

# Intraoperative Neurophysiological Monitoring: Interactive Clinical Case Discussion

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A young adult man with a mid-thoracic fracture and uncleared cervical spine s/p fall presented for spinal stabilization and fusion.

**What neuromonitoring modalities could be applied to this surgery?**

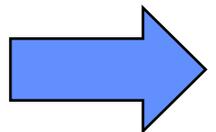
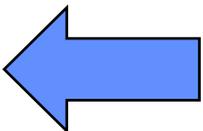
- A) Electromyography (EMG)-triggered only
- B) Somatosensory Evoked Potentials (SSEP)
- C) Electromyography (EMG)-spontaneous only
- D) Transcranial Motor Evoked Potentials (tcMEP)
- E) SSEPs, EMG (triggered and spontaneous), and TcMEPs



E) SSEPs, EMG, and tcMEPS- Yes!

Multimodality intraoperative neuromonitoring is what should be anticipated for this case, and it will improve the sensitivity of neuromonitoring for detecting neurologic system trespass. Combining methods offers the ability to overcome limitations of individual monitoring methods and offers more information about the nervous system as a whole. Combining SSEP and MEPs modalities offers the ability to monitor both ascending and descending pathways. Adding EMG (spontaneous and triggered) offers the ability to better detect nerve root injuries.

However, it should be noted that there is no “standard of care” for the exact neuromonitoring modalities to employ for this kind of surgery (although it should be expected that some neuromonitoring will be performed), and there is a variety of neuromonitoring practices depending on surgeon and institution preference and experience.



## A)EMG (triggered only)

Triggered EMG for spine surgery is used primarily in monitoring for pedicle screw breach via electrically stimulating the pedicle screw and assessing the lowest voltage at which a compound muscle action potential is obtained (a lower threshold response is obtained if cortical bone is not intact and, therefore, a pedicle breach has occurred). Thus, this modality gives responses based on pedicle integrity, and it does not provide information regarding neurologic injury. Triggered EMG is widely used in minimally invasive spine surgery where it helps with pedicle screw trajectory under limited visualization, but it can also be used for thoracic pedicle screw placement in non-minimally invasive surgery. While this modality may be employed for this surgery, there is a more correct answer.



Try again

## B)SSEPs

This is the modality most commonly applied to spine surgery. SSEPs are usually obtained by stimulating the median or ulnar nerves of the upper extremities and the posterior tibial of the lower extremities. SSEPs can be recorded at several points in the dorsal column-medical lemniscus pathway, including the cerebral cortex. They can be monitored continuously during surgery, but temporal summation is required to obtain recordable responses. While this modality will likely be employed for this surgery, there is a more correct answer.



[Try again](#)

### C) EMG (spontaneous only)

During spinal instrumentation and pedicle screw placement, postoperative radiculopathy can occur and free-running EMG (i.e. spontaneous EMG) can monitor selective nerve root function. Throughout the procedure, continuous recordings are obtained from appropriate muscle groups based on the nerve roots at risk. A healthy nerve root experiencing no irritation should have no muscle activity. While this modality may be employed for this surgery, there is a more correct answer.



