Introduction to Intraoperative neuromonitoring in Spine surgery:

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Abstract:

Introduction:

Intraoperative neuromonitoring (IONM) is widely used in spine surgeries and is now part of standard medical practice. The purpose of IONM is to allow early intervention by identifying neural insults intraoperatively which can help minimize or eliminate irreversible damage to the neurological structure thereby preventing a postoperative neurologic deficit. The American Society of neurophysiological monitoring defines neurophysiologic monitoring as "includes any measure employed to assess the ongoing functional integrity of the central or peripheral nervous system in the operating theatre or other acute care setting. Its mission is protection of the patient's nervous system. Neurophysiologic signals are monitored continuously during surgery for adverse changes, detection of which enables corrective action. Risk of postoperative neurological deficit, such as weakness, loss of sensation, hearing loss and impairment of other bodily functions is thereby reduced."

Techniques:

IONM helps to improve patient outcomes by preventing post-operative neuro deficits. Multi-modality neuromonitoring with commonly used modalities or techniques for spinal surgeries include:

SSEP-The somatosensory evoked potentials (SSEP) are electrical potentials recorded from the somatosensory cortex in response to stimulation of a peripheral nerve (most commonly the median nerve at the wrist or the posterior tibial nerve at the ankle). These potentials are recorded by subdermal needle electrodes placed along the medial lemniscus dorsal column pathway and over the scalp as they travel from the peripheral nerve through the pathway to the sensory cortex. A decrease in amplitude of greater than 50% or an increase in latency of greater than 10% is considered as alarm criteria for post-operative deficit. SSEP is monitored continuously throughout procedures to assess the functional integrity of the somatosensory pathway.

TcMEP-Transcranial motor evoked potentials (TcMEP) monitor the descending motor pathways from the motor cortex to the peripheral muscles. MEP responses are generated by transcranial electrical stimulation on the scalp by using subdermal needle electrodes and Compound muscle action potentials (CMAP) are measured over the spinal cord or in the muscle of interest. At the spinal level, the response is measured in the epidural or intrathecal space and is called a D-wave (direct). The muscle responses are recorded from electrodes placed on the muscle innervated by specific nerve root, brain region or cranial nerve. Muscles are selected based on the surgical procedure and spinal levels involved. Frequently used sites are thenar muscles for the arm, tibialis anterior and abductor hallucis for the leg. The muscle groups above the surgery level are typically used as a control. A decrease in amplitude of greater than 50% is considered as alarm criteria for post-operative deficit.

EMG-Electromyography (EMG) is real time recording of selective nerve root function specific to a muscle during spine surgery. One muscle group per nerve is monitored by using spontaneous EMG or triggered EMG technique. In Spontaneous EMG(SpEMG), subdermal needle electrodes are directly placed in the specific muscle to record its activity without any stimulation. SpEMG is sensitive to surgical manipulation such as compression or stretching of nerves which produces firing in the corresponding innervated muscles. Continuous, repetitive firing indicates a high probability of nerve injury.

Triggered EMG for pedicle screw stimulation- Triggered EMG is used to check pedicle integrity and proper positioning during pedicular screw placement. A monopolar electrode stimulates the top of the pedicle screw with increasing current intensities. Subdermal needle electrodes are placed in the appropriate muscle groups to record CMAPs in response to the stimulation. Direct stimulation of nerve root can also be performed with less than 5mA intensity to identify target muscle activity. A screw that breaches the medial or inferior pedicle wall reduces the stimulation threshold and increases the risk of damage. An irritated or damaged nerve root produces a response at a significantly lower stimulation intensity. A muscle response at less than 10mA intensity is considered an alert for a possible breach.

SSEPs and TcMEPs are susceptible to anesthetic and physiologic changes, EMG relies on absence of neuromuscular blockade. For IONM to be reliable and prevent neurological insult, communication and cooperation between intraoperative neuromonitoring (IONM) technician, anesthesiology team, and surgery team, is essential.

Conclusion:

Intraoperative neurophysiological monitoring (IONM) use during spine surgery, with a multimodality approach including SSEP, MEP and EMG, aids in early recognition of a neurological insult and, by management of signal changes during the procedure, can predict a favorable surgical outcome. Any significant variation from baseline IONM signals or a loss of signal during surgery indicates a neural insult and predicts a possible postoperative deficit.

Effective communication between multidisciplinary teams is critical to provide efficient patient care by decreasing adverse events and improving outcomes. IONM team works with the surgical and anesthesiology team to optimize signal acquisition and provide reliable monitoring. The goal of IONM is to detect surgical or physiological insults early while they are still reversible and help prevent damage to the neural structures by continuously evaluating the neural pathways while the patient is anesthetized, where clinical evaluation is not possible.

