ORIGINAL ARTICLE

Evaluating the Safety of Motor Evoked Potentials During Pregnancy: A Literature Review

J of Neurophysiological Monitoring 2025; 3(2): 22-30 ISSN 2995-4886

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KEYWORDS: IONM, MEP, SEP, motor evoked potentials, pregnancy, safety.

CITE AS: Khan A, Khan A, Malik A, Satsangi M, Khan MI, Jakkamsetti PS, Mehra S, Jahangiri FR. Evaluating the Safety of Motor Evoked Potentials During Pregnancy: A Literature Review. J of Neurophysiological Monitoring 2025; 3(2): 22-30. doi:10.5281/zenod.15284110.

ARTICLE HISTORY:
Received: Mar 25, 2025
Accepted: Apr 23, 2025
Available online: April 26, 2025

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Motor Evoked Potentials (MEPs), a vital component of intraoperative neurophysiological monitoring (IONM), are instrumental in preserving motor function during complex neurosurgical procedures. However, their application in pregnant patients presents unique clinical challenges due to concerns about fetal safety, including the potential for uterine contractions and fetal distress. This case series evaluates the safety and feasibility of MEP monitoring in pregnant women undergoing neurosurgical interventions.

A targeted literature review identified four peer-reviewed case reports involving pregnant patients who underwent procedures such as craniotomies and spinal tumor resections with intraoperative MEP monitoring. In each case, uterine tone and fetal heart rate were continuously monitored, and stimulation parameters were carefully adjusted. Postoperative outcomes revealed preserved maternal neurological function and no maternal or fetal complications. These findings suggest that with meticulous interdisciplinary planning and optimized monitoring protocols, MEPs can be safely employed in neurosurgical procedures during pregnancy without adverse outcomes.

INTRODUCTION

Motor Evoked Potentials (MEPs) are a critical tool in intraoperative neurophysiological monitoring (IONM), providing surgeons with real-time insight into the integrity of the corticospinal tract and motor pathways. This allows for the early detection and prevention of potential motor pathway damage during high-risk neurosurgical procedures, which can otherwise result in irreversible neurological deficits. MEPs are typically generated through transcranial electrical stimulation (TES) or transcranial magnetic

stimulation (TMS), which help guide surgical interventions by identifying motor function abnormalities as they occur.

However, the application of MEPs in pregnant patients presents distinct challenges, primarily due to concerns about fetal safety. The potential for electrical stimulation to cause uterine contractions, fetal distress, or preterm labor has raised caution regarding their use in this population. On the other hand, delaying critical neurosurgical procedures during pregnancy can also pose significant risks, potentially compromising maternal neurological health and function. In some instances, where conditions such as spinal cord compression, neoplasms, or aggressive intracranial tumors demand immediate surgical intervention, the benefits of using MEPs to monitor and preserve motor pathways may outweigh the associated risks.

This review explores the safety, effectiveness, and practical considerations of incorporating MEP monitoring in pregnant patients, drawing on a case series of four women who underwent neurosurgery with IONM. The aim is to outline key strategies and protocols for ensuring maternal and fetal safety while utilizing MEPs in these high-risk procedures.

METHODS

A comprehensive literature review explored intraoperative neurophysiological monitoring (IONM) in pregnant patients undergoing neurosurgical procedures. The search was performed using the PubMed database, employing a range of relevant keywords, including “intraventricular tumor,” “craniotomy,” “IONM,” “MEP,” “SSEP,” “glioblastoma,” “EMG,” “myometrial tone,” and “pregnancy.” These keywords were selected to capture a broad spectrum of research related to the use of MEP monitoring during neurosurgery and the specific considerations required when managing pregnant patients undergoing such procedures.

The review's inclusion criteria were carefully defined to ensure the relevance and quality of the selected studies. Only studies that involved pregnant patients who underwent neurosurgery and documented the use of MEP monitoring during their procedure were included in the analysis. This criterion was essential to ensure that the studies addressed the primary objective of assessing the safety, efficacy, and clinical implications of using MEPs in this unique patient population.

