



Comparison of visual evoked potential monitoring during spine surgeries under total intravenous anesthesia versus balanced general anesthesia



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HIGHLIGHTS

- SightSaver™ visual stimulator is a reliable method for intraoperative visual evoked potential monitoring.
- Total intravenous anesthesia (TIVA) leads to higher VEP amplitude and shorter latencies, compared to balanced general anesthesia.
- TIVA is the most efficient anesthesia regimen for monitoring VEP during prone spinal surgeries.

ABSTRACT

Objective: To determine the comparison of its clinical utility and safety profile for visual evoked potential (VEP) monitoring during prone spine surgeries under total intravenous anesthesia (TIVA) versus balanced general anesthesia using the SightSaver™ visual stimulator.

Methods: The protocol was designed as a pilot, single center, prospective, randomized, and double-arm study. Subjects were randomized to receive either TIVA or balanced general anesthesia. Following induction and intubation, 8 electrodes were placed subcutaneously to collect VEP recordings. The SightSaver™ visual stimulator was placed on the subject's scalp before prone positioning. VEP waveforms were recorded every 30 min and assessed by a neurophysiologist throughout the length of surgery.

Results: A total of 19 subjects were evaluated and VEP waveforms were successfully collected. TIVA group showed higher amplitude and lower latency than balanced anesthesia.

Conclusions: Our data suggested that TIVA is associated with higher VEP amplitude and shorter latencies than balanced general anesthesia; therefore, TIVA could be the most efficient anesthesia regimen for VEP monitoring.

Significance: The findings help to better understand the effect of different anesthesia regimens on intraoperative VEP monitoring.

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Abbreviations: VEP, visual evoked potential; TIVA, total intravenous anesthesia; VIMA, volatile induction/maintenance anesthesia; ERG, electroretinogram; EBL, estimated blood loss; ASA, American Society of Anesthesiologist; OR, operating room; LED, light emitting diodes.

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1. Introduction

Visual evoked potential (VEP) is the illustration of electrical activity recorded from sensors placed on the subject's scalp overlying the visual cortex in response to visual stimuli. Changes in this electroencephalographic signal are characterized by a waveform, where changes in latency, amplitude, and morphology could be associated with specific pathologies (Holy et al., 2009; Ota et al., 2010; Andersson et al., 2012; Chung et al., 2012; Kamio et al., 2014; Luo et al., 2015). There exists a variety of stimuli that can

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be used in awake subjects, the most common being checkboard pattern-reversal VEP (Andersson et al., 2012). However, in sedated or comatose subjects a stronger stimuli is required, typically using a bright flash (Andersson et al., 2012).

Unfortunately, VEPs have been inconsistent in eliciting responses in the operating room (OR) environment using standard techniques. The inability to deliver stable visual stimuli and obtain an adequate VEP recording can be caused by technical interventions, effects of volatile anesthesia, or inappropriate visual stimuli (Chung et al., 2012; Kamio et al., 2014). Other physiological factors that reduce its clinical application are body temperature, blood pressure, hematocrit, pH balance, and O₂ saturation (Banoub et al., 2003). VEP is also less likely to be detected in subjects with prior severe visual impairment (Neuloh, 2010; Kamio et al., 2014; Luo et al., 2015). Furthermore, surgical complications associated with loss of intraoperative VEP monitoring include epileptic seizure, burr hole drilling and bone milling, electrode detachment, use of certain intraoperative drugs such as sodium thiopental or midazolam, and other unidentifiable causes (Kamio et al., 2014; Luo et al., 2015). Loss of VEP monitoring may or may not be directly correlated to post-operative visual changes (Harding et al., 1990; Goto et al., 2007; Chung et al., 2012). Chung et al. asserted that changes in VEP waveform failed to indicate visual decline (Chung et al., 2012). Therefore, due to controversial and conflicting reports, a consensus of the usefulness and feasibility of intraoperative VEP monitoring with acceptable outcomes and sensitivity remains inconclusive (Kodama et al., 2010).