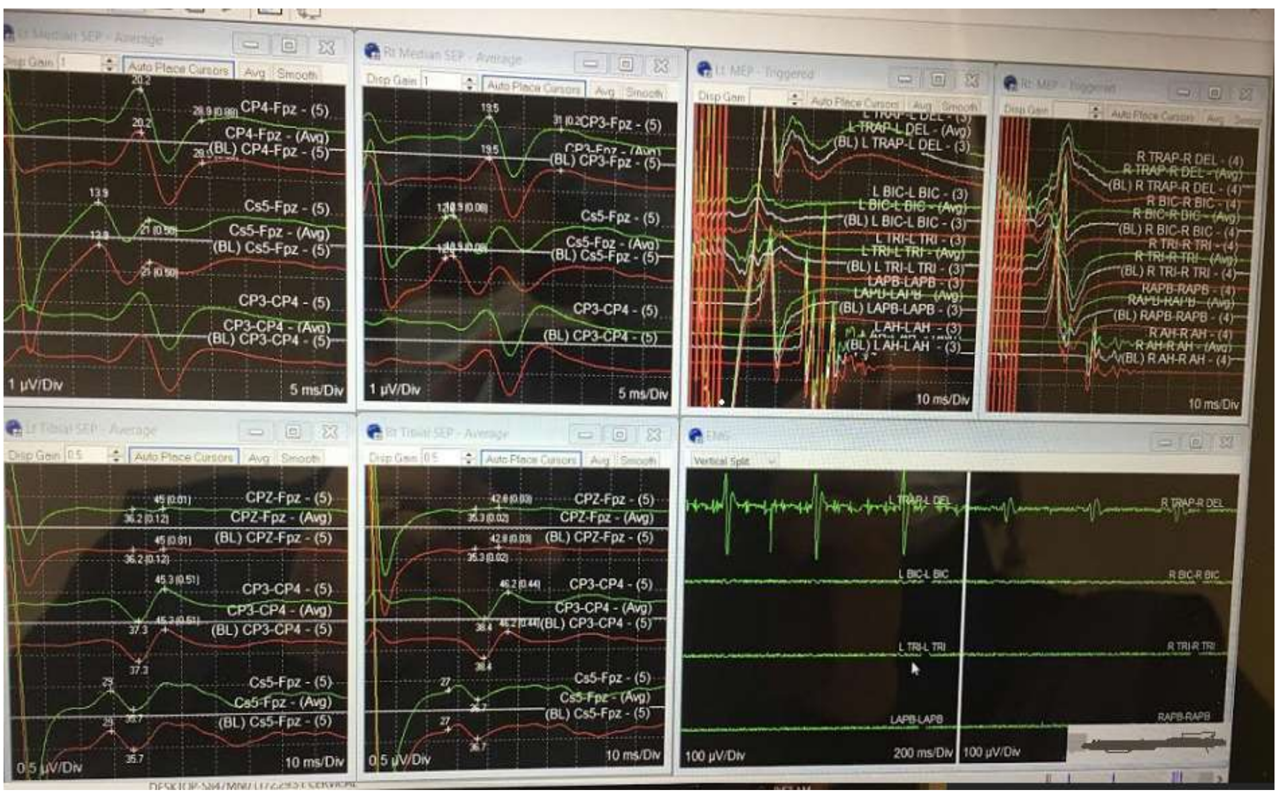

Figure 1: Left side of picture- Left and Right Median Nerve and Posterior Tibial Nerve SSEP responses.

: Right upper corner- Left and Right Upper and Lower extremity MEP responses.

: Right lower corner- Spontaneous EMG responses from muscles specific to surgical levels.

References:

1. The American Society of Neurophysiological Monitoring
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2. Intraoperative neurophysiological monitoring in spinal surgery
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3. Intraoperative neurophysiological monitoring
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About the author:

Dr. Nimesha Cheruku is the Regional manager for Intraoperative Neuromonitoring at OverWatchNeuro, whose goal is to provide highest quality monitoring services to all of USA. Her interest in Neurophysiology peaked during her graduate studies. Since then, she has worked in the field of Intraoperative Neuromonitoring, performing IONM studies during surgeries in the OR, interpreting the studies, teaching, writing and finally leading the Department of Intraoperative Neuromonitoring.

Dr. Nimesha Cheruku graduated with a Masters in Neuroscience from University of Texas at Dallas in 2007, MBA in Hospital and Healthcare Administration from IMSR in 2012. She earned her CNIM (Certification for Intraoperative neuromonitoring) from ABRET shortly after her graduation in 2008. She lives in Georgia, USA with her husband and 2 kids.