Anesthetic Management in Pediatric Craniotomy with Intraoperative Neurophysiological Monitoring: A Case Report of Midcerebellar Medulloblastoma

Irwan Setiadi [1], Muhammad Rezanda Alifahna [1*], Radian Ahmad Halimi [1], Dewi Yulianti Bisri [1]

Abstract

Intraoperative neurophysiological monitoring (IOM) aims to minimize nerve pathway injuries during neurosurgical procedures. Understanding the impact of anesthetic drugs on IOM is crucial for anesthesiologists. IOM utilizes various electrophysiological methods such as brainstem auditory evoked potential (BAEP), visual evoked potential (VEP), electroencephalography (EEG), electromyography (EMG), motor evoked potential (MEP), and sensory/somatosensory evoked potential (SEP) to monitor the brain, spinal cord, and associated nerves. Different anesthetic agents, particularly inhaled ones, can significantly affect evoked potentials. This case report discusses a pediatric patient diagnosed with infratentorial SOL at the midcerebellum, suspected medulloblastoma, who underwent craniotomy tumor removal with IOM. The patient was induced with propofol, fentanyl, lidocaine, and dexmedetomidine, followed by maintenance using propofol and dexmedetomidine. The patient's hemodynamics remained stable throughout the 10-hour surgery, and there were no issues with IOM recordings. This case highlights the anesthetic challenges in pediatric craniotomy, emphasizing the importance of selecting appropriate anesthetic agents and techniques to maintain neurological function and hemodynamic stability. The successful use of total intravenous anesthesia (TIVA) with propofol, fentanyl, and dexmedetomidine demonstrates a viable approach for maintaining anesthesia depth without compromising IOM signals, underscoring the need for interdisciplinary collaboration in complex neurosurgical procedures.

Keywords: Intraoperative neurophysiological monitoring (IOM), Pediatric craniotomy, Anesthetic management, Medulloblastoma, Total intravenous anesthesia (TIVA)

Significance | Understanding anesthetic effects on IOM is crucial for safe neurosurgical outcomes, especially in complex pediatric craniotomies.

*Correspondence. Muhammad Rezanda Alifahna , Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, Padjadjaran University, Dr Hasan Sadikin Hospital, Bandung

Editor Aman Shah Abdul Majid And accepted by the Editorial Board Jun 17, 2024 (received for review Apr 22, 2024)

Introduction

Intraoperative neurophysiological monitoring (IOM) was developed to minimize the risk of injury to nerve pathways during neurosurgical procedures. It is important for an anesthesiologist to understand how the IOM can be affected by the anesthetic drugs used during surgery (Yu Winghay & Chung Chun Kwong, 2019). Basically, IOM refers to the use of various electrophysiological methods to monitor the function of the brain, spinal cord, and associated nerves during surgery. Examples of IOM include brainstem auditory evoked potential (BAEP), visual evoked potential (VEP), electroencephalography (EEG), electromyography (EMG), motor evoked potential (MEP), or sensory/somatosensory evoked potential (SEP). Each of these techniques involves applying stimulation to a specific part of the nervous system, and then the response is recorded to determine whether that specific pathway is functioning properly, but not all surgical procedures require all

Author Affiliation.
[1] Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, Padjadjaran University, Dr Hasan Sadikin Hospital, Bandung

Please cite this article.
Irwan Setiadi, Muhammad Rezanda Alifahna et al. (2024). Anesthetic Management in Pediatric Craniotomy with Intraoperative Neurophysiological Monitoring: A Case Report of Midcerebellar Medulloblastoma, Journal of Angiotherapy, 8(6), 1-5, 9746

IOM monitoring. Most anesthetic agents alter nerve function by producing depression in nerve function depending on the dose used. It is generally found that inhaled agents have a greater effect on evoked potency compared with intravenous anesthetic agents (Jeker, Beck, & O., 2022). Therefore, it is important to consider the choice of anesthetic agent as well as the anesthetic technique that will be used in neurosurgical operations that require intraoperative neurophysiological monitoring (Jeker et al., 2022).

