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Transcranial Electrical Motor Evoked Potential (TceMEP) Low Threshold Comparison and Patient Movement Analysis:

Bipolar vs Linked Quadri-Polar (LQP) Stimulation

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INTRODUCTION:

Motor evoked potentials (MEP) obtained with transcranial electrical stimulation (TES) are routinely used in neurophysiologic intraoperative monitoring (IONM) to assess the integrity of the motor pathways during surgery. The high intensity electrical stimulation (400-800-1000V) used in TES can have potential complications, including significant patient movement and lacerations to the tongue and lips. The bipolar, C3-C4 (Fig.1), TceMEP technique uses one anode on the contralateral side of the scalp paired with one cathode on the ipsilateral side of the scalp, to activate the motor pathway during surgery. Using our Linked Quadri-Polar (LQP)-TceMEP technique, two anodes and two cathodes on each side of the scalp (Fig.2), we have found that we can significantly reduce the voltage stimulation intensity (80-150-250) and also, in most cases, reduce the patient movement. We have been using the (LQP)-TceMEP technique for over 15 years. In the current research, we would like to compare the bipolar, C3-C4 vs (LQP)-TceMEP electrode placement thresholds as well as patient movement. Additionally, we employed a flexible adhesive Polyvinylidene Flouride (PVDF) movement sensor (Fig.3) connected to an intra-operative monitoring (IONM) machine. This PVDF film possesses a voltage difference across top and bottom surfaces that, when moved, creates a potential that can be recorded from the amplifiers on an IONM machine. This sensor allowed us to further test our hypothesis that (LQP)-TceMEP will reduce intensities and reduce stimulated patient movement compared to bipolar TceMEP by providing an exact value of the magnitude and duration of the stimulated movement.

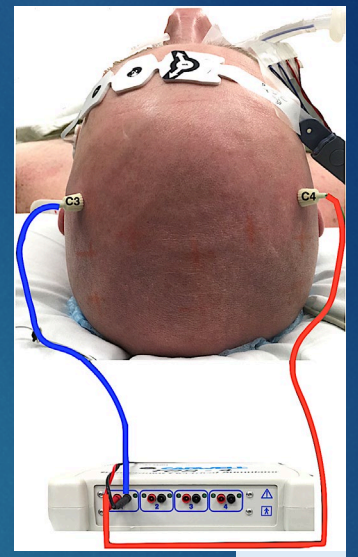


Figure 1

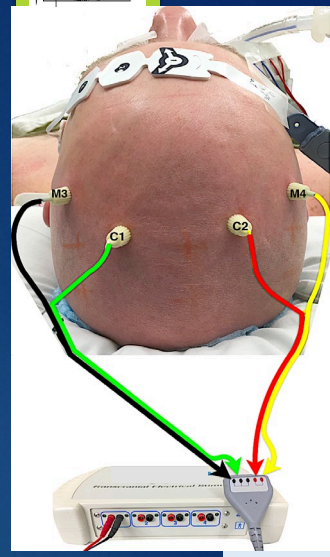


Figure 2

Figure 3

METHODS:

*8 patients: 4M, 4F. Age range between 42-78 years (median 49.1). This research was approved by the IRB of St Marys Hospital Madison WI
*Surgical procedures: spinal instrumentation (6) and spinal tumor removal (2)
*The patient's head was measured using the 10-20 system by a certified EEG, CNIM technologist.
*Anesthesia Regimen: TIVA was used in all cases, with Propofol (range 125-175µg/kg/min.) and Remifentanil (range 0.05-0.2µg/kg/min.).
*(LQP)-TceMEP parameters protocol: Train of 7, ISI of 2, Pulse Duration or Power Width of 75µs
*Lower extremity EMG recording: vastus lateralis (VL), tibialis anterior (TA), gastrocnemius medialis (GM), abductor hallucis (AH), extensor digitorum brevis (EDB)
*Accelerometer (PVDF) constantly place 30-35cm midline proximal to incision site
*Data was collected at three regular intervals: a) prior to incision b) during images or before tumor removal and c) at closing
*Data presented is from the time period of image collection (middle of study)
*The IONM system used was a Cadwell Elite
*All cases were monitored by the same certified technologist (CNIM) and the same neurophysiologist (CNIM, D.ABNM)
*Bite blocks: We strongly recommend using bilateral bite gauze rolls along with a roll of 4x4s between teeth.

