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SNI: Neuroendoscopy

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Case Report

Monitoring of visual-evoked potentials during fat packing in endoscopic resection of a giant pituitary adenoma

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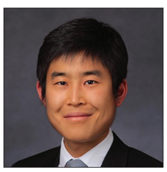

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Received: 23 August 2024
Accepted: 30 September 2024
Published: 25 October 2024

DOI
10.25259/SNI_719_2024

Quick Response Code:

ABSTRACT

Background: Endoscopic transsphenoidal surgery has become a mainstay surgical approach for sellar pathologies and can effectively decompress mass effects on the optic nerves. Visual-evoked potentials (VEPs) have been utilized as an intraoperative adjunct during endoscopic transsphenoidal surgery to monitor the integrity of the optic pathways, but the data surrounding its reliability and efficacy remain heterogeneous.

Case Description: An 80-year-old male underwent endoscopic transsphenoidal resection of a pituitary macroadenoma with preoperative visual deficits related to optic nerve compression. During fat packing of the resection cavity, a decrease in VEPs was noted, which seemingly improved after partial fat removal, although with paradoxically reduced VEP latencies. Despite this, the patient developed a visual field deficit postoperatively, requiring re-operation for further removal of the fat packing.

Conclusion: This was a case of initially poorly formed VEPs that deteriorated and apparently improved following surgical intervention. The finding of shortened latencies of the VEPs was likely from noise contamination, creating the illusion of improved signal amplitudes. We recommend careful assessment of VEP data for baseline reproducibility, particularly in patients with pre-existing visual field deficits. Appropriate anesthetic selection is also important to reduce noise interference from the electroencephalogram.

Keywords: Endoscopic, Neuromonitoring, Pituitary adenoma, Visual-evoked potentials

INTRODUCTION

Endonasal transsphenoidal surgery remains the gold standard for pituitary tumor surgery. A key consideration during this surgical approach is the proximity of the normal pituitary gland and nearby pathologies to the optic nerves, and as such, ample care must be taken to avoid iatrogenic damage to the optic apparatus.

Visual-evoked potentials (VEPs) have been a longstanding method of monitoring the electrophysiologic activity of the visual pathways from the optic nerves to the occipital cortex for a variety of neurological pathologies. Historically, VEPs have been used widely in neuro-ophthalmology to diagnose and monitor various disease states such as multiple sclerosis, ischemic optic neuropathy, and various neurodegenerative diseases, among others.[1,2,35,46] In addition, VEPs have been utilized to diagnose and follow optic nerve compression from nearby tumors.[5,12] More recently, VEPs have been employed in intraoperative monitoring of the integrity of visual pathways during endoscopic transsphenoidal surgery of sellar and parasellar pathologies.[11,45]

Briefly, to record VEP waveforms, visual stimuli are presented to the right and left eye using goggles. Flashes can be used while the eyelids are closed during surgery. Adequate stimulation is assured by electroretinogram (ERG) recordings from electrodes placed around the eye. The VEPs are subsequently recorded from needle electrodes placed on the occipital scalp. For intraoperative monitoring, each patient serves as his or her control. Signals are elicited and recorded during the entire surgery and compared to baseline data. Changes in wave morphology, such as decreased amplitude or increased latency, indicate potential pathological insults to the optic pathways.

VEPs can be difficult to interpret during transsphenoidal surgeries. The OR environment can introduce noise. Criteria for the interpretation of VEPs during surgery have been suggested but are not uniform.[17,33] Data surrounding the reliability and reproducibility of this technology remain heterogeneous.[20]

At our institution, we routinely utilize intraoperative VEPs for all patients undergoing endoscopic transsphenoidal surgery. While our experience has been overall very reliable in the correlation of VEPs with clinical outcomes, in this report, we describe a case of overpacking of the sellar resection cavity with fat that led to a postoperative visual deficit despite the seemingly reassuring reversal of the intraoperatively observed changes in the VEPs. We discuss the possible reasons why the VEPs were less reliable in this case and suggest strategies to avoid repeating this scenario.

