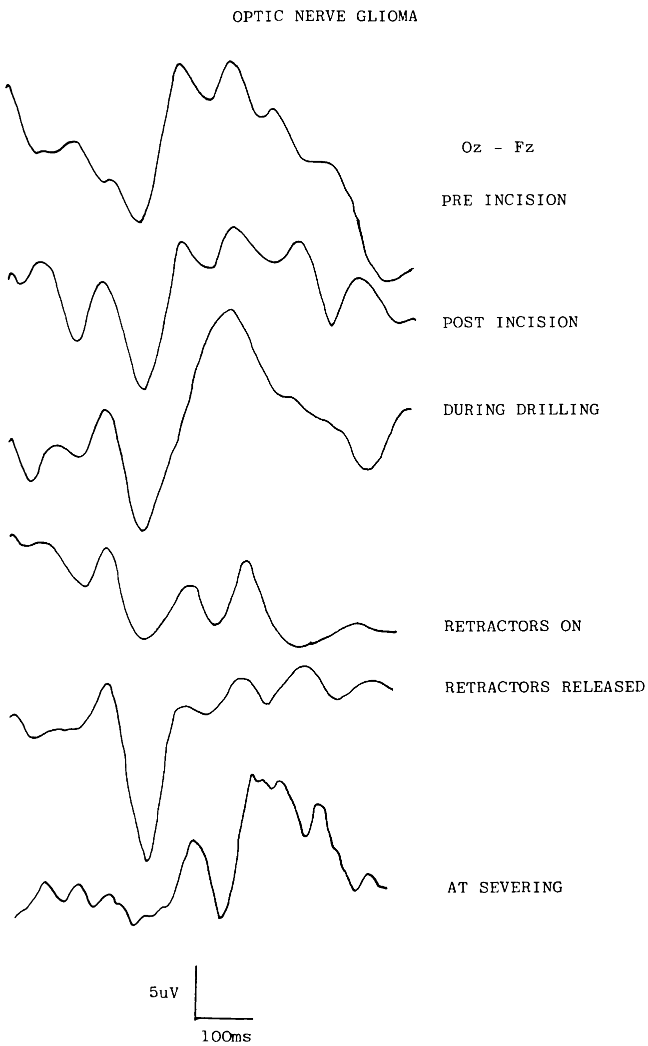

FIG 79–3.
Flash VEP obtained from a patient undergoing surgery for an optic nerve glioma. The major positive component of the flash VEP can be clearly seen preincision, following anesthetic induction using Dipravan with maintenance on 1% enflurane and nitrous oxide. Postincision the VEP remains much the same as it does during drilling of the zygomatic arch prior to its removal. The use of mechanical retractors to produce lateral movement of the globe clearly reduced the amplitude of the VEP, and the tension of the retractors was reduced until the VEP returned. When the optic nerve was ligatured prior to severing, the responses disappeared as seen in trace 8. (From Harding GFA, Smith VH, Yorke HC: Visual evoked potential monitoring of orbital surgery using a contact lens simulator, in Barber C, Blum T (eds): *Evoked Potentials III. The Third International Symposium,* vol 29. Stoneham, Mass, Butterworths, 1987, pp 240–251. Used by permission.)

Hrbeck et al.[14] investigated 16 newborn infants with RDS. The results showed that the VEP amplitude was reduced regardless of RDS severity and that most components of the VEP tended to be integrated into a slow negative wave more than 2 SD above the normal latency. VEP latencies reduced to normal levels in surviving infants, but only after several days or weeks.

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