Compound Muscle Action Potential (CMAP) and DyMedIx Movement Sensor Waveforms

Examples of motor evoked potentials (MEP) waveforms and the DyMedIx movement sensor waveforms.

The **PVDF** recording window was set to the all store window mode to capture the waveform immediately after MEP stimulation.

A. Lower extremity 4 electrodes (LE4), red arrows

B. Upper extremity 4 electrodes (UE4), white arrow

C. Lower extremity 2 electrodes (LE2), green arrow

D. Upper extremity 2 electrodes (UE2), blue arrow

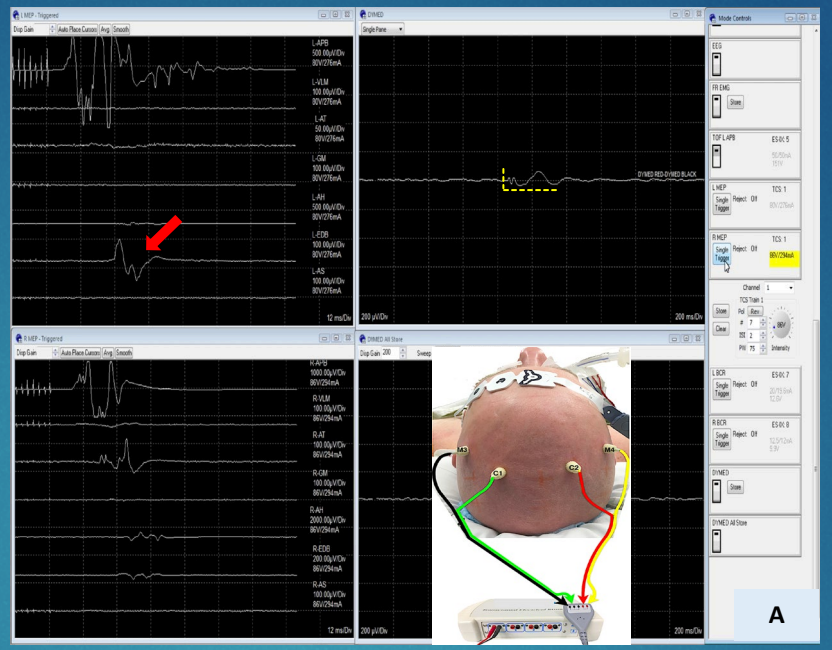
MEP gains set at 100 µV/div

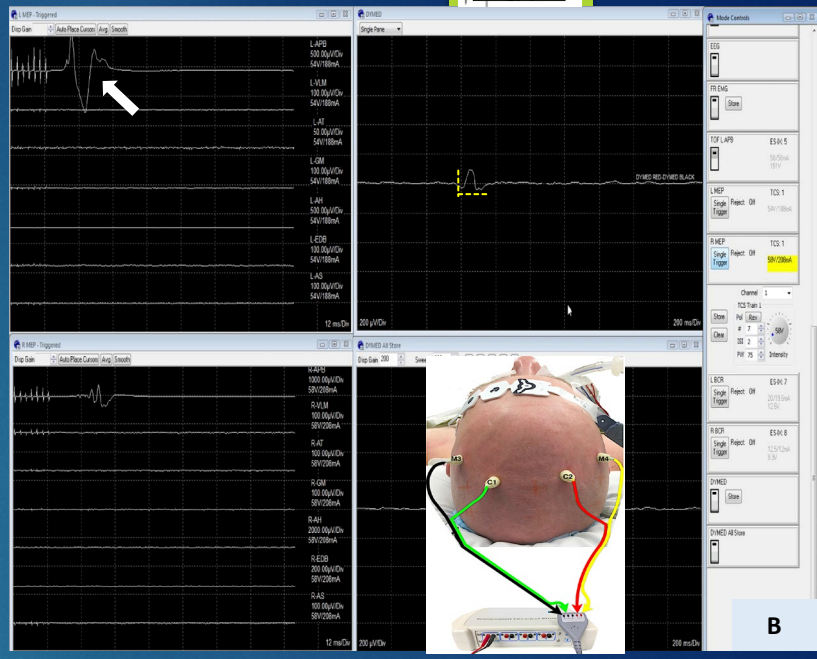
MEP sweep at 10-12ms/div

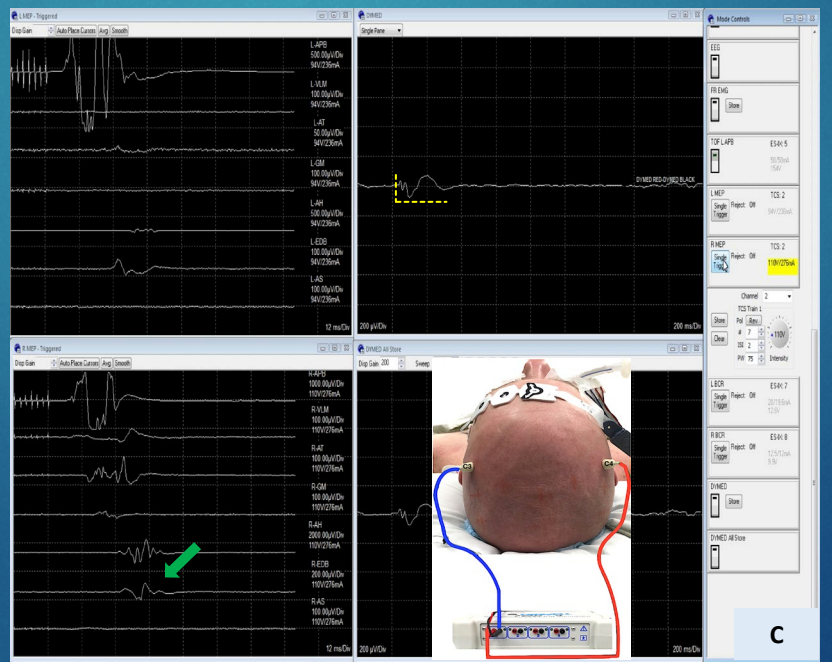
DyMedIx **PVDF** gain set at 200 µV/div

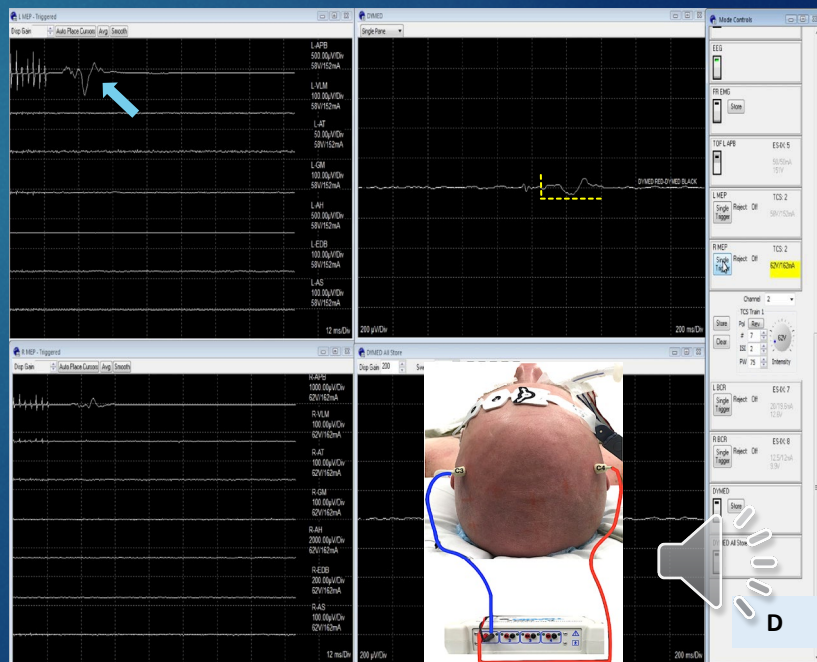
DyMedIx **PVDF** sweep at 200 msec/div.

