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Electrophysiologic assessment of neurologic injury

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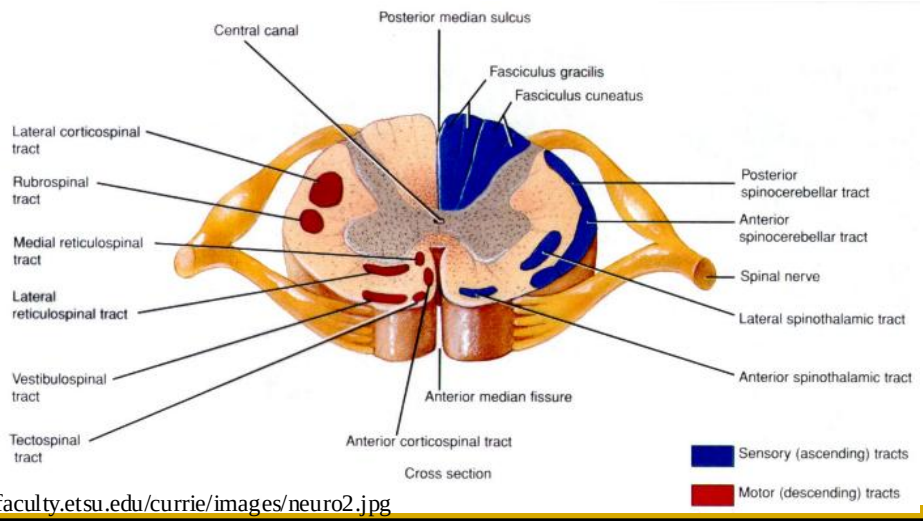
Electrophysiologic Monitoring of Spinal Cord Function



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Preserving Nervous System Function During Spine Surgery

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Preserving Nervous System Function During Spine Surgery

- Somatosensory Evoked Potentials (SEPs)

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Preserving Nervous System Function During Spine Surgery

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- Motor Evoked Potentials (MEPs)

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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

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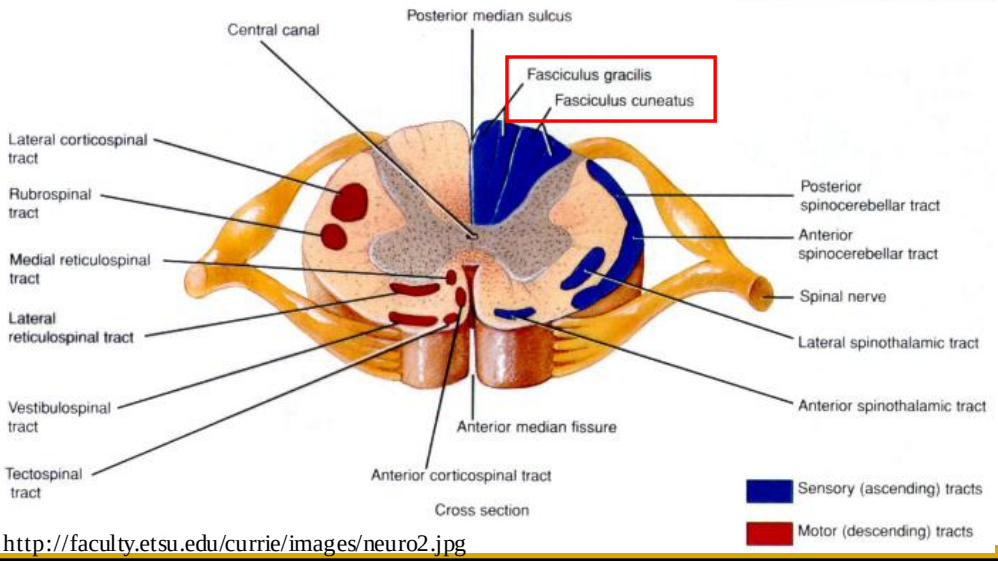
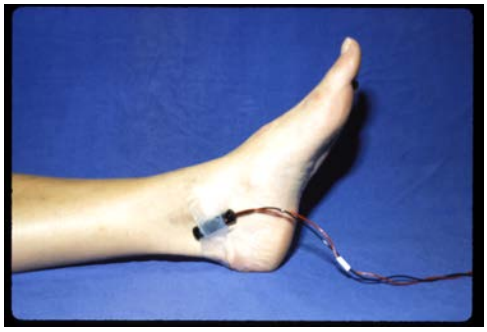
Somatosensory Evoked Potentials