CASE DESCRIPTION

An 80-year-old male was referred to our institution after a large pituitary lesion was seen on magnetic resonance imaging (MRI), obtained as a part of a work-up for short-term memory loss. A full panel of endocrine labs was within normal limits [Table 1]. A dedicated pituitary protocol MRI demonstrated a heterogeneously enhancing sellar mass with suprasellar extension, measuring up to 3.1 cm in greatest diameter with an upward mass effect on the optic chiasm [Figure 1]. His neuro-ophthalmologic evaluation was notable for bitemporal hemianopsia, worse on the left such that he could not see past midline, as well as 20/400 visual acuity in the left eye secondary to glaucoma. Otherwise, his neurologic examination was unremarkable. Given the size of the tumor, compression of the optic apparatus, and corresponding visual deficits, he was counseled on and consented to surgical resection of the tumor through an endoscopic transsphenoidal approach.

Table 1: Preoperative endocrine panel.

Laboratory marker	Value	Reference range
Sodium	139	135–145 mEq/L
TSH	4.94	0.5–5.0 mlU/L
A.M. Cortisol	17	5–25 mcg/dL
ACTH	32	10–60 pg/mL
FSH	7	1.42–15.4 IU/mL
LH	5.7	1.24–7.8 IU/mL

TSH: Thyroid-stimulating hormone; ACTH: Adrenocorticotropic hormone; FSH: Follicle-stimulating hormone; LH: Luteinizing hormone

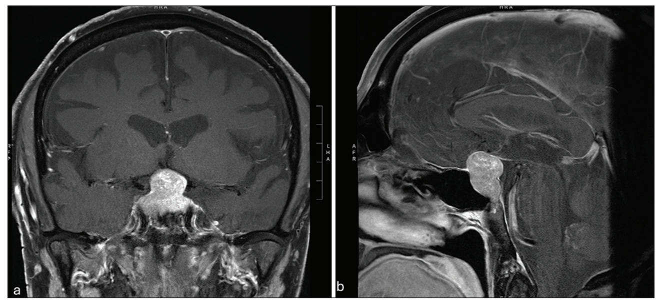

Figure 1: Postoperative T1-weighted post-contrast magnetic resonance imaging. Representative (a) coronal and (b) sagittal images demonstrating a heterogeneously enhancing sellar mass with suprasellar extension, measuring up to 3.1 cm in greatest diameter with upward mass effect on the optic chiasm.

He was subsequently taken to the operating room for this procedure. Routine surgical adjuncts were utilized, including 3-D endoscopy, intraoperative neuronavigation, and VEPs with electroretinogram (ERG) and scalp electroencephalogram (EEG). The patient's ERG responses were well formed and reproducible, but baseline VEP signals were not robust. This was not unexpected given the preoperative visual field deficits, and monitoring continued using these baselines. A low-to-moderate flow cerebrospinal fluid (CSF) leak was encountered intraoperatively, which was repaired with an inlay of abdominal fat, followed by a pedicled nasoseptal flap. During the packing of the fat into the sella, there was a transient decrease in the amplitude of the VEPs, and the surgical team was alerted immediately by the neuromonitoring team [Figure 2]. As such, the fat was removed with subsequent apparent normalization of VEP amplitudes, although paradoxically with decreased signal latencies [Figure 3]. VEPs appeared to persist until the end of the procedure, but latencies remained somewhat variable.

Postoperatively, the patient awoke grossly able to count fingers. As the anesthesia wore off, he thought the vision in his left eye had possibly worsened but was not sure, given

