Acta Scientific Clinical Case Reports

Volume 1 Issue 2 March 2020

Case Report

Protecting the Visual Pathways During Optic Nerve Surgery Using Intraoperative Visual Evoked Potentials (VEP)

Faisal R Jahangiri[1]*, Sidra Ilyas[2], Rabehah Asdi[3], Esther Escobedo[1] and Michael Seals[4]

[1]*Axis Neuromonitoring LLC, Richardson, TX, USA*

[2]*Department of Anatomy, School of Medicine, University of California, San Francisco, CA, USA*

[3]*School of Behavioral and Brain Sciences, The University of Texas at Dallas, Richardson, TX, USA*

[4]*Atlas Neuromonitoring LLC, Richardson, TX, USA*

***Corresponding Author:** Faisal R Jahangiri, Axis Neuromonitoring LLC, Richardson, TX, USA.

Received: January 30, 2020

Published: February 10, 2020

Abstract

This case report illustrates the benefit of utilizing Intraoperative Neurophysiological Monitoring (IONM) during the resection of an optic nerve lesion. A multimodality IONM utilized Electroretinogram (ERG), Visual Evoked Potentials (VEP) and Electroencephalography (EEG).

A 47-year-old female presented with left intracranial meningioma and decreased vision in the right eye. An MRI showed tumor attached to the left optic nerve and posteriorly displacing optic nerve and chiasm to the right. After induction and patient positioning, LED goggles were placed and secured on both eyes for performing VEP. The VEP responses were absent at baseline due to the inhalational agent. After switching to Total Intravenous Anesthesia (TIVA), ERG responses were recorded bilaterally. Baseline VEP and EEG recordings were obtained with good left VEP and absent right VEP responses. During tumor resection there was sudden decrease in left VEP responses. Retractors were removed immediately and the responses came back to baseline within few minutes. The tumor was resected without any loss of vision intraoperatively.

The patient noticed an improvement in her right eye four days post-operatively. One month post-operatively she continued to feel improvement. In this patient, the VEP was used effectively for the prevention of any loss of vision intra-operatively. The neurophysiological monitoring utilizing ERG and VEP helped prevent any further loss of vision and directing the surgeon intra-operatively.

Keywords: Electroretinogram (ERG); Visual Evoked Potentials (VEP); Electroencephalography (EEG); Intraoperative Neurophysiological Monitoring (IONM); Tumor

Introduction

When resecting lesions near the optic nerve, there is a risk of postoperative neurological deficit. The major concern is the loss of vision. A multimodality intra-operative neurophysiological monitoring (IONM) with Electroretinography (ERG) and Visual Evoked Potentials (VEP) is a well-recognized method to identify any injuries to the optic nerve during the tumor resection. IONM provides real-time feedback to the surgeon during the resection. This immediate feedback decreases the risk of neurological injury.

Electroretinography (ERG) is a test that is used to detect any abnormality of the retina. Specifically, in this test, the examination of the light-sensitive cells of the eye, the rods and cones, and their connecting ganglion cells in the retina are performed. During this test, a contact electrode is placed on the cornea to measure the electrical responses to light of the cells that sense light in the retina of the eye. The ERG consists of a cornea-negative a-wave followed by a cornea-positive b-wave (Figure 1). An ERG test is performed for the evaluation of ophthalmologic diseases of the retina. An absent ERG suggests a widespread retinal disease. Intact VEP with absent ERG may be seen if the macular vision is spared. The various factors that may influence the ERG values include state of adaptation, light intensity, light stimulus color, and stimulation frequency [1].

Figure 1: Schematic diagram of a biphasic Electroretinogram (ERG) waveform. A cornea-negative a-wave (N35) followed by a cornea-positive b-wave (P50).

Visual Evoked Potentials (VEP), also known and VER (visual evoked response) is a type of electrophysiological testing done to measure the electrical potential resulting from a visual stimulus [2,3]. Specifically, in this test, the visual pathways are examined (Figure 2). Light omitting goggles are placed on the eyes bilaterally, and responses are recorded from visual pathways including cornea, optic chiasm and the occipital lobe (visual cortex) (Figure 3).

Figure 2: Schematic diagram of the visual pathways [reprinted with permission from Faisal R. Jahangiri (2012), Surgical Neurophysiology: Second Edition. A Reference Guide to Intraoperative Neurophysiological Monitoring (IONM), CreateSpace, Columbia, SC.