After applying these inclusion criteria, four studies met the requirements. These studies provided valuable insights into the feasibility and outcomes of utilizing MEP monitoring in pregnant women undergoing neurosurgical interventions. Each of the four studies involved a distinct case. Still, all shared a focus on the interdisciplinary approach required to ensure maternal and fetal safety while using MEPs to monitor the integrity of motor pathways during surgery.

These studies were thoroughly analyzed to assess common themes, including the methods of MEP monitoring used, the anesthetic management protocols implemented, the specific neurosurgical procedures performed, and the clinical outcomes observed for both the mother and fetus. Additionally, the literature was scrutinized to evaluate any complications or challenges encountered during the procedures and the strategies employed to mitigate these risks.

CASE SERIES

Case 1: Intraventricular Tumor Resection at 26 Weeks of Gestation

Patient Info: A 28-year-old woman at 26 weeks of gestation with a right intraventricular tumor underwent craniotomy with IONM.

Anesthesia: The patient was placed under general anesthesia, with induction using fentanyl (2 mcg/kg) and propofol (2 mg/kg). Maintenance dose was achieved through a continuous infusion of propofol (4–5 mg/kg/hour) and fentanyl (1 mcg/kg/hour). Atracurium (0.5 mg/kg) was administered as a short-acting muscle relaxant to facilitate tracheal intubation. A wedge-shaped support was positioned under the patient's right hip to avoid inferior vena cava compression. During the surgery, the anesthesia team closely monitored vital signs, including ECG, oxygen saturation (SpO2), blood pressure, capnography, and temperature. The fetal heart rate was also continuously tracked using an ECHO probe placed in the left infraumbilical region. In contrast, cardiotocography (CTG) was used to monitor uterine contractions, ensuring maternal and fetal stability throughout the procedure.

Motor Evoked Potentials (MEP) Protocol: In this case, IONM was performed using MEPs while also closely monitoring the uterine myometrial tone and fetal heart rate to ensure the safety of both the mother and the baby. Eighteen (18) MEP train stimulations were applied during the surgery, with the stimulation parameters adjusted to minimize the risk using a lower voltage range of 150-175 volts. Each MEP stimulation was carefully controlled, and the number of simulations was kept to a minimum to prevent uterine hypercontraction. The total energy applied through MEP stimulation was relatively low, but it provided essential feedback on the integrity of the motor pathway throughout the procedure. Additionally, continuous monitoring of fetal heart rate and uterine contractions was done via cardiotocography (CTG) and fetal echocardiography. That ensured no adverse effects were occurring during the 320-minute surgery. There is insufficient reporting of both MEP output data and fetal safety monitoring. While electrode placement and stimulation parameters are described, key intraoperative neuromonitoring outcomes—such as motor thresholds, waveform amplitudes, and latencies—are either omitted or incompletely documented, restricting the ability to evaluate the effectiveness and reproducibility of MEP monitoring. Similarly, fetal safety reporting remains vague. However, fetal heart rate monitoring is mentioned, specific data such as heart rate ranges, signs of distress (e.g., bradycardia or tachycardia), and CTG findings are absent.

Fetal Monitoring, Risks and Benefits: The tumor's proximity to critical neural structures, like the thalamus and internal capsule, made it crucial to use IONM to preserve the integrity of the motor pathways. Given the potential risks of neurological deficits, using MEPs was considered essential for real-time monitoring of motor function. However, the risk of uterine hypercontraction and potential fetal distress due to MEP stimulation requires careful management. Despite these concerns, the benefits of using MEPs outweighed the risks, as they provided valuable feedback to guide the surgeon in avoiding damage to vital motor structures. The careful adjustment of stimulation parameters and continuous fetal monitoring ensured that both the mother and fetus remained safe throughout the procedure.

Complications/Outcome: A 28-year-old woman at 26 weeks of gestation underwent a craniotomy for a right intraventricular tumor. MEPs were monitored using low-voltage stimulation (150–175 V), with 18 stimulation trains applied. Fetal heart rate and uterine tone were continuously monitored using cardiotocography (CTG) and echocardiography. While transient uterine contractions occurred, no maternal or fetal complications were reported. The patient recovered without new neurological deficits. The absence of detailed MEP output data limits reproducibility, but the favorable outcome supports the feasibility of MEP use when performed cautiously.