http://faculty.etsu.edu/currie/images/neuro2.jpg

SOMATOSENSORY SYSTEM

- **STIMULUS**
- ***ELECTRICAL PULSES***
- **AIRPUFFS**
- **TAPPING, BRUSHING**



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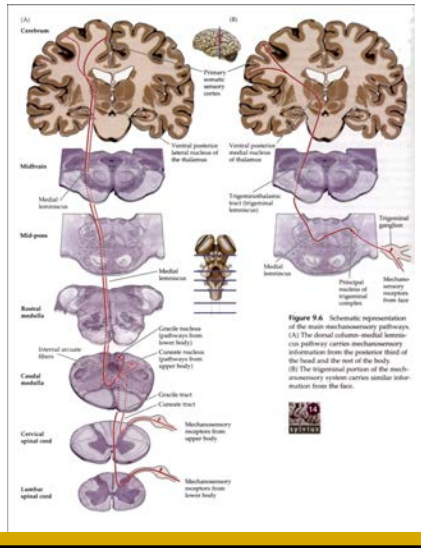
NEURAL GENERATORS: SOMATOSENSORY SYSTEM

- **SOMATOSENSORY EVOKED POTENTIAL**
- **CORTICAL:**
  - **Field potential**
- **BRAINSTEM:**
  - **field and conducted**
- **SPINAL CORD:**
  - **Field and conducted**
- **PERIPHERAL NERVE:**
  - **Conducted**



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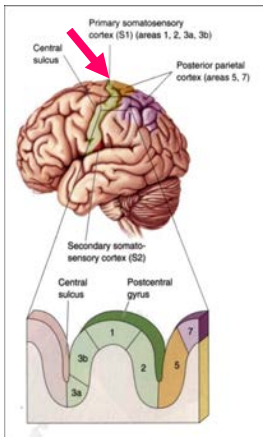
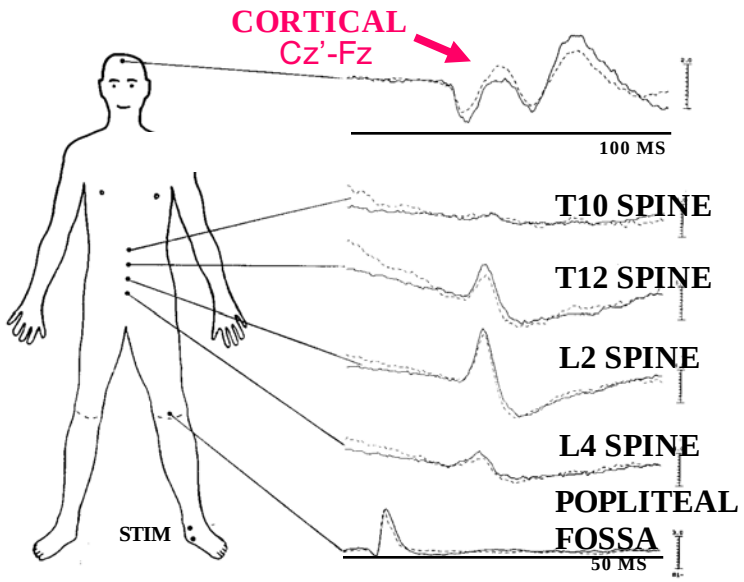
TIBIAL NERVE SEPs