Figure 3: Schematic diagram of Visual Evoked Potentials (VEP) to flash stimulation showing the occipital responses N75, P100, and N145. The amplitude of the responses is maximal at the MO electrode recordings and lower amplitude responses at the LO and RO recording channels. A bandpass filter of 1-250 Hz.

This case report was designed to determine if multimodality IONM utilizing the ERG and VEP could effectively identify any changes the visual evoked potentials intraoperatively and help in preventing any neurological/visual deficits. This case report illustrates the benefit of utilizing The multimodality IONM including ERG, VEP, and EEG during the resection of an optic nerve lesion.

Patient history

A 47-year-old female known of hypothyroidism with decreased vision in her right eye was referred to ophthalmology from the family physician. She was seen by an ophthalmologist after one year, and was diagnosed with right optic disc atrophy and was found to have pale disc in the temporal area. Brain CT showed planum sphenoidale and tuberculum meningioma. The patient was referred to neurosurgery where she was admitted and brain MRI was done which showed the same findings and posteriorly displaced the optic nerve and the chiasm to the right side (Figure 4).

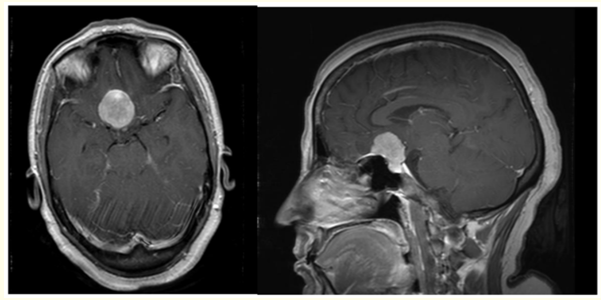

Figure 4: Pre-op MRI Axial and Sagital View: A large 2x2.5x3 cm T1 isointense lesion homogenously enhancing with contrast seen over the planum sphenoidale extending posteriorly to the suprasellar cistern causing mass effect on the adjacent posterior frontal gyri and posteriorly displacing the optic nerves and chiasm and stalk of the pituitary gland.

Material and Methods

The intraoperative neuromonitoring was performed by a CNIM certified technologist [4] and a D.ABNM board-certified neurophysiologist [5]. A board-certified neurologist with a specialty in IONM was also present online for remote monitoring during the entire surgical procedure [6].

Anesthesia

The patient was intubated with sevoflurane and propofol. The inhalational agent was stopped due to the suppressive effect of VEPs. Anesthesia was switched to total intravenous anesthesia (TIVA) with propofol and fentanyl infusion [7]. After induction and patient positioning, eyes were closed using transparent tape. Contact electrodes (Fabrinal, Switzerland) were placed at cornea with transparent antibiotic gel to avoid corneal abrasions (Figure 5). Goggles were placed and secured on eyes bilaterally for performing visual evoked potentials (VEP). Subdermal needle electrodes were placed on the occipital lobe for VEP recordings per queen square system (Figure 6). Subdermal needle electrodes were also placed on the scalp for EEG recordings.

Figure 5: Placement and labeling of the Electroretinogram (ERG) recording electrodes. L: 1.0 cm away from left eye outer margin; R: 1.0 cm away from right eye outer margin; A1: Left ear; A2: Right ear.

Figure 6: Placement and labeling of the recording electrodes for Visual Evoked Potentials (VEP). The electrodes should be placed and labeled according to queen square system. MO: Mid-occipital; LO: Left lateral occipital; RO: Right lateral occipital; MF: Mid-frontal, in midline; A1: Left ear; A2: Right ear.

Surgical procedure

The patient was then positioned in the supine position with his head affixed to the three-pin Mayfield frame. The stereotactic navigational system was then registered and used to make an appropriate skin incision. The head was prepped using betadine and alcohol solutions. Local anesthetic was injected into the dermis. A skin incision was made. The skull surface overlying the tumor was exposed and the stereotactic system was used to identify the tumor margins. A standard craniotomy was performed.

Intraoperative visual evoked potentials (VEP)

At the baseline the VEP responses were absent. The anesthesiologist was consulted and was requested to stop the inhalational agent (sevoflurane) and switch to TIVA. ERG and VEP baseline responses were recorded with left eye stimulation with good morphology and repeatability. Responses were absent on the right side, where the patient was blind (Figure 7). The tumor was attached to the left optic nerve and during the tumor resection, there was a significant change in the left VEP responses (Figure 8). The surgeon was immediately informed. The surgeon decided to remove the retractor and pause the freeing of the optic nerve. Soon after signals returned to the baseline and stayed stable until closing (Figure 9).