Anesthesiologists face additional challenges when dealing with pediatric patients undergoing craniotomy surgery, as anesthesia for pediatric craniotomy requires a deep understanding of both general pediatric anesthesia principles and neuroanesthesia basics. The main challenges of this operation are the risk of bleeding, preventing air embolism, maintaining hemodynamic stability, managing cerebral blood flow, and preventing intracranial hypertension, with the overall goal being to maintain neurological function and hemodynamic stability (Keown, Bhangu, & Solanki, 2022). This case report discusses a child with a diagnosis of infratentorial SOL at the midcerebellum due to suspected medulloblastoma who underwent craniotomy tumor removal with IOM. This case is a challenge in itself because the surgical procedure in cases of tumors in the posterior fossa is very complicated due to limited space and the large number of nerve and vascular structures, so it requires complex treatment..

Case Report

A 7 year old child diagnosed with infratentorial SOL at midcerebellum due to suspected medulloblastoma came to the hospital with complaints of intermittent headaches that had become increasingly severe over the past year. Complaints are accompanied by balance disorders in the patient. There were no complaints of nausea, vomiting, seizures. On physical examination, the patient was compos mentis, blood pressure 105/70 mmHg, pulse 88 times per minute, respiratory rate 20 times per minute, temperature 36.8 degrees, weight 20 kg, height 119 cm. Other examinations showed isochore pupils, light reflex +/+, visual acuity ODS 6/60, fundoscopy ODS papilledema, Romberg test +, and other examinations within normal limits. Laboratory examination and chest x-ray were within normal limits. CT scan examination (figure 1) showed that the gyrus sulcus was compressed, the sylvian fissure was compressed, there was peritumoral edema, and there was no midline shift.

Patients begin fasting from solid food 8 hours before surgery and water 2 hours before surgery. The patient was given pre-medication using paracetamol 300mg intravenously 2 hours before surgery and midazolam 0.05mg/kgbb immediately before entering the operating room. The patient was induced using propofol 2.5 mg/kgbb, fentanyl 3mcg/kgbb, lidocaine 1mg/kgbb and dexmedetomidine given in a maintenance dose of 0.2-0.6mcg/kgbb/hour. After all the induction drugs have been achieved, a 5.5 size non-kinking type endotracheal intubation is performed. After that, a central venous catheter, arterial line, and regional scalp block anesthesia were placed on the patient using 0.25% bupicakaine. The patient underwent IONM installation by a neurologist. The patient is in the parkbench position, the IOM signal is confirmed as the initial modality assessment. Maintenance of anesthesia using propofol 50-150mcg/kg/min, fentanyl 10mcg/kg/hour, and dexmedetomidine 0.2-0.6mcg/kgb/hour. The operation lasted for 10 hours with monitoring of ECG, invasive blood pressure, pulse oximetry, temperature, urine catheter, and $EtCO_2$. It was found that the hemodynamics during the operation were relatively stable (figure 2) and there were no problems with the IOM examination. After surgery, the patient was detained and treated in the intensive care unit.

Discussion

Anesthesiologists face unique challenges in managing pediatric craniotomy anesthesia as it integrates general pediatric anesthesia principles with basic neuroanesthesia concepts. The main challenges include managing the risk of bleeding, air embolism, unstable hemodynamics, impaired cerebral blood flow, and intracranial hypertension, with the goal of maintaining neurological function and hemodynamic stability (Tomita, Alden, & Dipatri, 2022).

In craniotomy operations involving IOM, the choice of anesthetic agent is crucial. High doses of barbiturates do not affect the SSEP signal, but the MEP signal is highly sensitive to this agent. Ketamine can enhance both SSEP and MEP responses, which may be beneficial for monitoring (Xing, An, Xue, Zhao, & Bai, 2019). Etomidate increases the amplitude of cortical SSEP recordings without affecting peripheral or subcortical responses (Yu Winghay & Chung Chun Kwong, 2019). Benzodiazepines used at premedication doses, such as midazolam, do not suppress SSEP or MEP (Xing et al., 2019). Opioids, while increasing sensory and motor responses, allow for recording of evoked potentials even at high doses; short-acting opioids like remifentanil are often used to minimize the need for other anesthetic agents during IOM (Bruder & Ravussin, 2010). Prior to headpin placement and scalp incision, a scalp block with 0.25% bupivacaine was performed, and fentanyl dose was increased to manage hemodynamic spikes (Tomita et al., 2022).