Using the Cadwell Elite system, these parameters allowed accurate calculations of the CMAP amplitude as well as the amplitude and duration of the patient movement with the PVDF movement sensor, (yellow dotted lines on graphs).

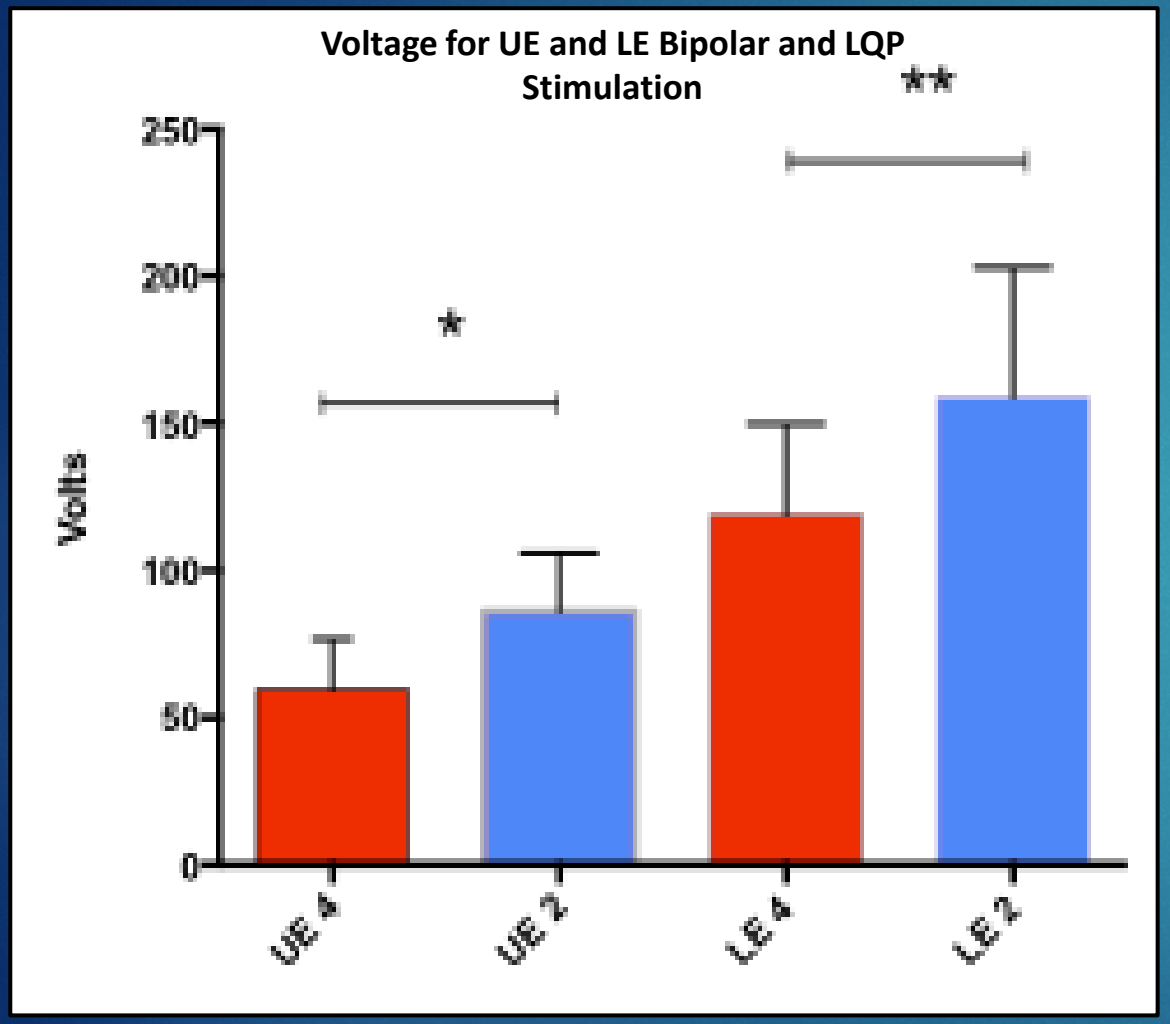


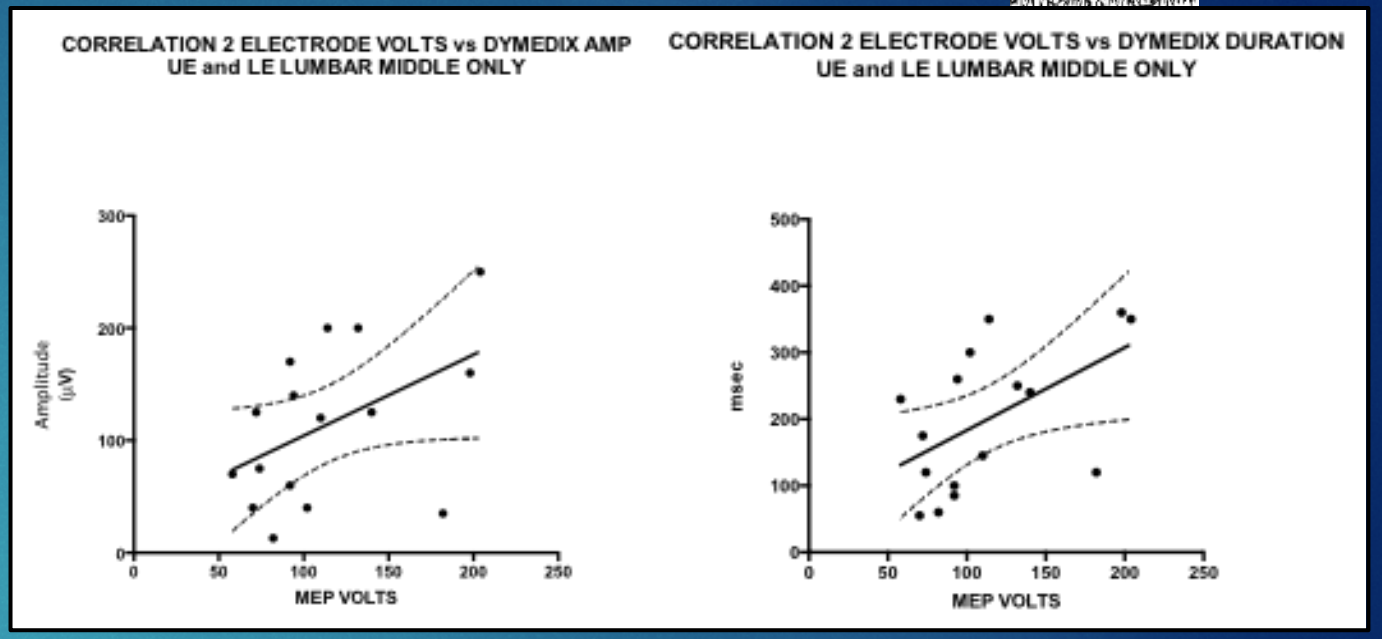


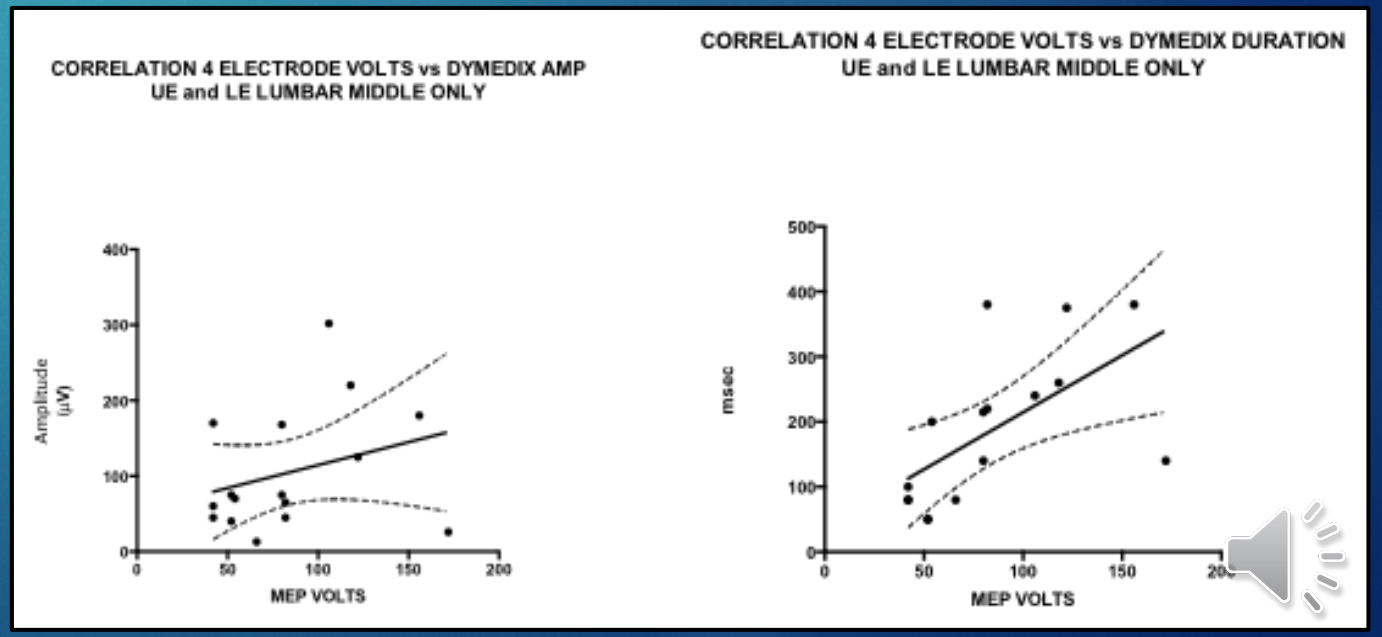




RESULTS:


Voltage for UE and LE Bipolar and LQP Stimulation
Volts
250
200
150
100
50
0
*
**
UE 4
UE 2
LE 4
LE 2


CORRELATION 2 ELECTRODE VOLTS vs DYMEDIX AMP
UE and LE LUMBAR MIDDLE ONLY
Amplitude (µV)
MEP VOLTS
CORRELATION 2 ELECTRODE VOLTS vs DYMEDIX DURATION
UE and LE LUMBAR MIDDLE ONLY
msec
MEP VOLTS


CORRELATION 4 ELECTRODE VOLTS vs DYMEDIX AMP
UE and LE LUMBAR MIDDLE ONLY
Amplitude (µV)
MEP VOLTS
CORRELATION 4 ELECTRODE VOLTS vs DYMEDIX DURATION
UE and LE LUMBAR MIDDLE ONLY
msec