Figure 7: Baseline Electroretinogram (ERG), Visual Evoked Potentials (VEP) responses showing present ERG and VEP responses to left eye stimulation (Left), and present ERG and absent VEP responses to right eye stimulation (Right).

Figure 8: Visual Evoked Potentials (VEP) responses during tumor resection showing present ERG and loss of VEP responses to left eye stimulation (Left), and present ERG and absent VEP responses to right eye stimulation (Right). Green arrow: baseline P100 responses, Red arrows: loss of P100 responses.

Figure 9: Closing Electroretinogram (ERG), Visual Evoked Potentials (VEP) responses showing bilaterally present responses. Improvement in left P100 responses can be seen to left eye stimulation (Left), with absent VEP responses to right eye stimulation (Right). Green arrow: baseline P100 responses, Yellow arrows: return of P100 responses.

Results

In this patient, the intraoperative neurophysiological monitoring (IONM) helped in guiding the surgeon during the high-risk procedure. Due to a sudden decrease in left VEP responses surgeon was alerted and this resulted in no postoperative neurological deficit. Tumor attached to the left optic nerve was resected without any loss of vision intraoperatively.

Post-operative

The patient noticed an improvement in her right eye four days post-operatively. At the one-month postoperative follow-up, she continued to feel improvement (Figure 10).

Data set	ERG	P100	Anesthetic Effect	Surgical changes
Pre-inclination baseline	Present	Absent	Yes	No
Post draping baseline	Present	Present	No	No
Tumor resection	Present	Decreased	No	Yes
Closing	Present	Present	No	No

Table 1: Intraoperative Electroretinogram (ERG), Visual Evoked Potentials (VEP) Data.

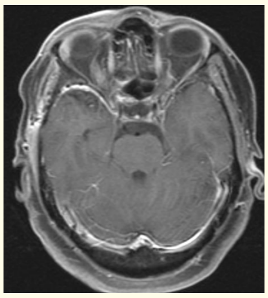

Figure 10: Post-op MRI: Surgical Cavity is demonstrated along the posterior aspect of the gyrus with no residual disease identified. Postoperatively the compression on the chiasm has been significantly resolved secondary to the complete resection of the meningioma.

Discussion

The generator site for VEPs is believed to be the peristriate and striate occipital cortex. Prolongation of P100 latency is the most common abnormality and usually represents an optic nerve dysfunction. VEP is an objective and reproducible test for optic nerve function. A normal VEP virtually excludes an optic nerve or anterior chiasmatic lesion.

Intraoperative use of VEP during the surgical procedures involving the optic nerve can be highly beneficial to the patient and as well as the surgeon by providing real-time physiological data of the nervous system [8,9]. Utilizing the ERG and VEP during manipulation and tumor resection helps in identifying any pressure or stretch on the optic nerve. However, it is important to remember that intraoperative visual testing is only reliable for surgeries involving areas around optic chiasm and optic nerves. Real-Time feedback to the surgeon about the visual pathways can minimize any post-operative visual deficits [10]. Accurate real-time feedback to the surgeon about the integrity of the visual pathways can reduce any post-operative visual deficits.

VEP during brain aneurysm surgery

Intraoperative VEPs were sensitive enough to detect vascular damage during aneurysm clipping and mechanical manipulation of the anterior visual pathway in an early reversible stage. Intraoperative VEP monitoring influenced surgical decisions in selected patients and proved to be a useful modality of IONM.

VEPs as a marker for visual function during orbital surgery

In graves disease, the increase in fat tissue and muscles leads to optic neuropathy in severe cases. In the study performed by Clause., *et al.* VEP amplitude and latency improved after orbital decompression. VEP was proven to be reliable indicator for the detection of optic neuropathy caused by stretching of the optic nerve [11]. In study done by Harding., *et al.* transient abolition of VEP was seen under surgeries and did not correlate with the outcome of surgery, but they concluded that absence of previously normal VEP for more than four minutes during surgical manipulation within the orbit did show correlation. Hence, they concluded that the technique provides early warning to threat to integrity of the optic nerve.