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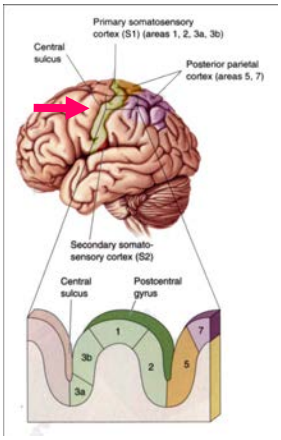
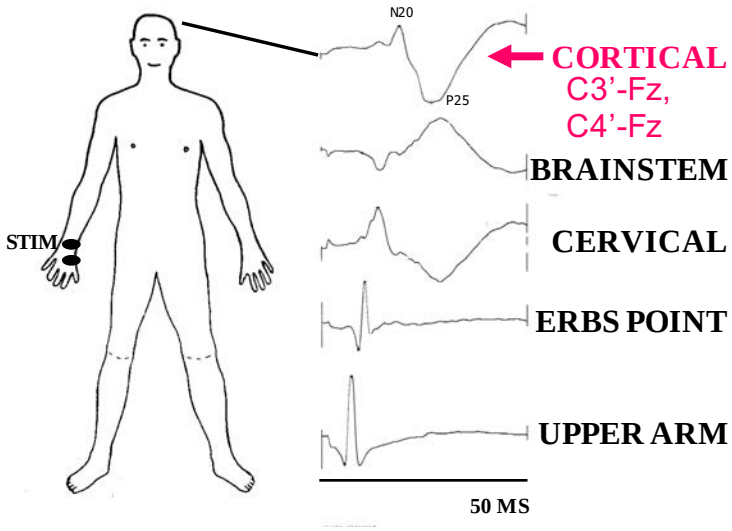
MEDIAN/ULNAR NERVE SEPs





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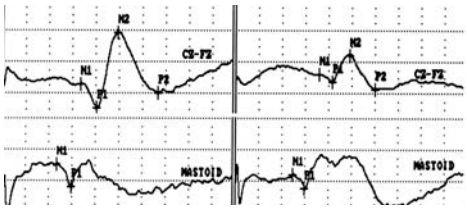
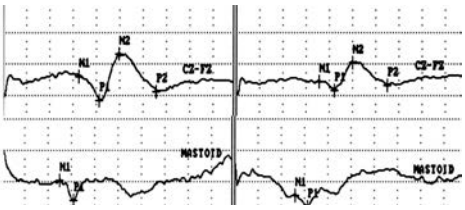
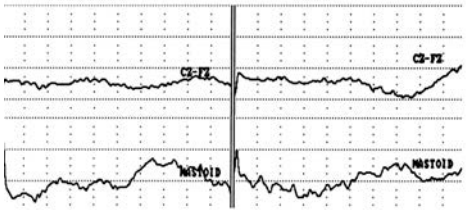
COMPLICATION ASSOCIATED WITH REDUCTION OF KYPHOSIS



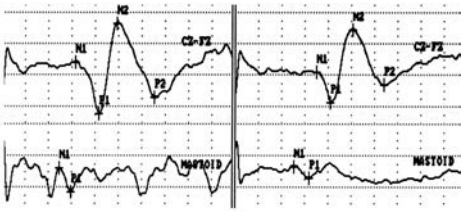
BASELINE



POSTINSTRUM. - PREREDUCTON



5 MIN POSTREDUCT. TO CLOSING



BASELINES TAKEN 5 DAYS LATER

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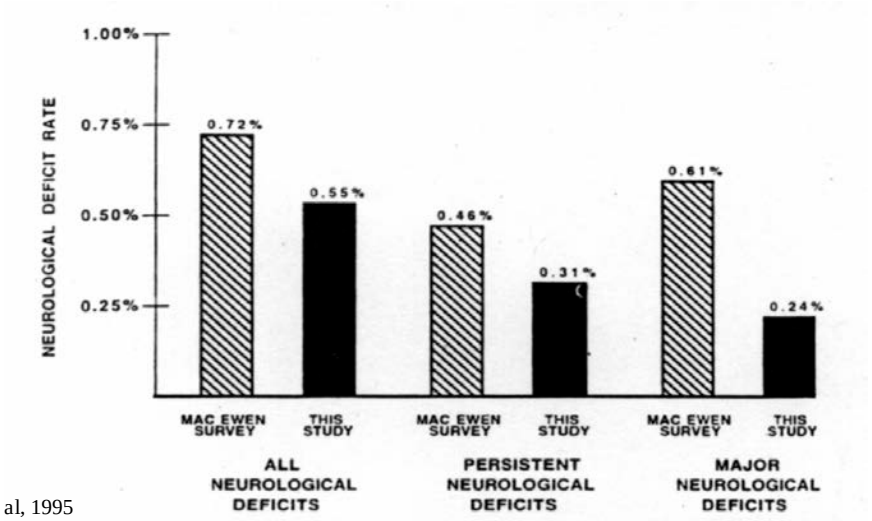
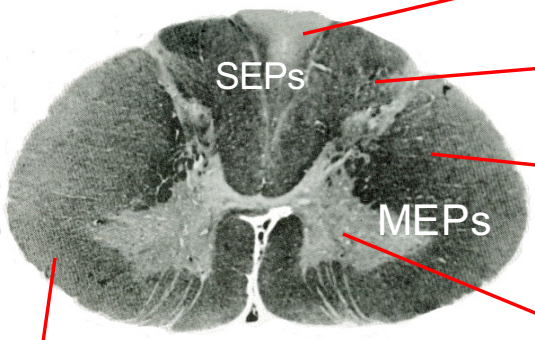
Effectiveness of SEPs:

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

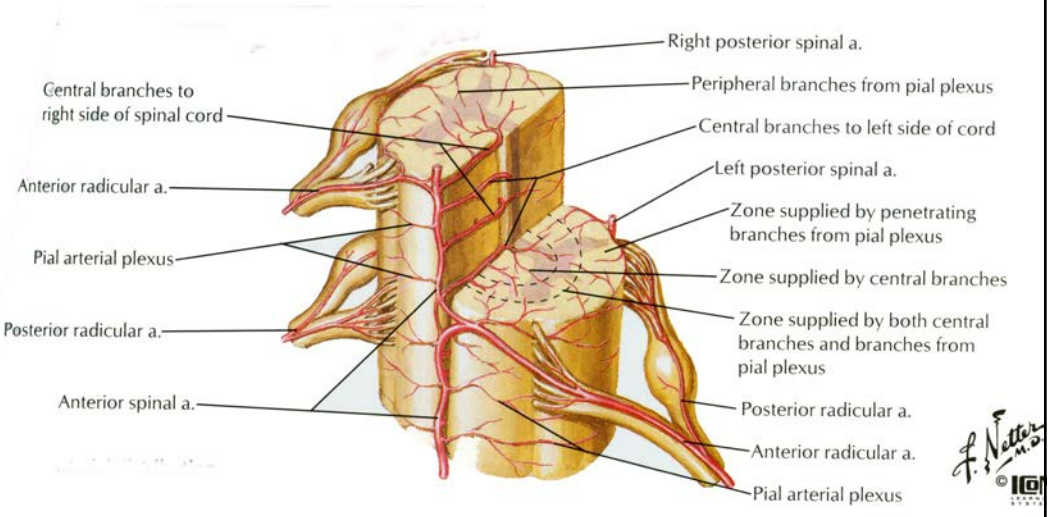
MOTOR:

CORTICOSPINAL PATHWAY

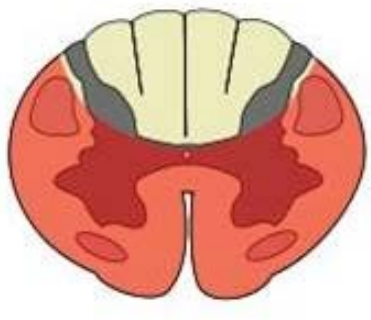
ANTERIOR HORN

SPINOTHALAMIC (PAIN/TEMPERATURE)