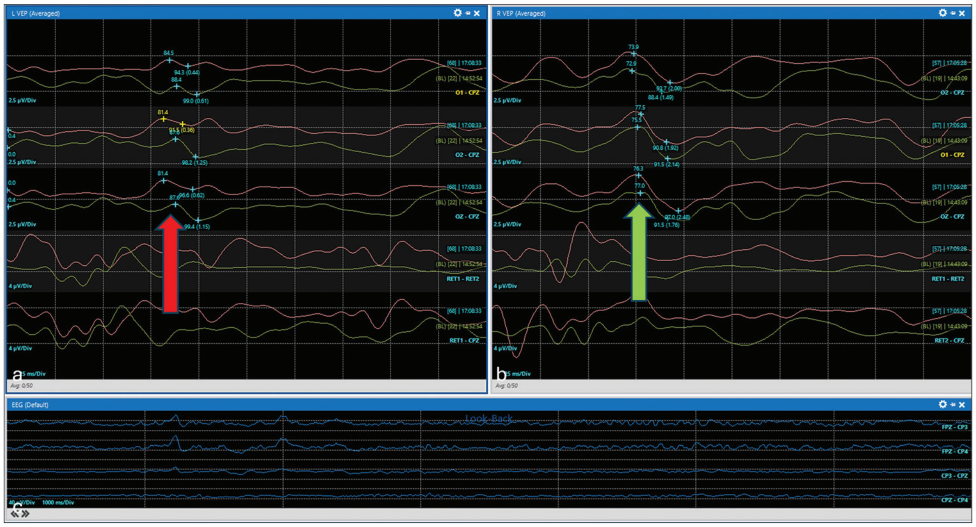

Figure 2: Decrease in VEPs during fat packing. Red and green tracings represent current and baseline waveforms, respectively. (a) Representative VEPs from the left eye demonstrated decreased amplitude with no definitive peak in the red tracing compared to baseline (0.62 vs. 1.15 µV), best illustrated in the OZ-CPZ channel (red arrow). (b) In contrast, VEPs from the right eye showed no amplitude changes compared to the baseline (green arrow). (c) Continuous electroencephalogram monitoring. Visual-evoked potentials (VEP).

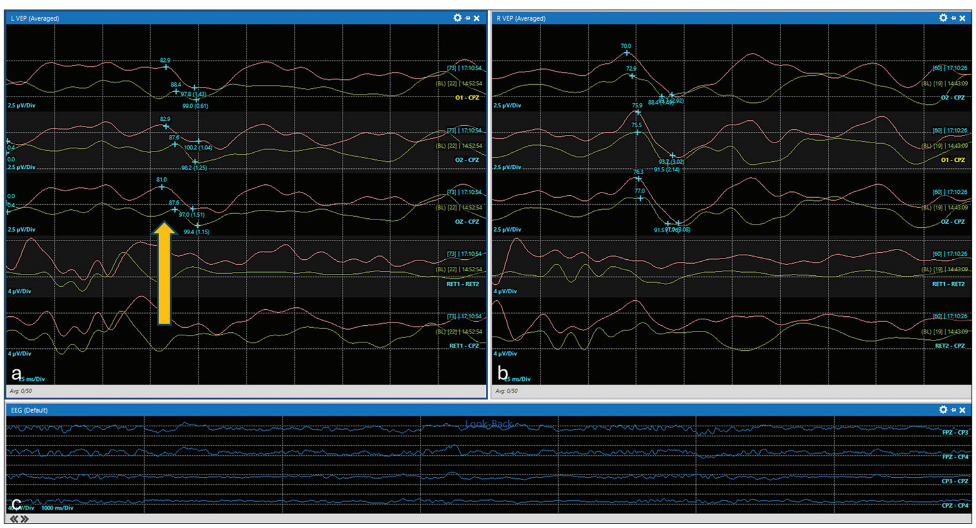

Figure 3: Apparent improvement of VEPs after fat removal. Red and green tracings represent current and baseline waveforms, respectively. (a) Representative VEPs from the left eye demonstrated improved amplitude in the red tracing compared to baseline (1.51 vs. 1.15 µV) but with paradoxically shortened latencies (81.0 vs. 87.6 ms) (yellow arrow). (b) In contrast, VEPs from the right eye remained stable. (c) Continuous electroencephalogram monitoring demonstrated persistent activity that may have contributed to potential noise contribution. Visual-evoked potentials (VEP).

that he had not taken his glaucoma eye drops. By the next morning, however, he was confident that his peripheral vision in his left eye had worsened and on examination, his temporal field deficit of the left eye had extended nasally toward complete midline. An ophthalmology consult was obtained, and the left visual field cut was confirmed. Otherwise stable visual acuity of 20/25 was noted on the right and with a stable visual acuity of 20/400 on the left. A stat MRI was obtained demonstrating expected postoperative changes with fat packing in the sella as well as the mass effect on the optic nerves and chiasm [Figure 4]. The patient was, therefore, taken back to the operating room that evening. At the start of the case, baseline VEPs were noted to be variable bilaterally, with a poor noise-to-signal ratio. The nasoseptal flap was taken down, and approximately half of the fat was removed. Subsequently, the flap was repositioned. At the

