

HMC-UWMC Consensus Statement on Acceptable Anesthetic Techniques for Monitoring Motor Evoked Potentials (MEPs) in Adult Patients (Alternatives to Propofol / Narcotic Anesthetics)

These guidelines are meant to be used for patients having MEPs monitored. Management should be based on careful assessment of the patient's co-existing illnesses and procedure using sound clinical judgement. Anesthetic considerations for intracranial surgery may be different from spinal surgery. If you are using something other than propofol / narcotic anesthesia when MEPs are being monitored, PLEASE LET YOUR ELECTROPHYSIOLOGY (EP) TECHNICIAN KNOW AT THE START OF THE CASE! The EP technicians need to know when the anesthetic regimen is altered so that they can accurately assess the differential diagnosis for a significant decrease in MEP amplitudes to appropriately inform the surgeons. The cornerstone of successful use of these alternative anesthetic regimens (esp. volatile anesthesia) is frequent communication with the EP technicians re: the adequacy of the MEP waveforms.

There are many alternatives to using propofol as the primary anesthetic when monitoring MEPs and each anesthetic / adjunct has its advantages and disadvantages which may be dose dependent. These infusions and volatile anesthetic may be mixed in various combinations. Typical dosing for primary and adjunct anesthetics is provided below for the various agents and will vary depending on the dose of co-administered agents and patient age and condition.

	Primary Anesthetic Dosing	Adjunct Dosing	Effect on MEP amplitude	Advantages	Disadvantages
Propofol	100-150 mcg/kg/min	50-75 mcg/kg/min	Preserves	Familiarity of use; antiemetic; smooth emergence; euphoria; amnesia	Accumulates over time – slow emergence if not titrated down appropriately; peripheral vasodilation / hypotension
DES*	4.5-6% et	2-3% et	Decreases, but in neuro-intact pts, usually ok either as primary anesthetic or adjunct	Familiarity of use; low solubility; amnesia ; little peripheral vasodilation	Effect on MEP amplitudes inconsistent b/w patients.
SEVO*	1.5-2% et	0.5-1% et	Decreases, but may be ok in neuro-intact pts as primary anesthetic or adjunct	Familiarity of use; low solubility; amnesia ; little peripheral vasodilation	Effect on MEP amplitudes inconsistent b/w patients. <u>[DES has more published studies with successful MEPs than SEVO – no comparative studies on MEPs]</u>
Ketamine	2-3 mg/kg/h (may be higher in children)	8mg/h during case for postop analgesia; 0.5-2 mg/kg/h for more potent adjunct ^{†‡}	Preserves	Better hemodynamic stability; NMDA antagonist – improved postop analgesia; Amnesia at higher dose	At higher doses, may have increased emergence delirium, hallucinations / psychedelic effects (41%) very prolonged emergence. Transition to other agent 30-45 mins before end of surgery. (BIS readings are elevated and less reliable with higher dose ketamine), Limited experience in intracranial surgery –do not use high dose ketamine in craniotomies
Dexmedetomidine	NA	0.2-0.4 mcg/kg/h (low dose)	Negligible at low dose; <u>decreases MEP amplitudes with bolus or higher doses</u>	Smooth emergence; decreased use of other anesthetics; possible neuroprotectant / anti-inflammatory	At low doses can cause bradycardia and hypotension; at high doses or bolus can decrease MEP amplitude; poor amnestic ; EXPENSIVE (UWMC pharmacy is tracking use), <u>Difficulty in acquiring adequate MEP signals has been reported at higher doses.</u>
Remifentanyl ⁺	NA	0.1-0.4 ucg/kg/min	Negligible	Potent analgesic; allows decreased use of other anesthetics, facilitates immobility	Bradycardia, hypotension, blunts reflex tachycardic response to hypotension; causes postop hyperalgesia; no amnestic effect ; need for transitional analgesia, EXPENSIVE

***It is essential to communicate with the electrophysiology (EP) technicians about your anesthetic if you are using volatile anesthesia when MEPs are being monitored until adequate amplitudes are obtained.**

[DES has more published studies with successful MEPs than SEVO – comparative studies lacking].

[‡]See HMC guidelines for higher dose ketamine during spine surgery for postop analgesia.

⁺Remifentanyl is very expensive (\$70 / syringe @ UWMC) – for spine surgery, other opioids an option (bolus MS, hydromorphone or sufenta / fentanyl gtts - may need to stop gtts 45-60 min prior to end of operation)

USE OF DESFLURANE / SEVOFLURANE WHEN MONITORING MEPS

Because higher dose ketamine and dexmedetomidine have significant disadvantages, using DES / SEVO as the primary or adjunct anesthetic is very useful when not using propofol as the primary anesthetic. DES / SEVO will decrease MEP amplitudes, but in patients without significant motor weakness, most patients will have acceptable MEP waveforms with DES / SEVO as either the primary or adjunct anesthetic. Use of DES / SEVO for MEP monitoring has been found to be acceptable in previous studies in neuro-intact patients, but its effect on MEP amplitudes is variable between patients. Therefore, it is essential to communicate with the EP technician about your anesthetic if you are using DES / SEVO when MEPs are being monitored until adequate amplitudes are obtained.