VASCULAR SUPPLY OF SPINAL CORD



Anterior Cord Syndrome



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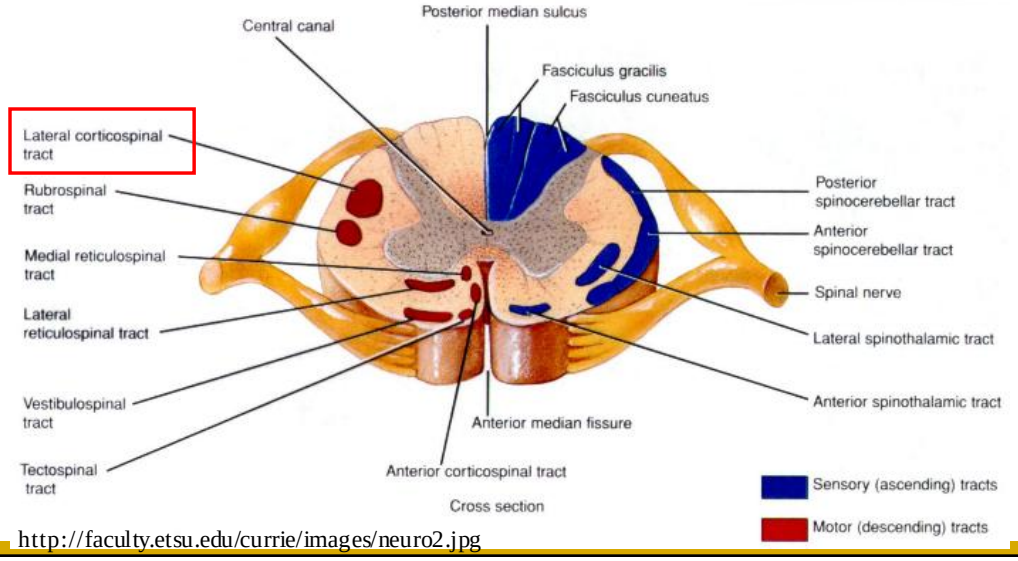
Motor Evoked Potentials

- 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



http://faculty.etsu.edu/currie/images/neuro2.jpg

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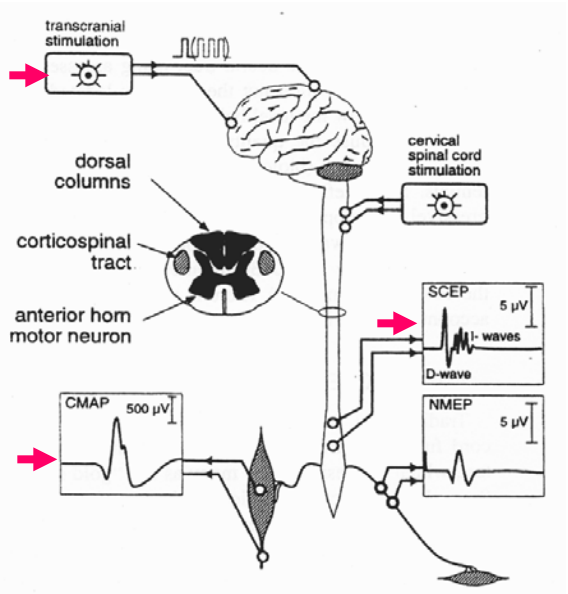
Transcranial Electrical Motor Evoked MEPs

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

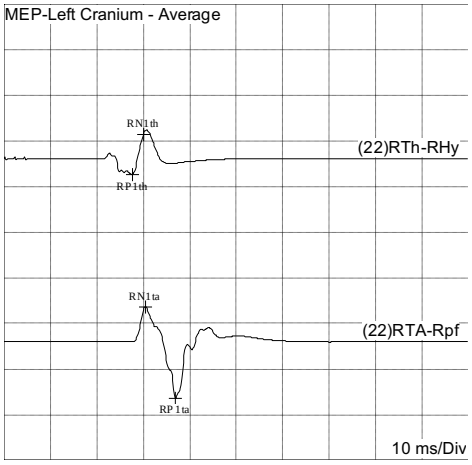
Reflects activity in corticospinal pathway