Case 2: Glioblastoma Resection at 26 Weeks of Gestation

Patient Info: A 34-year-old female at 26 weeks of gestation who had been diagnosed with a right glioblastoma.

Anesthesia: The patient was operated on under general anesthesia. A bolus of propofol (1.5 mg/kg) and remifentanil (1 μg/kg) was used to induce and maintain anesthesia, which was then followed by propofol (6–10 mg/kg/h) and remifentanil (0.5 μg/kg/h). A short-acting muscle relaxant (succinylcholine 20-mg bolus) was administered for intubation. Fetal heart rate and myometrial tone were continuously monitored during the surgery.

Motor Evoked Potentials (MEP) Protocol: IONM was performed with MEP and somatosensory evoked potential (SSEP). A total of 43 MEPs and 35 SSEPs were applied during a period of 189 min. The total energy used was 2.37 J for MEP and 0.46 J for SSEP (83.7% and 16.3%, respectively). Therefore, more energy was applied through MEPs.

Fetal Monitoring, Risks and Benefits: The localization of the tumor made the use of a great number of stimuli essential to preserve important structures like the corticospinal tract (inner capsule) and thalamocortical radiations. During this surgery, the use of MEP and SSEP was considered indispensable.

Complications/Outcome: A 34-year-old woman at 26 weeks of gestation underwent surgery for a right-sided glioblastoma. MEPs and SSEPs were utilized, totaling 43 and 35 stimulations, respectively. The anesthesia was maintained with propofol and remifentanil. Fetal heart rate and uterine tone were

monitored continuously. No changes in fetal status or neurological deficits were observed postoperatively. The high number of stimulations reflects the complexity of the tumor location near critical motor pathways.

Case 3: Cervical Spinal Tumor Resection at 29 Weeks of Gestation

Patient Info: A 32-year-old female at 29 weeks of gestation, who presented with an intraspinal cervical tumor.

Anesthesia: Anesthesia was achieved via remifentanil (concentration between 4 and 6 ng/mL), with anesthesia maintenance with propofol administration (2.5 to 3.6 μg/mL) and a single dose of rocuronium (20 mg). The Bispectral index (BIS) was between 40 and 60. The patient's mean arterial pressure was continuously monitored (maintained at 60-70 mmHg). Fetal monitoring was performed throughout the procedure, placing the patient in a semi-prone position. The patient was put on volume-controlled mechanical ventilation, and serial blood gas measurements were performed.

Motor Evoked Potentials (MEP) Protocol: IONM was performed using the Cadwell Cascade (Kennewick, WA, USA) device, with MEPs of 100 ms, 100 mV/division and SSEPs-t 100 ms, 2.0 μV/division. Fetal heart rate and maternal blood pressure were continuously monitored throughout the procedure. SSEPs at baseline were detected in the right upper limb, with no responses to stimulation of the left upper or the lower limbs, and spontaneous SSEP recovery. MEP was maintained throughout the surgery. A hemilaminectomy was performed at cervical spine C2-C3-C4 alongside an intramural extramedullary lesion resection. The patient was hemodynamically stable following the procedure, with no noted abnormalities on the fetal ultrasound, and regular uterine contractility monitoring was performed postoperatively. There is a recommendation for gynecological monitoring to address the associated risk between MEPs and premature birth. Furthermore, continued utilization of IONM is recommended to ensure complete tumor excision and decreased neurological complications postoperatively.

Fetal Monitoring, Risks and Benefits: The benefits of IONM surgery include greater tumor resection and the preservation of neurological functions. Additional benefits are avoidance of fetal exposure to treatments with teratogenic associations and radiation, as IONM surgery allows for immediate spinal cord decompression. Risks of IONM surgery include blood loss that occurs intraoperatively, alongside the maternal-fetal surgical risk of the use of anesthetics during the procedure.

