Intraoperative Neurophysiological Monitoring During Spinal Cord Stimulator (SCS) Placement Surgery: Retrospective Study of 111 Patients

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Background:

It is estimated that 50,000 spinal cord stimulators are placed for chronic pain worldwide on a yearly basis. Studies have shown a long term success rate of around 75%[1] and an electrode repositioning rate of approximately 18%.[2] Recent literature suggests that intraoperative neurophysiological monitoring (IONM) using SSEP collision[3] or EMG activation[4] can help reduce these rates by helping to define the position of the stimulator on the spinal cord (left, midline, or right) and identify any intraoperative neurological or positional risk to the patient.

Methods:

Charts of 111 consecutive SCS placement surgeries monitored between August 1, 2013 and December 31, 2013 were reviewed. Localization of SCS leads was performed by EMG activation and / or SSEP collision. Stimulator devices were engaged at 2 – 60 Hz frequency, beginning at 1 V and increasing at 1 V increments until EMG activity was seen. Successful left sided placement was indicated by EMG activity seen only in the left sided muscles while midline activation was indicated by bilateral EMG activity and right sided placement was indicated by EMG from the muscles on the right side. Successful myotomal activation was indicated by the match of activated myotomes to preoperative pain sensation. SSEP collision testing was accomplished by engaging the spinal cord stimulator device at 40 Hz or higher while simultaneously stimulating a peripheral nerve (median, ulnar, or posterior tibial at 4.47 Hz, 0.3 ms) and recording cortically generated SSEPs. Lateralization was confirmed when the amplitude of the rostrally recorded SSEP was notably reduced or abolished in the presence of the activated spinal cord stimulator. Similarly to the EMG method, left side placement was indicated by the attenuation of left sided SSEPs, midline placement was indicated by the attenuation of bilateral SSEPs, and right sided placement was indicated by the attenuation of right sided SSEPs. In addition to lateralization, neuroprotection was offered through standard SSEP, EMG, and TcMEP throughout the entire procedure.

Results:

A total of 111 patients were monitored for SCS placement. 106/111 patients (95.5%) were monitored for neuroprotection. 43/111 patients (38.8%) were monitored for spinal cord stimulator placement using SSEP collision, EMG activation, or both. EMG activation was able to confirm laterality in 29/31 cases (93.5%) and activated the desired target muscles in 27/31 (87%) cases. SSEP collision was successful in 18/28 cases (64.3%) and achieved greater than 75% abolition of the rostral response in 13/28 cases (46.4%). The location of the stimulator was adjusted based on IONM feedback in 8/43 (18.6%) cases. Positional compromise was identified by continuous SSEP in 4/111 cases (3.6%) while potential spinal cord injury was detected by SSEP change in 2/111 (1.8%) cases. All positional and spinal cord changes resolved intraoperatively following arm repositioning and surgical intervention accordingly.

Conclusion:

These initial findings indicate that EMG activation and SSEP collision are effective methods for determining the relative position of spinal cord stimulating devices on the spinal cord. Standard neuroprotective monitoring continues to identify and help resolve positional and spinal cord changes during spinal procedures. The higher success rate for EMG activation may be explained by the relative simplicity of the method that provides nearly instantaneous feedback and does not require additional time for an averaged SSEP response to resolve. By choosing EMG muscles that correspond to the area of the patient's pain, EMG activation can give further assurance to the surgeon that the stimulator placement will be effective for the patient. Further refinement in monitoring technique is likely to increase monitoring efficiency and will allow for a class I prospective study to determine whether IONM reduces failure and revision rates.

References:

1. Kumar K, Hunter G, Demeria D. Spinal Cord Stimulation in Treatment of Chronic Benign Pain: Challenges in Treatment Planning and Present Status, a 22-Year Experience. Neurosurgery 2006;58(3):484-496
2. Falkowski SM, Celii A, Sestokas AK, Schwartz DM, Matsumoto C, Sharan A. Awake versus asleep placement of spinal cord stimulators: A cohort analysis of complications associated with placement. Neuromod 2011;14(2):130-5.
3. Balzer JR, Tomycz ND, Crammond DJ, Habeych M, Thirumala PD, Urgo L, Moossy JJ. Localization of cervical and cervicomedullary stimulation leads for pain treatment using median nerve somatosensory evoked potential collision testing. J Neurosurg 2011;114(1): 200-5
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Illustrative Case:

The patient - 57 year old female diagnosed with chronic pain syndrome. Experienced pain in left lumbar region radiating into left hip, left groin and down to her left foot. History of C5-7 fusion. Trial SCS at T7 resulted in 80% reduction of her lower extremity pain.

The case –
FRAME 1: Baseline SSEP data was strong and repeatable from posterior tibial and ulnar nerve (PTN and UN).
FRAME 2: During stimulator placement, a greater than 50% bilateral PTN reduction was noted as the surgeon attempted to advance the stimulating device. Surgical intervention consisted of removal of the stimulator device which returned the responses to baseline.
FRAME 3: SSEP collision. Stimulator activated at 4 V, 40 Hz, 0.24 ms. PTN stimulation at medial malleolus at 50 mA, 0.3 ms, 1.41 Hz. Greater than 75% reduction of bilateral PTN cortical responses observed.
FRAME 4: PTN and UN SSEPs at baseline amplitude and latency at closing with the stimulator placed but off.

FRAME 1

FRAME 2

FRAME 3

FRAME 4