Try again

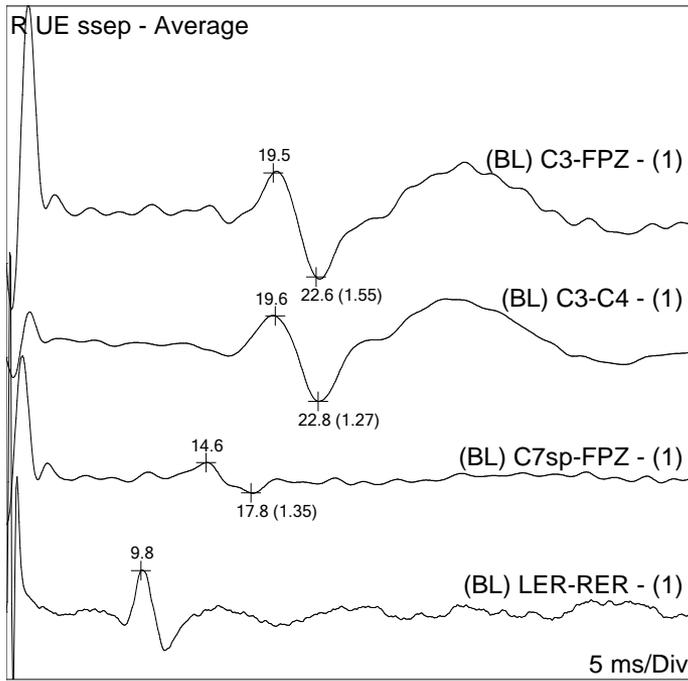
## D) tcMEPS

TcMEPs are the neuromonitoring modality that directly monitors the corticospinal tract. Cortical electrical stimulation is applied, and responses are recorded usually as a compound muscle action potential from the upper and lower extremities. Muscle tcMEPs are only assessed periodically, so monitoring periodically throughout surgery and more frequently during higher risk surgical maneuvers is imperative to detect neurological system trespass in a timely manner. TcMEP changes indicating neurologic injury usually lead SSEP changes by a number of minutes. While this modality may be employed for this surgery, there is a more correct answer.



Try again

For this case scenario, let's focus on SSEPs. Below are generic SSEP tracings from a right upper extremity (RUE) and right lower extremity (RLE).



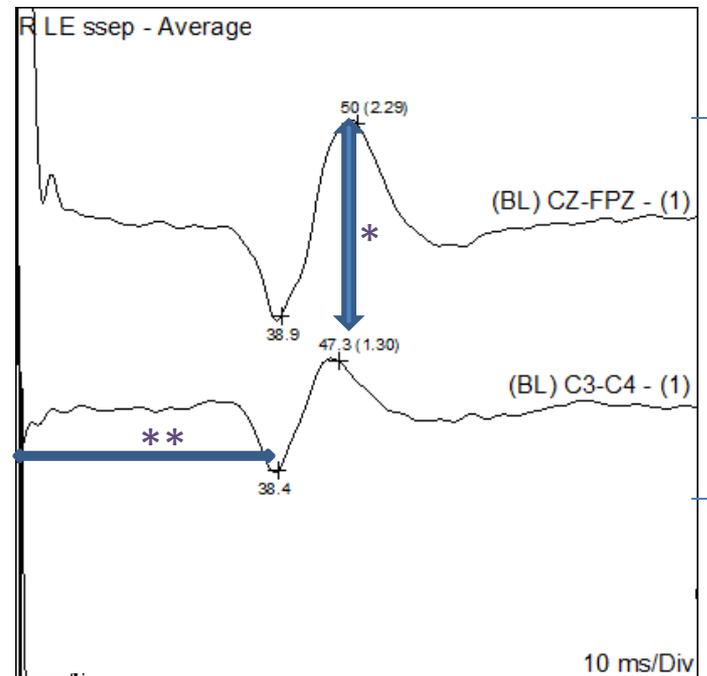
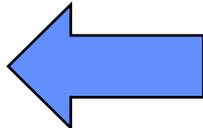
Cortical signals from RUE (also called N20)

RUE SSEP measured at cervical point (also called N14)

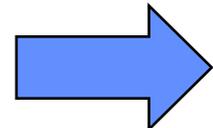
RUE SSEP Erb's Point signal (latency around 10ms)

\*Amplitude (measured peak-to-peak)

\*\*Latency



Cortical signals from RLE



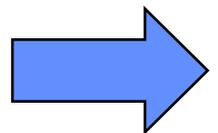
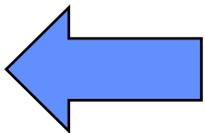
After uneventful awake fiberoptic intubation (patient moved all 4 extremities post-intubation), anesthesia was induced, additional intravascular access was obtained, and the patient was placed in right lateral decubitus position by the OR team as requested by the surgeon.

Baseline cortical SSEPs obtained from the bilateral upper extremities are shown below.



Left upper extremity

Right upper extremity



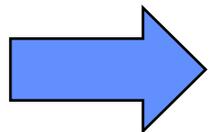
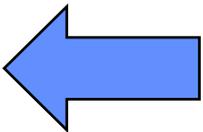
Intraoperatively, the patient's head position, which had been supported by foam padding and blankets, was noted to have slipped with resulting loss of cervical spine neutrality. Head positioning was carefully fixed.