Research on dexmedetomidine's effects on evoked potency is limited, with evidence showing SSEP and MEP can be recorded at low clinical doses, but MEP recordings may be lost at higher doses (You & Qiao, 2021). Dexmedetomidine, used in combination with propofol-based total intravenous anesthesia, weakens

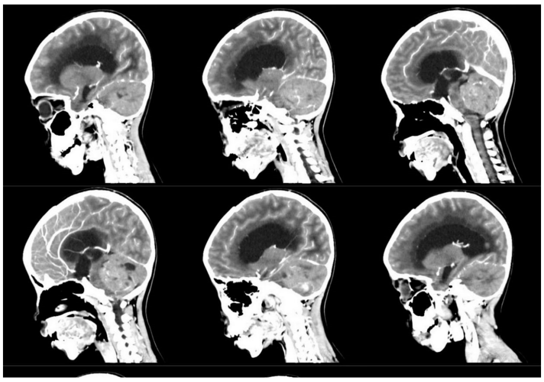

Figure 1. CT-Scan shows compressed gyrus sulcus, compressed sylvian fissure, peritumoral edema.

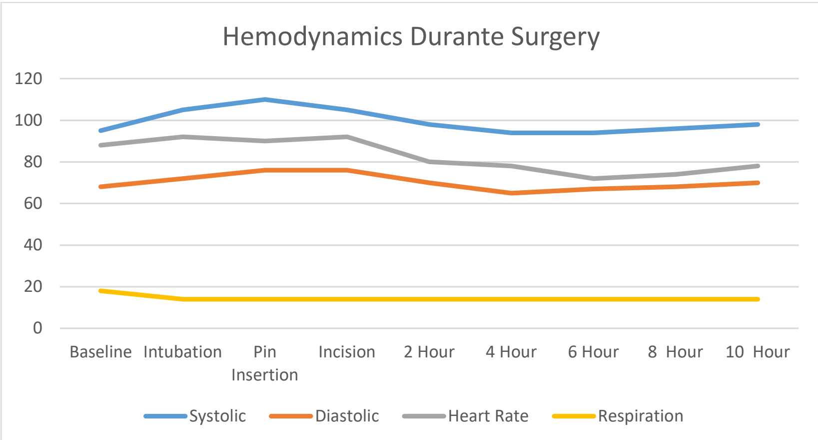

Figure 2. Hemodynamics Durante Surgery.

amplitude but does not show differences in SEP and MEP amplitude or latency compared to placebo (Gunes et al., 2009). However, dexmedetomidine can facilitate brain relaxation, improve surgical field conditions, reduce postoperative pain, and decrease opioid requirements (Fei et al., 2019). In this case, dexmedetomidine was used to enhance analgesia and sedation without affecting IOM recordings.

Muscle relaxants impact MEP and EMG monitoring by inhibiting electrical activity at the neuromuscular junction, affecting signal recording. Intubation without muscle relaxants can be achieved with adequate anesthesia from propofol and opioid infusion; if muscle relaxants are required, a reversal agent should be administered before IOM, and muscle relaxant monitoring should be performed using train-of-four stimulation (Yu Winghay & Chung Chun Kwong, 2019).

Inhaled agents cause a dose-dependent decrease in amplitude and increase in latency of evoked responses, with a more pronounced effect on cortical responses compared to subcortical and peripheral responses (Gunes et al., 2009). For patients with underlying neurological conditions or systemic diseases, lower levels of inhaled agents may be necessary to maintain potency (You & Qiao, 2021). Nitrous oxide (N2O) should be avoided after induction to minimize risks of increased cerebral blood flow and CMRO2 (Jain et al., 2017). Intracranial hypertension can be exacerbated by hypercarbia and hypoxia, conditions to which children are particularly sensitive (Bruder & Ravussin, 2010).