[Because of the lack of predictability of the effect of DES / SEVO on MEP amplitudes, *TIVA is strongly preferred for use in patients with unstable spinal fractures, acute spinal cord injuries, or spinal cord tumors (see below)* where the chances of surgical, hemodynamic, or positioning effects on spinal cord blood flow / ischemia are much higher. *Please communicate with your attending re: the planned anesthetic especially for these patients.* TIVA is also preferred in patients who have stable, but incomplete spinal cord injuries (upper/lower extremity weakness) as their MEP amplitudes will already be decreased.]

1. For induction/intubation:

A) When Baseline MEPs Needed Are Prior to Turning Prone: Use lower dose of nondepolarizing muscle relaxant (or use succinylcholine if no significant motor weakness or other contraindication; or can also use no muscle relaxant and give dose of remifentanyl with induction agent) for intubation to allow a relatively quick reversal of the muscle relaxant so that the baseline MEPs can be adequately assessed. (Use sound clinical judgement when assessing how much induction agent, narcotic, and muscle relaxant to use.)

B) When Baseline MEPs To Be Obtained After Turning Prone: For the vast majority of stable spines without an acute spinal cord injury, the initial MEPs will not be obtained until the patient is turned prone, thus making 0.6mg/kg rocuronium or 0.1mg/kg vecuronium suitable for intubation and easily reversible by the time the first set of MEPs will be run.

2. For spine surgery, keep DES / SEVO preferably < 1 MAC (DES has more published studies with successful MEPs than SEVO) with heavy narcotic (e.g., remifentanyl 0.1-0.4 mcg/kg/min – use caution with elderly pts, pts with significant cardiac disease, etc as it can cause significant bradycardia and hypotension, and blunt the reflex tachycardic response to hypotension) and ketamine (8mg/h at UWMC; 0.5mg/kg/h at HMC). (Low dose ketamine does not seem to interfere with BIS, but ketamine boluses or higher doses of infusion may falsely elevate the BIS reading because of increased EEG activity.) If you are using higher doses of ketamine for most of the case (which may increase the amplitude of SSEPs) and decrease the dose later, be aware that this may be associated with a decrease in SSEP amplitudes.
3. For intracranial surgery with signs / symptoms of raised intracranial pressure or pre-existing motor deficits, use propofol as the primary anesthetic without volatile anesthesia. However, for elective intracranial surgery with no evidence of raised ICP or motor deficits, ≤1 MAC desflurane / sevoflurane may be acceptable in combination with remifentanyl (0.1-0.4 mcg/kg/min) with or without low dose dexmedetomidine (0.2-0.4 mcg/kg/hr). If MEPs are inadequate, cut volatile concentration in half, and add low dose propofol infusion (50-75 mcg/kg/min). If MEPs remain inadequate after 20-30 min of changing volatile concentration to half dose, then discontinue its use, and adjust doses of intravenous agents appropriately. (There is limited experience with ketamine for intracranial surgery – do not use at high dose.)
4. Please communicate with EP technician and ask them to tell you before they obtain baseline MEPs so that you can ensure that the patient has a full TO4 and no fade with tetanic stimulation x 5sec (reverse if necessary). Full reversal will provide the optimal MEP amplitudes. Also ensure that the MAP is at least 80% of baseline values and etCO₂ is > ~ 35 mm Hg, as hypotension and hyperventilation may decrease spinal cord blood flow. (If the patient's temperature is <36° C, please inform the EP technicians as hypothermia can increase the latency of the MEPs.)
5. If you are using DES or SEVO as the primary or adjunct anesthetic after adequate MEP signals are obtained, DO NOT increase the DES or SEVO concentration as it may decrease the MEP amplitudes. If additional anesthetic is needed, then bolus with propofol or ketamine, and/or remifentanyl; and increase the propofol or ketamine and / or remifentanyl infusions – and INFORM the EP TECHNICIAN.
6. If baseline MEP amplitudes are inadequate after patient has been reversed, then cut DES or SEVO concentration in half (e.g. decrease DES from 6% ET to 3%ET, or 4% ET to 2% ET) and

- start propofol gtt at 50-75 mcg/kg/min as needed along with low dose ketamine and heavy narcotic. After ~ 20 min, have EP technician run another set of MEPs to see if they are improved. If baseline MEPs show no signs of improvement, discontinue all volatile anesthetic and increase propofol to 100-150 mcg/kg/min and continue ketamine and high dose narcotic. Repeat MEPs in 20-30min. (Try to titrate DES/SEVO down and propofol up proportionately because higher total anesthetic dose can adversely affect MEP amplitudes.)