Complications/Outcome: A 32-year-old woman at 29 weeks' gestation underwent hemilaminectomy and tumor resection for an intraspinal cervical lesion. MEPs and SSEPs were recorded using the Cadwell Cascade device. Anesthesia included propofol, remifentanil, and a single dose of rocuronium. The patient remained stable, and fetal monitoring showed no abnormalities. The use of multimodal IONM contributed to tumor resection while preserving motor function. Recommendations emphasized the need for gynecological involvement due to the potential for preterm labor.

Case 4: Vertebral Hemangioma Resection at 22 Weeks of Gestation

Patient Info: A 29-year-old, 22 weeks pregnant patient posted for surgery for aggressive vertebral body hemangioma (hemangioma of 7th dorsal vertebra). Presented with symptoms of backache, tingling numbness in legs, difficulty walking

Anesthesia: The patient was induced with a propofol (70 mg) and fentanyl (100 micrograms) anesthesia for intraoperative neurophysiological monitoring (IONM). Tracheal intubation was facilitated with 50 mg of rocuronium using a C-MAC video laryngoscope and rapid sequence intubation. The total intravenous anesthesia with a titrated dose of propofol and fentanyl infusions with 50% O2 in air targeted to bispectral index (BIS) values between 40 and 60 was used for maintenance. The procedure utilized MEP and SSEP to monitor the neural tracts during surgery for aggressive vertebral body hemangioma, due to the high risk of injury to motor tracts. The MEP of a 250- 500 Hz stimulus, SSEP of 30 mA intensity, 200- 400 microseconds pulse width, and 3-5 Hz frequency.

Motor Evoked Potentials (MEP) Protocol: Corkscrew electrodes were placed at C3 and C4 for stimulation, with a train of 8 pulses, 75 μs duration each, 250–500 Hz. Single or double stimulation was given to elicit MEP response, and a dual twisted needle electrode was placed bilaterally in the abductor pollicis brevis as a control, rectus abdominus, rectus femoris, tibialis anterior, extensor hallucis longus, and abductor hallucis to record the evoked potentials. Stimulation strength gradually increased from 50 V with continuous fetal heart rate monitoring. It was limited to 500 V to reduce risk. MEP provides important intraoperative information to monitor motor tracts. However, electrical stimulation of the motor cortex is required to elicit an evoked potential in all muscles. This is accompanied by a muscular contraction in the whole body, and the magnitude of the contraction increases with the strength of stimulation, which can precipitate fetal distress or preterm labor.

Fetal Monitoring, Risks and Benefits: The benefits of intraoperative monitoring of motor tracts include no motor or new sensorimotor deficits after surgery in the glioblastoma and intraventricular tumor, and improvement in neurological deficits in the cervical intracranial tumor. The risks include fetal distress and pre-term labor. However, risks can be minimized by titrating the IONM protocols to elicit the best response with minimal stimulation or by sufficient monitoring and preparation for unfavorable events.

Complications/Outcome: A 29-year-old woman at 22 weeks of gestation underwent surgery for a hemangioma of the 7th thoracic vertebra. MEP and SSEP monitoring were used, with stimulation gradually titrating from 50 to 500 V. Stimulation sites included multiple motor groups. Anesthesia was maintained with propofol, fentanyl, and rocuronium. Continuous fetal monitoring showed no signs of distress. Although theoretical concerns about fetal effects remain, no complications occurred, and the patient's neurological function improved.

DISCUSSION

This case series highlights the value of intraoperative neurophysiological monitoring, particularly MEPs, in safeguarding motor function during neurosurgical procedures in pregnant patients. In all cases, using MEPs facilitated precise surgical navigation without resulting in adverse fetal or maternal outcomes. The consistent absence of new neurological deficits postoperatively further supports the utility of these techniques.

Despite the encouraging outcomes observed in recent studies, several important limitations warrant attention. One significant issue is the frequent absence of quantitative data concerning MEP parameters, including crucial aspects such as motor thresholds, specific waveform characteristics, and latency periods. This lack of comprehensive data hampers the development of standardized safety protocols and complicates the ability to effectively compare results across different cases.

Additionally, although fetal monitoring was reported consistently across the board, the documentation of specific fetal metrics, such as cardiotocography (CTG) tracings, heart rate ranges, and indicators of fetal distress, remained inconsistent and insufficiently detailed.