Additionally, the anesthetic regimen used during surgery presumably has a strong influence on the stability of intraoperative VEP recording (Neuloh, 2010). Total intravenous anesthesia (TIVA), volatile induction/maintenance anesthesia (VIMA), and balanced general anesthesia (combination of TIVA and VIMA) are the current anesthesia regimens used for spine surgeries. These regimens have been proven to offer an adequate level of anesthesia, hemodynamic stability, and safety profile (Watson and Shah, 2000). A few researchers describe TIVA as the anesthetic regimen with fewer effects on VEP monitoring, whereas VIMA decreases VEP accuracy with direct proportionality to the dosage received, increasing latency, and decreasing amplitude and reliability (Watson and Shah, 2000; Neuloh, 2010).

Several light-stimulating devices have been designed to monitor VEP during surgery, however, due to incompatibility with other surgical devices and unconventional subject positioning required during neurological surgeries, few of them are able to be customized to neurosurgical settings (Kodama et al., 2010; Sasaki et al., 2010; Chung et al., 2012). The SightSaver™ visual stimulator consists of disposable adhesive foam padding designed to contour the periocular region. It contains high intensity light emitting diodes (LED) that are connected with the standard clinical neurophysiology systems used for intraoperative neurophysiological monitoring (IONM) (Fig. 1).

This pilot study presents a new approach, different from current intraoperative methods of monitoring VEP, relying upon the use of SightSaver™ visual stimulator to determine the comparison of its clinical utility and safety profile for VEP monitoring during prone spine surgeries under TIVA versus balanced general anesthesia.

2. Methods

The protocol was designed as a pilot, single center, single blinded, prospective, randomized two-arm study. After institutional review board's (Office of Responsible Research Practices) approval, a total of 19 subjects completed the study between October 2014 and May 2015 at The Ohio State University Wexner



Fig. 1. The SightSaver™ flash visual evoked potential stimulator.

Medical Center. The clinical trial registry number of this study is NCT02643615.

Eligible subjects that provided voluntary, written informed consent were included in the study. Study inclusion criteria consisted of subjects scheduled for spine surgery that required prone positioning, at least two hours of general anesthesia and intraoperative neurophysiological monitoring, American Society of Anesthesiologists (ASA) physical status I to IV and ages 18 years or older. Exclusion criteria were prisoners, pregnant women or breastfeeding female subjects, and history of contact allergy to foam or plastic devices.

The randomization method used in this study was simple randomization using a random list generator. Consequently, subjects were randomized to receive either TIVA or balanced general anesthesia. Both regimens were standardized as follows: pre-induction medication consisted of the administration of 2–4 mg of midazolam IV. Induction was performed with 1–2 mg/kg of propofol IV, 40–100 mg of lidocaine IV and 50–100 µg of fentanyl IV. For the TIVA group, maintenance was performed with continuous infusion of propofol IV (suggested dose of 100–200 µg/kg/min). The recommended regimen for the balanced general anesthesia group was performed with desflurane (0.5 MAC), 0.05–0.25 µg/kg/min of remifentanyl IV, 0.2–0.5 µg/kg/h of dexmedetomidine IV and 20–75 µg/kg/min of propofol IV. Reversal of muscle relaxation was performed with 0.03–0.07 mg/kg of neostigmine IV. PONV prophylaxis was done with the administration of 4–8 mg of ondansetron IV and 4–8 mg of dexamethasone IV.

After anesthesia induction and intubation, the neurophysiology team placed needle electrodes for IONM, including the electrodes for VEP monitoring. A total of 8 electrodes for VEP monitoring were placed subcutaneously as follows: one in the lateral canthus of each eye that recorded early potentials from the retina called the electroretinogram (ERG); the recordings from the visual cortex were performed with three electrodes placed on the scalp 5 cm above mid-occipital (MO) and 5 cm lateral (right occipital (RO) or left occipital (LO)) from the external occipital protuberance (inion). Reference electrodes were placed subcutaneously in the mastoid process bilaterally, with another one placed in the mid-frontal (MF) area, 12 cm above the nose. Fig. 2 illustrates the locations of electrodes for VEP recording.

Following the completion of electrode placement, the SightSaver™ visual stimulator was placed around the orbital area of the subjects (Fig. 3A–D). The light for the pulse stimulus (flash) was obtained from the six high intensity diodes mounted in the SightSaver™ visual stimulator and applied to each eye individually as single or double stimuli. Therefore, the data presented as a single latency or amplitude corresponds to the results obtained by apply-

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