OR

- (for spine surgery: if **no** propofol available– do not use high dose ketamine with craniotomies): increase ketamine gtt to 1-2 mg/kg/hr (but patients may have increased risk of dysphoria / hallucinations – use midazolam 1-2 mg), and continue narcotic. After ~ 20 min, have EP technician run another set of MEPs to see if they are improved. If baseline MEPs show no signs of improvement, discontinue all volatile anesthetic and increase ketamine to 2-3 mg/kg/hr and continue narcotic. Repeat MEPs in 20-30 min. **(Higher doses of ketamine will delay time for awakening and possibly increase emergence delirium / psychedelic reactions – up to 41%).**
 - Another alternative is to use ½ propofol and ½ ketamine with narcotic- one study showed decreased emergence/psychedelic reactions of 14% compared to ketamine/narcotic/N2O (41%). Kawaguchi et al, Spine 2000 (25(8):974).
 - May also be able to decrease dose of ketamine needed by adding low dose dexmedetomidine (~0.2-0.4 mcg/kg/h).

The goal is to obtain adequate MEP signals before the surgical exposure is complete, but MEP monitoring can be useful for detecting (impending) nerve injury at any point in the case from multiple causes including intubation, positioning, surgical manipulation, and hypotension. Once exposure is complete, the surgeons heavily rely on changes in MEPs, SSEPs, and EMG to assess whether or not there is an (impending) nerve / spinal cord injury from surgical manipulation.

2nd ALTERNATIVE: Start dexmedetomidine infusion at 0.2 mcg/kg/hr without a bolus after induction. Leave it at this rate for entire case, up to and including extubation. As above, use higher infusion rates of remifentanyl (0.1-0.4 mcg/kg/min) for immobility, and run propofol at 80 to 120 mcg/kg/min for spine surgery (or lower for craniotomies) and titrate up or down as needed.

Additional Information:

1. Many places will use nitrous oxide as an adjunct anesthetic, but it also decreases MEP amplitudes. UWMC and HMC electrophysiologists strongly prefer that N₂O not be used because of detrimental effects on MEP amplitudes.
2. SSEPs do not require TIVA – volatile anesthesia is fine if MEPs are not being monitored.
3. For unstable spinal fractures, acute spinal cord injuries, and spinal cord tumors, TIVA is strongly preferred to minimize any concern about anesthetic causing a reduction in MEP amplitudes. Communicate with your attending and EP technicians re: the anesthetic approach, especially in these patients. For patients with significant motor deficits that may or may not be stable, TIVA is also preferred as the MEP amplitudes are likely to be decreased already.
4. When using remifentanyl in opioid-tolerant patients for spine surgery, please make sure to administer long-acting opioids prior to the end of the procedure to avoid grossly inadequate analgesia in the PACU. Remifentanyl provides potent analgesia and allows reduction of other anesthetics. It is preferred when patients are in Mayfield pins or when anterior cervical operations near the trachea are being done, but its use can be substituted or decreased with other longer-acting opioids. (HMC has analgesia guidelines for its spine surgery patients.)
5. Please be aware that very high MAC levels of anesthesia – if transitioning to volatile at the end of the case or after a large bolus of induction agent – can significantly affect the MEP amplitudes. Please communicate with your EP technician in these circumstances.
6. The EP technicians can frequently detect “light” anesthesia with EMG and SSEP monitoring prior to any changes in blood pressure, HR, or BIS changes. Their reliability is higher than the BIS (but not 100%). Please do not ignore any concerns they may have re: this issue – evaluate the anesthetic depth and delivery carefully. They cannot be used as a failsafe for detecting “light” anesthesia as the EP technicians are not always in the OR during the case.
7. In major spine operations, if using high dose ketamine, may need other agents (e.g., nicardipine) to control hypertension. Do not use long-acting antihypertensives (e.g., labetalol) because blood loss can be rapid and excessive.

Approved by the HMC- UWMC Neuro and Spine Anesthesia Groups Feb 2013.

This document is not binding with respect to clinical care. It is intended as an informational document to provide alternative options to propofol / narcotic for anesthesia when MEPs are being monitored. Doses may vary depending on patient co-morbidities and procedure. Sound clinical judgement and caution are essential when utilizing anesthetic regimens unfamiliar to the provider. Please contact any of the neuro-spine anesthesiologists for questions.