About 15 minutes later, the following cortical SSEP signals were obtained.



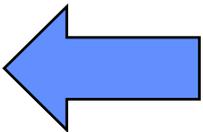
Left upper extremity

Right upper extremity



## What could be the cause of the SSEP signal change?

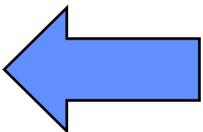
- A) systemic hypotension
- B) technical problem with signal acquisition
- C) change in end-tidal sevoflurane from 0.5 to 0.8 MAC
- D) positioning problem
- E) surgical neurological system trespass





D) positioning problem:

- Yes! A number of positioning etiologies could cause this change in a unilateral upper extremity, as follows.
  - As the OR team feared, injury to the uncleared cervical spine could have occurred when the head was noted intraoperatively to have slipped out of its position. Evaluation of the SSEP at the ipsilateral Erb's point could have potentially helped exclude this etiology if the signal at Erb's point was also monitored. (Erb's point was not monitored in this patient, unfortunately.)
  - Other positioning problems that would directly affect the "down" arm in lateral decubitus position, such as ischemia from arterial compression or brachial plexus injury could also cause these signal changes.
    - In the case of ischemia from arterial compression to the dependent arm, this would have been ruled out if pulse oximetry or invasive blood pressure monitoring had been performed on this arm. (These were monitored elsewhere in this patient, unfortunately.)
    - Inspection of the axillary roll found it to be maintained in a good position, so brachial plexus injury was less likely in this patient.
  - In our young patient without presumed significant carotid atherosclerotic disease, the change in neck position would not be expected to compromise carotid artery flow and result in cerebral ischemia with changed cortical SSEPs.
  - Severe neck malpositioning resulting in vertebral artery damage would be more likely to compromise blood flow to the posterior circulation and would therefore be less likely to cause loss of upper extremity SSEPs also.
  - Other problems often grouped into the positioning problem etiology, such as a malfunctioning blood pressure cuff which stays inflated or an infiltrated IV, could also cause these unilateral SSEP changes.
- When an evoked potential signal change or loss occurs in an extremity, the anesthesiologist should always inspect the affected extremity. In this case, inspection revealed a malfunctioning blood pressure cuff that was remaining inflated and, therefore, acting as a tourniquet on the right upper extremity. Soon after removal of the blood pressure cuff, the SSEPs began to improve.
- If inspection had not revealed a problem with the blood pressure cuff, concern for cervical spine trauma would have been high and the anesthesiologist in this case would have raised the blood pressure to augment cervical spine perfusion while preparing for an intraoperative wakeup test if requested by the neurosurgeon.



A) systemic hypotension: Hypotension would be categorized as a physiological problem that can cause changes to SSEPs. However, system hypotension (as well as other physiological derangements) would be expected to cause a global change in SSEPs. In our presented patient, signal change occurred in the right upper extremity but SSEPs were preserved in the left upper extremity.



Try again

B) technical problem with signal acquisition: Technical problems can result in unilateral SSEP changes. Inspection of the stimulating pads on the arm shoes they have remained in unchanged position. Also, a technical problem in this patient might be less likely (although not excluded) since the signal change progressed from a signal change (decreased waveform amplitude) to a complete signal loss. Since this is not definitively a technical problem, we must keep searching for other etiologies to ensure we are not missing a true neurologic insult.



Try again

C) change in end-tidal sevoflurane from 0.5 MAC to 0.8 MAC: This would be categorized as a pharmacological problem which can cause changes to SSEPs. However, pharmacological effects would be expected to cause a global change in signals. In our presented patient, signal change occurred in the right upper extremity but SSEPs were preserved in the left upper extremity. In addition, 0.8 MAC should be an acceptable volatile anesthetic level to allow for successful SSEP monitoring.



Try again

E) surgical neurological system trespass: Since the surgical area is mid-thoracic there should not be surgical compromise to neural structures serving an upper extremity where our signal change occurred.



Try again