Understanding anesthetic agent selection in neurosurgical operations with IOM is complex. In this case, midazolam was used for premedication, with propofol, fentanyl, lidocaine, and dexmedetomidine for induction, alongside regional scalp block anesthesia as multimodal analgesia (Fei et al., 2019). Avoiding sympathetic stimulation during anesthesia induction is crucial to prevent exacerbation of intracranial hypertension. Premedication with anxiolytics, an initial dose of remifentanil, and titration of propofol to the appropriate depth of anesthesia are essential. Proper depth of anesthesia is vital to reduce airway responses that could increase intracranial pressure, with lidocaine used intravenously to prevent increased hemodynamic responses (Jain et al., 2017).

For anesthesia maintenance, a total intravenous anesthesia (TIVA) technique using continuous propofol and fentanyl was employed. Propofol infusion had less effect on MEP compared to volatile anesthetics, which can impair the quality of SEPs and MEPs and should be avoided during IOM (Fei et al., 2019). EEG monitoring using a frontal EEG sensor, such as a bispectral index (BIS) with a range of 40-60, indicates adequate anesthesia depth and avoids risks associated with excessive anesthesia depth (Gunes et al., 2009). One study demonstrated that balanced anesthesia with desflurane, dexmedetomidine, and scalp block can achieve neuroanesthesia goals without muscle relaxants, though this case did not utilize BIS for assessing anesthesia depth (Xing et al., 2019).

Post-craniotomy pain is influenced by surgical duration, age, and infratentorial surgery. Pediatric patients receiving a multimodal analgesia regimen, including strong opioids, report lower pain scores. Acetaminophen and NSAIDs are administered intraoperatively and up to 24 hours post-surgery. This patient was given multimodal analgesics including fentanyl and paracetamol (Fei et al., 2019).

Patient positioning during surgery can also lead to vascular or neurological complications affecting signal quality. For instance, lateral positioning may cause brachial plexus compression or vascular insufficiency, while neck flexion may stress important nerves or vessels. For high-risk patients, measuring evoked potentials before and after positioning is advisable to identify and correct positional issues (Jain et al., 2017).

Physiological factors such as oxygen supply, systemic or regional blood pressure, hyperventilation, and anemia can influence IOM. For instance, decreased cerebral blood flow or embolism can increase SSEP and MEP latency and decrease amplitude (You & Qiao, 2021). Maintaining normovolemia helps reduce hemodynamic fluctuations and venous air embolism risk. Latest guidelines recommend hemoglobin >7-10 g/dL and platelets >100,000/uL for pediatric brain surgery (Tomita et al., 2022).

Conclusion

Intraoperative neurophysiological monitoring is very useful to minimize the risk of injury to nerve pathways during neurosurgical procedures. The anesthetist has an important role in evaluating the impact of anesthesia and physiological changes on the IOM signal. The IOM technique using a total intravenous technique using a combination such as propofol, fentanyl, and dexmedetomidine can maintain the depth of anesthesia without interfering with the IOM signal. Collaboration between neurosurgeons, neurology and anesthesia is needed so that the operation runs smoothly and reduces morbidity and mortality.

Author contributions

I.S. (Irwan Setiadi) conceptualized the study, designed the methodology, and prepared the original draft. M.R.A. (Muhammad Rezanda Alifahna) handled data curation, performed formal analysis, and contributed to the review and editing of the manuscript. R.A.H. (Radian Ahmad Halimi) was responsible for investigation, acquiring resources, and creating visualizations. D.Y.B. (Dewi Yulianti Bisri) supervised the project and managed administrative tasks. All authors have read and approved the final manuscript.

Acknowledgment

Author was grateful to their department.

Competing financial interests

The authors have no conflict of interest.

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