Electrophysiologic assessment of neurologic injury

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Electrophysiologic Monitoring of Spinal Cord Function

http://faculty.etsu.edu/currie/images/neuro2.jpg
Preserving Nervous System Function During Spine Surgery

- Somatosensory Evoked Potentials (SEPs)
Preserving Nervous System Function During Spine Surgery

- Somatosensory Evoked Potentials (SEPs)
- Motor Evoked Potentials (MEPs)

- EMG – spontaneous and triggered
Somatosensory Evoked Potentials

- Electrophysiological signals that:
  - Assess the integrity of sensory pathways
  - Identify the anatomical locus of abnormality
SOMATOSENSORY SYSTEM

- STIMULUS
  - ELECTRICAL PULSES
  - AIRPUFFS
  - TAPPING, BRUSHING

NEURAL GENERATORS: SOMATOSENSORY SYSTEM

- SOMATOSENSORY EVOKED POTENTIAL
- CORTICAL:
  - Field potential
- BRAINSTEM:
  - Field and conducted
- SPINAL CORD:
  - Field and conducted
- PERIPHERAL NERVE:
  - Conducted
WHO DEPARTMENT OF REHABILITATION MEDICINE

TIBIAL NERVE SEPs

CORTICAL Cz’-Fz

100 MS

T10 SPINE
T12 SPINE
L2 SPINE
L4 SPINE
POPLITEAL FOSSA

STIM

WHO DEPARTMENT OF REHABILITATION MEDICINE

MEDIAN/ULNAR NERVE SEPs

CORTICAL C3’-Fz, C4’-Fz

BRAINSTEM
CERVICAL
ERBS POINT
UPPER ARM

STIM
COMPLICATION ASSOCIATED WITH REDUCTION OF KYPHOSIS

Effectiveness of SEPs:
Neurological Deficits With (Solid Bars) And Without (Hashed Bars)
Neuromonitoring During Scoliosis Repair

Nuwer et al, 1995
REGIONS OF THE SPINAL CORD

SENSORY (PROPRIOCEPTION)
- POSTERIOR COLUMNS
- POSTERIOR HORN
- CORTICOSPINAL PATHWAY

MOTOR:
- ANTERIOR HORN

SPINOThALAMIC (PAIN/TEMPERATURE)

VASCULAR SUPPLY OF SPINAL CORD

- Right posterior spinal a.
- Peripheral branches from pial plexus
- Central branches to left side of cord
- Left posterior spinal a.
- Zone supplied by penetrating branches from pial plexus
- Zone supplied by central branches
- Zone supplied by both central branches and branches from pial plexus
- Posterior radicular a.
- Anterior radicular a.
- Pial arterial plexus
Anterior Cord Syndrome

Motor Evoked Potentials

- Electrical signals:
  - Elicited by transcranial stimulation
  - Directly evaluate the motor columns of the spinal cord
  - Evaluate the function of specific motor nerve roots of the spinal cord
Motor Evoked Potentials

- Stimulate at the scalp overlying the motor cortex
  - Record Compound Muscle Action Potential (CMAP) in hands and legs
  - Spinal cord

Reflects activity in corticospinal pathway

Relatively non-invasive

Allows bilateral analysis and evaluation of motor nerve roots
Monitoring findings:
Tibial and peroneal SEPs were absent throughout the case.

MEPs were lost bilaterally after instrumentation implanted.
Waited for recovery.
When no recovery, changed head positioning. Signals recovered.
Stimulus Parameters

• Pulse Duration: 0.05 msec
• Train of pulses: 2-9
• Stimulus Amplitude: 100-800 V

• Parameters and responses may vary considerably between patients, and even within the same procedure

Motor Evoked Potentials

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  – Directly evaluate the motor columns of the spinal cord
  – Evaluate the function of specific motor nerve roots of the spinal cord

• Used with SSEPs, provide a relatively complete monitoring of spinal cord function
Advantages of MEPs

- Rapid feedback
- Directly tests descending motor pathways
- Detection in the absence of SEP changes
- Highly sensitive to spinal cord blood flow changes
- Earlier detection than SSEPs*
- For neuromonitoring, MEPs should reduce the complication of paraplegic/motor impairment
  - Recent studies have shown combination SEP/MEP monitoring is more effective at preventing injury/improving outcomes than SEP alone

* Neurophysiological detection of impending spinal cord injury during scoliosis surgery.


Limitations of Combined SEP+MEP Monitoring (multimodal IONM)

- False positives
  - Not uncommon with MEPs
Limitations of Combined SEP+MEP Monitoring (multimodal IONM)

• False positives
  – Not uncommon with MEPs

• False negatives

• Nerve Root Complications
Spontaneous/Triggered EMG Monitoring

Use of sEMG in the Operating Room

- Protection and identification, not diagnosis
Peripheral Nerve/Muscle Innervation

- Single motor unit not desirable
- Large muscle groups innervated by multiple nerve fibers/fascicles
  - Potential injury site unknown
- Comprehensiveness with limited specificity
- EMG activity not well correlated with outcome

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**TABLE 1** Summary of TES-induced MEP, EMG activity, and SSEP changes, and postoperative C-5 deficit

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<th>Neuromonitoring Technique</th>
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<th>No. of Patients w/o Postop C-5 Deficit</th>
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<tr>
<td>TES-induced MEP change</td>
<td>10</td>
<td>24</td>
<td>34</td>
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<td>no TES-induced MEP change</td>
<td>1</td>
<td>202</td>
<td>203</td>
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<tr>
<td>EMG activity change</td>
<td>5</td>
<td>33</td>
<td>38</td>
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<tr>
<td>no EMG activity change</td>
<td>7</td>
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<td>SSEP change</td>
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MEPs for Nerve Root Complications

- C5 nerve Root Palsy
- Lumbar Sacral Fusion*

*The Role of TceMEPs in Detection of Iatrogenic Spinal Nerve Root Deficit during Instrumented Lumbosacral Fusion

Bikash Bose MD, FACS, FICS1, Anthony Sestokas PhD2 and Daniel Schwartz PhD