Nonetheless, this series adds to the expanding body of evidence that suggests motor evoked potential (MEP) monitoring can be safely and effectively integrated into clinical practice during pregnancy. This can be achieved through meticulous stimulation techniques, vigilant fetal surveillance, and thorough multidisciplinary planning. Furthermore, the implementation of multimodal monitoring—incorporating MEPs, somatosensory evoked potentials (SSEPs), and electromyography (EMG)—demonstrates distinct advantages in procedures that engage delicate and eloquent motor pathways.

While current evidence supports the feasibility of MEP monitoring in pregnant patients, several areas still require further investigation to enhance our understanding and ensure the safety of both the mother and fetus during these high-risk surgical procedures. First, the' limited number of cases (n=4) underscores the need for larger, prospective multicenter trials. Such studies would help establish standardized protocols for MEP monitoring in pregnant patients, offering more robust data on its safety and efficacy. Further research is needed to explore the long-term fetal outcomes of repeated MEP stimulations. It remains unclear whether these stimulations could have any lasting developmental effects on the fetus, and investigating this is crucial for ensuring the safety of the unborn child. Another promising avenue of research involves exploring alternative stimulation techniques, such as transcranial magnetic stimulation (TMS), which could offer a safer alternative to electrical stimulation in pregnancy. While TMS is not currently available in the operating room, its inclusion in future research could open new possibilities for intraoperative monitoring during pregnancy. Lastly, developing quantitative risk models to estimate the threshold of electrical stimulation that could induce uterine contractions, or fetal distress would be highly beneficial. Such models could guide clinicians in determining safe levels of stimulation and preventing potential complications during surgery.

RESULTS

The reviewed cases consistently demonstrated that intraoperative MEP monitoring and vigilant fetal and maternal surveillance did not result in adverse outcomes. The literature indicates that electrical stimulation does not provoke harmful uterine activity or fetal heart rate abnormalities when carefully controlled. Best practices emerging from these cases include reduced stimulation intensities, minimized stimulation durations, and continuous fetal and uterine tone monitoring. A multidisciplinary approach—incorporating surgical, anesthetic, neurological, and obstetric expertise—was essential in achieving favorable outcomes.

Surgery Type	No. of Patients	Gestational Age	MEP Parameters Reported	Fetal Heart Rate Monitoring	Maternal Monitoring
Spinal Surgery	1	Not Specified	Not Reported	Mentioned, no HR data provided	Standard anesthesia monitoring
Craniotomy for Glioblastoma	1	Not Specified	Not Reported	Intermittent monitoring, no distress noted	Combined MEP + SSEP
Vertebral Hemangioma Resection	1	Not Specified	Not Reported	Monitoring mentioned, no trend data	MEP + SSEP Used
Cervical Spinal Tumor Resection	1	29 weeks	Not Reported	Stable fetal HR reported, no brady/tachycardia	Standard monitoring

Table 1. Summary of intraoperative monitoring parameters and observations during surgeries involving maternal patients. The table outlines the type of surgery, number of patients, gestational age, motor evoked potential (MEP) parameters reported, fetal heart rate monitoring techniques, and maternal monitoring methods. "Standard anesthesia monitoring" refers to routine monitoring techniques without specialized neurophysiological assessments. "Combined MEP + SSEP" and "MEP + SSEP Used" indicate utilization of motor and somatosensory evoked potentials for neurophysiological monitoring. Cases with "Not Specified" gestational age indicate unavailable data, while "Not Reported" highlights missing MEP parameters. Fetal heart rate trends are noted when available, and any changes, such as bradycardia or tachycardia, are specifically mentioned

CONCLUSION

MEPs are commonly employed in neurosurgery, and our case series demonstrates that their application during pregnancy can be effectively and safely managed. With careful oversight, MEP-based intraoperative monitoring poses no risk to fetal or maternal well-being. Successful outcomes are achievable through tailored stimulation protocols, continuous real-time fetal monitoring, and a strong collaborative multidisciplinary team. As we move forward, further research will establish standardized protocols and strengthen the evidence base, ultimately enhancing the care provided to pregnant patients facing high-risk neurosurgical procedures.

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