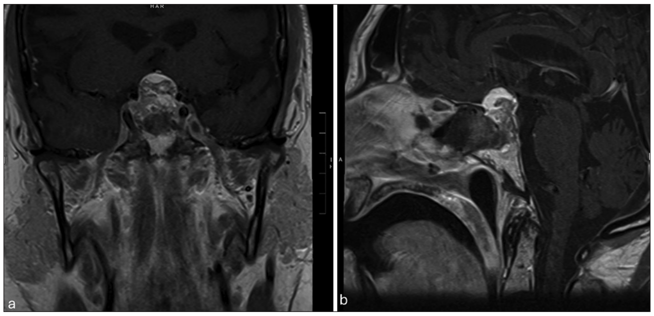

Figure 4: Postoperative T1-weighted post-contrast magnetic resonance imaging. Representative (a) coronal and (b) sagittal images demonstrating fat packing in the resection cavity with mass effect on the optic apparatus.

end of the case, the VEPs were deemed to be possibly worse than at the beginning in the setting of poor signals from the onset. However, on awakening, the patient reported definitive improvement in his vision and his left temporal field cut was noted to be back at baseline. The patient was discharged 3 days later to home and, at 2 week follow-up, was doing well with subjective improvement in peripheral vision, particularly on the right side. A formal 3 month follow-up ophthalmologic evaluation confirmed full visual fields on the right, a stable temporal field cut on the left, and improvement of visual acuity on the left to 20/150.

DISCUSSION

VEPs were first described during intra-orbital surgery in 1973, followed shortly by the first report during surgery around the sellar region in 1976.[42,43] However, subsequent early studies showed high rates of variability, such that the utility of VEPs was called into question.[6,7,30] Since then, there have been advances in technology, but a recent systematic review of VEPs in transsphenoidal surgery suggested that standardization of warning criteria is still necessary to improve reliability and reproducibility.[20] Some authors have suggested that each laboratory needs to establish its normative data.[18]

Several adjuncts may be useful to optimize the robustness of the VEP signal. First, the use of ERG in conjunction with intraoperative VEPs is useful as its presence establishes adequate stimulation of the retina and may avoid false positive results. Previous studies have suggested that a loss of signal may indicate a technical problem that needs to be rectified before VEPs can be reliably interpreted.[23,26] The choice of anesthetic agent is also important in optimizing the VEP signal. It is well known that volatile inhalation anesthetics produce a dose-dependent increase in signal latency and a decrease in signal amplitude, hindering accurate monitoring of neuromonitoring signals.[29,31,34] VEPs, in particular, are sensitive to volatile anesthetics due to the fact that they convey polysynaptic cortical signals and are also prone to inadequate retinal stimulation from anesthesia-related pupillary constriction.[9,37] As such, avoidance of inhalation anesthetics in favor of total intravenous anesthesia (TIVA) has improved the robustness of VEP signals.[27,38] That said, VEP signal integrity can also be adversely affected by the depth of TIVA and should be taken into consideration and discussed with the anesthesiologist during endoscopic transsphenoidal surgery.[17,41]

Taken together, several studies looking at the use of VEPs in patients undergoing transsphenoidal surgery for pituitary adenomas have demonstrated that a combination of using LED goggles with simultaneous ERG monitoring as well as TIVA for anesthesia may optimize the robustness of the VEP waveform.[15,19,36] That said, VEP recordings may not be as reliable in patients with severe preoperative visual field deficits and/or visual acuity, as baseline signals may be poor and not reproducible and are consistent anecdotally with our own institutional experience.[10,26,28] Mattogno *et al*. demonstrated in a large series of 64 patients undergoing pituitary tumor surgery that baseline VEP amplitudes significantly correlated with preoperative visual fields and acuity.[26] In addition, the literature ranges greatly in the sensitivity and specificity of VEPs in predicting postoperative visual field outcomes. In general, the sensitivity has been reported anywhere from 25% to 88%,[15,32] but the specificity has been more favorable, ranging from 85% to 100%.[8,15,22,25,28,32,36] Among studies with a larger patient population, Feng *et al*. found a significant positive association between improvements in VEP amplitudes and postoperative visual field improvement in 42 patients undergoing endoscopic transsphenoidal resection of pituitary tumors.[15] Likewise, Mattogno *et al*. found a similar significant correlation in their cohort of 64 patients.[26] On the other hand, Toyama *et al*. and Chung *et al*., in their series of 20 and 65 patients, respectively, found no significant relationship between intraoperative VEP waveform changes and postoperative visual outcomes.[10,36]