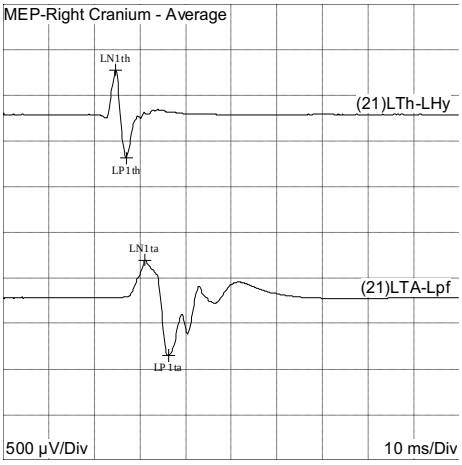
Relatively non-invasive

Allows bilateral analysis and evaluation of motor nerve roots



Typical Myogenic MEPs





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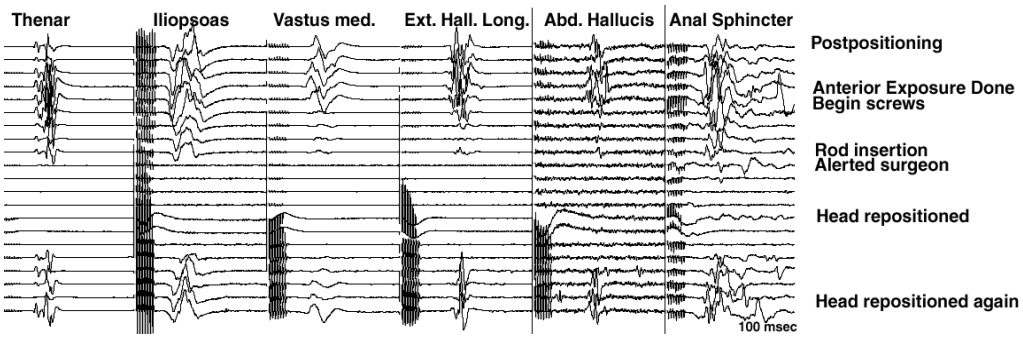
Monitoring findings:

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.



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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

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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
- Used with SSEPs, provide a relatively complete monitoring of spinal cord function

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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 cordinjury during scoliosis surgery. Schwartz DM, Auerbach JD, Dormans JP, Flynn J, Drummond DS, Bowe JA, Laufer S, Shah SA, Bowen JR, Pizzutillo PD, Jones KJ, Drummond DS. J Bone Joint Surg Am. 2007 Nov;89(11):2440-9.

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Limitations of Combined SEP+MEP Monitoring (multimodal IONM)

- False positives
  - Not uncommon with MEPs

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- False negatives

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Limitations of Combined SEP+MEP Monitoring (multimodal IONM)

- False positives
  - Not uncommon with MEPs
- False negatives
- **Nerve Root Complications**

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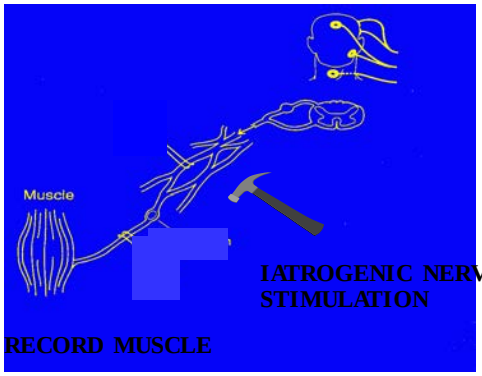
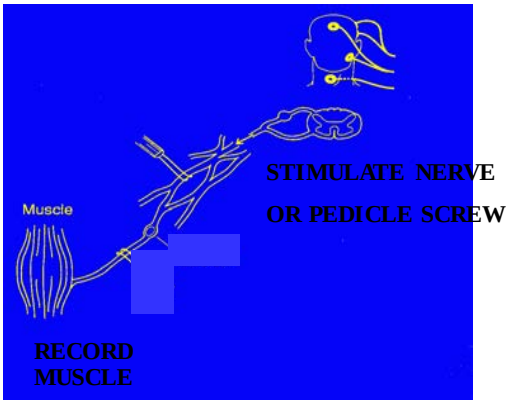
Spontaneous/Triggered EMG Monitoring





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Use of sEMG in the Operating Room

- Protection and identification, not diagnosis

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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

Neuromonitoring Technique	No. of Patients w/Postop C-5 Deficit	No. of Patients w/o Postop C-5 Deficit	Total No. of Patients
TES-induced MEP change	10	24	34
no TES-induced MEP change	1	202	203
EMG activity change	**5**	**33**	**38**
no EMG activity change	**7**	**193**	**200**
SSEP change	0	5	5
no SSEP change	12	221	233

Neurophysiological detection of iatrogenic C-5 nerve deficit during anterior cervical spinal surgery. Bose B, Sestokas AK, Schwartz DM. J Neurosurg Spine. 2007 May;6(5):381-5.

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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