VEPs as a marker for visual function during trans-sphenoidal surgery

Intraoperative monitoring of VEP with scalp electrodes under TIVA had a reproducibility of 89.6% during transsphenoidal surgery for sellar or perisellar lesions. However, the intraoperative VEP waveforms showed no association with postoperative visual outcomes. The transient abolition of the VEP was seen under many circumstances and did not correlate with the outcome of surgery, but the absence of a previously normal VEP for more than four minutes during surgical manipulation within the orbit did show a correlation with post-operative impairment of vision. The technique provides early warning to the surgeon of threats to the integrity of the optic nerve [11].

Nishimura., *et al*. performed VEP on 160 eyes to determine the relationships between VEP waveform changes in endoscopic transsphenoidal surgery and postoperative visual function. In the unchanged VEP amplitude group, 62 (50%) eyes showed improved postoperative visual function and 62 (50%) eyes had an unchanged visual function in the postoperative state. When the VEP amplitude decreased significantly, the surgeon paused the tumor removal procedure for several minutes. They concluded that VEP can be steadily monitored in patients with corrected visual acuity greater than 0.1. Permanent VEP loss may indicate severe visual dysfunctions postoperatively. Transient VEP changes do not indicate postoperative visual disturbance. Visual field defects without decreases in visual acuity may not be predicted by VEP monitoring [12].

VEPs as a marker for visual function during parasellar surgery

Gutzwiller., *et al.* performed Intraoperative VEPs with simultaneous recording of ERG, with protection from lights of the operating room and with white light-emitting diodes. Intraoperative VEPs were shown to be reliable in predicting postoperative visual field changes. In this series of intraaxial brain procedures, reliable intraoperative VEP monitoring was achieved, allowing at minimum the detection of new quadrantanopia. The standardization of this technique appears to be a valuable effort in regard to the functional risks of homonymous hemianopia [13].

VEPs as a marker for visual function during endoscopic surgeries in the brain

Chung., *et al.* performed endoscopic endonasal transsphenoidal surgery for sellar or perisellar lesions in 65 consecutive patients with intraoperative VEP monitoring using scalp electrodes under TIVA. The aim of this study was to elucidate the relationship between changes in the intraoperative VEP waveform and postoperative visual functional outcomes. Among the 65 patients, 53 patients were followed-up with postoperative visual function evaluation. VEP waveforms measured at baseline were compared with those obtained toward the end of surgery and the association between changes in VEP waveforms and visual outcomes measured preoperatively and postoperatively were assessed. Intraoperative monitoring of VEP under TIVA had a reproducibility of 89.6% during transsphenoidal surgery for sellar or perisellar lesions [14].

Intraoperative use of visual evoked potentials (VEP) during the surgical procedures involving the optic nerve can be highly beneficial to the patient and as well as the surgeon. Utilizing the ERG and VEP during manipulation and tumor resection helps in identifying any pressure or stretch on the optic nerve. However, it is important to remember that intraoperative visual testing is only reliable for surgeries involving areas around optic chiasm and optic nerves. Real-Time feedback to the surgeon about the visual pathways can prevent any post-operative neurological deficits.

False positives/negatives

Any abnormality or sudden change to the visual pathway may have direct effects on VEP recordings. Pressure on the optic pathways such as from hydrocephalus or tumor compression reduces the amplitude of wave peaks [15]. The temperature has a significant effect on the latency and reproducibility of flash VEP signals, with a drop in temperature of 1°C reduces central conduction by 15%, potentially causing inaccurate results. VEP amplitude is decreased and latency is extended under conditions of extreme hypoxia and hypotension. Other complications such as preoperative visual impairments, hypocapnia, and hemodilution have the ability to produce VEP false negatives during surgery [7].

Intraoperative VEPs provide valuable data to aid in preserving the visual capacity of patients due to being highly sensitive enough to detect vascular damage during aneurysm clipping and mechanical manipulation of the anterior visual pathway in an early reversible stage. Monitoring the visual pathway throughout surgery significantly decreases the possibility of postoperative vision complications in the patient [15]. Intraoperative VEP monitoring is often reproducible and influences surgical decisions, proving to be a valuable supplement to intraoperative neurophysiological monitoring [16].