The patient in our case had pre-existing visual field defects and poorly formed VEPs at baseline during the first surgery. Although anesthesia was optimized and TIVA was used, the signals were not robust and somewhat variable. Nonetheless, a critical insult was correctly identified during the surgery when overpacking with fat resulted in a decrease in the VEP amplitude. However, since the patient awoke with a deficit, it is questionable whether the observed amplitude improvement following the corrective removal of some fat during the first surgery was a true return to the signal baseline. In retrospect, the unusual paradoxical finding of decreased latencies may have indicated that noise intrusions occurred, potentially from high levels of EEG activity, that simulated a VEP signal with a peak at an earlier time, giving the false impression of restored signal amplitudes. During the second surgery, signals were so deteriorated that they were variable from the beginning and could not be monitored reliably. In the future, various strategies to minimize noise disruption from EEG, such as the use of burst suppression, may improve the accuracy of the VEP signal and, thus, produce more reliable amplitude and latency readings after surgical manipulation. In addition, others have described alternative methods to monitor the integrity of the optic nerves, such as direct epidural electrical stimulation of the optic nerves that could be considered in cases where there is bony exposure overlying the optic canals.[3] Likewise, some studies have utilized preoperative VEPs to predict both intraoperative VEP signal integrity and postoperative outcomes, although in primary ophthalmologic procedures such as cataract surgery and vitrectomies.[13,21,39] Potentially, preoperative VEP testing in patients undergoing endoscopic transsphenoidal surgery may help identify those for whom intraoperative VEP monitoring may be most reliable.

During endoscopic transsphenoidal surgery, there are various strategies to reconstruct the skull base in the setting of an intraoperative CSF leak. At our institution, we routinely harvest an abdominal fat graft to pack the resection cavity, followed by a nasoseptal flap, particularly for high-flow CSF leaks. In this case, we encountered a low to moderate flow CSF leak (Esposito Grade 2) during the gentle peeling off of the tumor from the diaphragm.[14] We were prepared for this, as the diaphragm was expectedly very thinly attenuated from the chronic mass effect from the macroadenoma. While we have had success with this technique, there is evidence that fat packing is not necessarily advantageous to prevent postoperative CSF leak.[40] Others have advocated for methods that do not necessarily require packing any material into the sella, such as the gasket-seal technique. This involves covering the bony defect with a fascia lata graft or another dural substitute, such as a fibrin sealant patch, reinforced with a rigid implant, and then the nasoseptal flap.[4,24,44] Admittedly, reconstruction techniques that avoid packing the resection cavity significantly reduce the likelihood of iatrogenic optic nerve compression, as illustrated in this report. Furthermore, lower flow CSF leaks may be managed successfully without sellar packing, which is a notion to consider in future cases.[14,16]

In our institutional experience spanning many years utilizing VEPs for all endoscopic transsphenoidal cases, we have found them to be helpful in demonstrating improvement of VEP signals after tumor resection, confirming adequate optic nerve decompression. In addition, in a handful of instances, transient decreases in VEPs have alerted us to overpacking of the resection cavity, which we rectified intraoperatively without any clinical consequences. However, as this case demonstrates, VEPs need to be interpreted with caution in patients with pre-existing pathological conditions of the visual apparatus.

CONCLUSION

While the general principle of intraoperative monitoring, which states that each patient is under his or her control, still holds for VEPs, the reproducibility of the signals needs to be carefully assessed. Burst suppression may be considered to minimize noise intrusions from EEG activity that may contribute to the precision of VEP signals. Unexpected findings, like the shortening of the VEP latencies in our case, should prompt further troubleshooting and discussion between the surgical, anesthesia, and neuromonitoring teams, as they may represent meaningful signal changes.

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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How to cite this article: Hong CS, Gerstl JVE, Corrales CE, Smith TR, Ritzl EK. Monitoring of visual-evoked potentials during fat packing in endoscopic resection of a giant pituitary adenoma. Surg Neurol Int. 2024;15:387. doi: 10.25259/SNI_719_2024