Somatosensory Evoked Potentials (SSEPs)

Viet Nguyen, MD
Clinical Associate Professor
Neurology, Neurophysiology & Intraoperative Monitoring
Stanford University School of Medicine

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Somatosensory Evoked Potentials

• Electrical sensory stimulus $\rightarrow$ electrical brain response

• Tests the functional integrity of sensory pathways:
  › the *posterior columns* of the cord
  › large-diameter fast-conducting sensory fibers
    • group IA muscle afferents
    • group II cutaneous afferents

• Signal path: how many neurons?
SSEPs = 3-neuron signal

Dorsal column - medial lemniscus pathway
1. Dorsal root ganglion
2. Medulla
   a. Cuneate nucleus (UE)
   b. Gracilis nucleus (LE)
3. Thalamus (VPL) → primary sensory cortex

Spinothalamic tract (not part of the SSEP)
1. peripheral nerve, dorsal root ganglion
2. spinal cord
3. thalamus, cortex
Stimulus

- Mixed peripheral nerve transcutaneous stimulation
  - UE: median nerve at palmar wrist
    - Backup: ulnar nerve
  - LE: posterior tibial nerve at medial ankle
    - Backup: peroneal nerve
- Placement: as close to the nerve as possible, 2–3cm apart
  - Cathode proximal, anode distal: avoid anodal block
    - Opposite of nerve conduction study
    - Nerve is depolarized under the cathode
Stimulus

- Electrodes:
  - Disc
  - Adhesive
  - Subdermal needles: if limb swelling
Stimulus parameters

stimulus: electric square wave pulses
  - pulse duration: 100 – 300 μsec
  - rate: 3.1 - 4.9/sec
    › but not a subharmonic of 60Hz

intensity:
  - supramaximal sensory but subnoxious (~3x sensory threshold)
  - 8 - 30mA

  - not too low:
    › above the motor threshold to ensure supramaximal sensory stimulation

  - not too high:
    › movement artifact
    › painful
Recording sites

cortex (Cz, C3, C4, C3’, C4’)
  - reference: Fz or Fpz (frontal)

thalamus (too invasive)

spine (cervical, lumbar)

dorsal root ganglion (too invasive)

peripheral nerve (Erb’s, popliteal)
Recording parameters

- Bandpass: 30 – 3000 Hz
- Sweep:
  - UE: 5-10ms/div
  - LE: 8-15ms/div
- Average: 200-1000 reps
- Sampling rate: >5000 Hz
- Replications: at least 2 per EP
shortcomings of SEPs

electrical noise
- lights
- heat lamps
- monitors / computers
- mobile phones

physiologic noise
- arm/leg/scalp muscle EMG
- background EEG
- pre-existing neuropathy
- body habitus
shortcomings of SEPs

magnitude of signals:
- SEP 1–2 μV
- EEG waves 50–100 μV
- EMG signals in mV

**ECG ~1Volt**

EP wave extracted by repetitive stimulation and computer-signal averaging techniques
averaging

“responses” are computer averaged into “potentials”

- record multiple responses
- time-locked each to the stimulus

reduces “noise” in individual responses
sweep

long enough to capture all relevant responses
repetition rate

repetition rate:
- 3-5Hz

- not too slow:
  › takes longer to get result

- not too fast:
  › amplitude wanes
  › if in doubt, err on the low side

Fig. 1. Effects of increasing the rate of stimulus presentation in one patient, for posterior tibial stimulation and scalp recordings. As rate is increased, EP amplitude decreases. The product rate × amplitude helps compare the advantageous increase in speed of testing and the disadvantageous loss of amplitude. In the patient, the rate 5.1/s appeared to be the best compromise between speed and attenuation. (Reprinted from Nuwer and Dawson, 1984a, with permission from the International Federation of Clinical Neurophysiology.)
leg SEPs: dipole variations

lower extremity somatosensory cortex:

- interhemispheric fissure
- location and gyral curvature is variable
leg SEPs: dipole variations

- vertex (non-lateralized) peaks
- paradoxical lateralization (ipsilateral to stimulus)
CLINICAL APPLICATIONS

- Demyelinating disease: Multiple Sclerosis, NMOSD
- **Prognosis in comatose survivors of cardiac arrest**
- Toxic/Nutritional Myelopathies
- Leukodystrophy
- Friedreich’s ataxia
- Peripheral neuropathies: prolongation of absolute latencies with normal interpeak latencies
- Brainstem tumor or stroke
- Intraoperative Monitoring
References


SSEPs

CASE EXAMPLES
57F
multiple sclerosis, leg pain & spasms, L-foot numbness
57F multiple sclerosis, leg pain & spasms, L-foot numbness
57F, multiple sclerosis, leg pain & spasms, L-foot numbness
57F multiple sclerosis, leg pain & spasms, L-foot numbness
normal median and posterior tibial SSEPs
23F MVA, polytrauma, unrestrained driver, ejected from car

avg=500 good twitch

Question: intact spinal cord function?
23F MVA, polytrauma, unrestrained driver, ejected from car

avg=500 good twitch

Question: intact spinal cord function?
abnormal study: no reproducible SSEP from lumbar, cervical, or scalp
- impaired central and/or peripheral sensory conduction

no popliteal channel
no median nerve study done
50F
myotonic dystrophy type 1
no CNS symptoms
normal BUE median SSEPs
50F
myotonic dystrophy type 1
no CNS symptoms
normal BUE median SSEPs
abnormal study
- BLE SSEP latencies prolonged bilaterally
- poorly recorded lumbar & cervical responses
- normal amplitude
- normal morphology

Dx:
- possible central conduction delay (e.g., myelopathy)
- possible peripheral conduction delay (e.g., neuropathy)
- partial factor: tall height (6’ 2”), does not fully explain latencies
74M
progressive
BLE paresthesias,
numbness,
imbalance.

BLE hypertonia

patellar DTRs 3+

bilateral Babinski sign
74M progressive BLE paresthesias, numbness, imbalance.
BLE hypertonia
patellar DTRs 3+
bilateral Babinski sign
74M progressive BLE paresthesias, numbness, imbalance.

BLE hypertonia

patellar DTRs 3+

bilateral Babinski sign
74M
progressive
BLE paresthesias, numbness, imbalance.

BLE hypertonia

patellar DTRs 3+

bilateral Babinski sign
abnormal study

- impaired conduction along gracile-medial lemniscal somatosensory pathway
  - absent cortical BLE SSEPs
  - intact lumbar SSEP?
- intact conduction along cuneate-medial lemniscal somatosensory pathway (normal BUE SSEPs)

Dx: myelopathy

- previous MRIs “normal”
- repeat MRI T-spine: intrinsic cord hyperintensity
- MRA T-spine: T6-11 spinal *dural AV fistula*
case 5

56M degenerative cervical stenosis
C3-C5 ACDF

EXAM:
L > R deltoid and biceps weakness
hyperreflexia of lower extremities
gait ataxia
difficulty with fine motor tasks (buttoning shirt, tying shoes)

PROTOCOL:
UE/LE SSEP
MEP
EMG: bilateral trapezius, deltoids, biceps, hands
case 5: 56M  C3-C5  ACDF

IMPRESSION:
- cervical myelopathy
- some peripheral neuropathy
Sweep should capture *entire* waveform

- **lengthen time base**
Sweep should capture entire waveform

HOORAY!