Conclusion

In this patient, the utilized visual evoked potentials (VEP) were effectively used for the prevention of any loss of vision intra-operatively. The neurophysiological monitoring utilizing ERG and visual evoked potentials (VEP) were helpful in preventing any further loss of vision and directing the surgeon intra-operatively. VEP can be abnormal in brain injuries, optic neuritis, and neuropathy, tumors compressing the optic nerve, retrobulbar neuritis surgery. Postoperative visual loss is a devastating complication of brain surgery. During surgeries that put the visual pathway at risk of injury, continuous monitoring of the visual function is desirable. However, the intraoperative monitoring of the visual evoked potential (VEP) is not yet widely used [17-20].

Bibliography

1. American Clinical Neurophysiology Society. "Guideline 9B: guidelines on visual evoked potentials". *American Journal of Electroneurodiagnostic Technology* 46.3 (2006): 254-274.
2. Jahangiri, FR. "Surgical Neurophysiology: An Introduction to Intraoperative Neurophysiological Monitoring (IONM)". Second Edition. 193-95, April (2012).
3. Abulaban A and Jahangiri FR. "Establishment of Normal Visual Evoked Potentials (VEPs) Values in Adult Saudi Males". *Abstracts published in the proceeding of King Saud Bin Abdulaziz University for Health Sciences 15th Resident's Day*. Riyadh, Saudi Arabia: King Abdulaziz Medical City (2012): 36.
4. ABRET Neurodiagnostic Credentialing and Accreditation. ABRET (2019).
5. ABNM: American Board of Neurophysiologic Monitoring. ABNM: American Board of Neurophysiologic Monitoring (2019).
6. Gertsch JH., *et al*. "Practice guidelines for the supervising professional: intraoperative neurophysiological monitoring". *Journal of Clinical Monitoring and Computing* 33 (2019): 175-183.
7. Hayashi H and Kawaguchi M. "Intraoperative monitoring of flash visual evoked potential under general anesthesia". *Korean Journal of Anesthesiology* 70 (2017): 127-135.
8. Cedzich C., *et al*. "Are flash-evoked visual potentials useful for intraoperative monitoring of visual pathway function?" *Neurosurgery* 21 (1987): 709-715.
9. Jahangiri FR., *et al*. "Protecting the Visual Pathways during Optic Nerve Surgery Using Neurophysiological Monitoring". Abstracts published in the proceeding of the Department of Medicine: 13th Research Day. Riyadh, Saudi Arabia: King Abdulaziz Medical City 32 (2012).
10. Thirumala PD., *et al*. "Neurophysiologic Intraoperative Monitoring of Olfactory and Optic Nerves". *Journal of Clinical and Neurophysiology* (2011).

11. Harding GF., *et al*. "Visual evoked potential monitoring of optic nerve function during surgery". *Journal of Neurology, Neurosurgery, and Psychiatry* 53.10 (1990): 890-895.

12. Nishimura F., *et al*. "Efficacy of the visual evoked potential monitoring in endoscopic transnasal transsphenoidal surgery as a real-time visual function". *Neurology India* 66 (2018): 1075-1080.

13. Gutzwiller EM., *et al*. "Intraoperative monitoring with visual evoked potentials for brain surgeries". *Journal of Neurosurgery* 130 (2018): 654-660.

14. Chung SB., *et al*. "Intraoperative visual evoked potential has no association with postoperative visual outcomes in transsphenoidal surgery". *Acta Neurochirurgica* (Wien). 154.8 (2012): 1505-1510.

15. Kamio Y., *et al*. "Usefulness of intraoperative monitoring of visual evoked potentials in transsphenoidal surgery". *Neurologia medico-chirurgica* (Tokyo) 54 (2014): 606-611.

16. Luo Y., *et al*. "Clinical utility and limitations of intraoperative monitoring of visual evoked potentials. *PLoS One* 10.3 (2015): e0120525.

17. Ezzat S., *et al*. "The prevalence of pituitary adenomas: a systematic review". *Cancer* 101 (2004): 613-619.

18. Asa SL. "Practical pituitary pathology: what does the pathologist need to know?". *Archives of Pathology and Laboratory Medicine* 132 (2008): 1231-1240.

19. Halliday AM. Evoked potentials in clinical testing, 2nd ed. London: Churchill Livingstone (1993).

20. McDonald WI., *et al*. "Recommended diagnostic criteria for multiple sclerosis: Guidelines from the international panel on the diagnosis of multiple sclerosis". *Annals of Neurology* 50 (2001): 121-127.