MEP VOLTS

CONCLUSIONS:

- This pilot study compared TceMEP patient movement, obtained with a movement sensor, in response to the use of Bipolar (2 electrodes) and Linked Quadri-Polar (LQP) (4 electrodes) in 8 lumbar cases.
  Stimulation was adjusted to elicit the most distal upper and lower extremity responses.
- Despite our small sample size, our data showed a significant increase in the amount of voltage needed when using Bipolar TceMEP stimulation versus LQP stimulation to elicit distal upper extremity and lower extremity musculature.
- Both Bipolar and LQP stimulation showed a similar linear relationship between the amount of voltage used and the amplitude and duration of the patient movement in response to stimulation.
- We found a slightly better correlation between voltage and movement amplitude during Bipolar stimulation and a better correlation of voltage and movement duration during LQP stimulation.
- It is important to note that significantly more voltage is needed during bipolar stimulation to have similar correlations to LQP stimulation.
- Our data indicates that LQP stimulation may be a better stimulation technique as it pertains to voltages need and the correlation with movement amplitude and duration. To the best of our knowledge, this is the first study to be able to quantify movement.
- Our future direction is to increase the sample size to further quantify and verify our initial conclusions. Additionally, we are looking at other cervical spine procedures to compare bipolar and LQP double train stimulation.
- We also continue to explore various methods of quantifying movement secondary to MEP stimulation.

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