Introduction to EMG

EMG and Nerve Conduction Studies
- An extension of the Physical Examination
- Quantitates nerve and/or muscle injury
- Provides Useful Data Regarding Nerve Injury
  - Site
  - Type
  - Severity
  - Duration
  - Prognosis
Importance of EDX Studies

- Diagnosis
- Localization
- Assist in further testing (i.e. identify potential biopsy sites, imaging studies, spinal fluid analysis, blood work)
- Prognosis
- Use in Research

NCSs and EMG

Points to Remember

- NCSs and EMG: assess physiology of nerve and muscle
- Not all radiculopathies are structural
- Neurologic consultation is best obtained before the testing is ordered
- If NCSs and EMG normal or non-contributory, justification for neurologic consultation is greater than before testing
When to order NCSs and EMG

- Mononeuropathy
- Mononeuropathy Multiplex
- Radiculopathy
- Plexopathy (Brachial or Lumbosacral)
- Anterior Horn Cell Disorders
- Diffuse neuropathies
- Cranial neuropathies
- Neuromuscular Junction Disorders
- Myopathy
When **Not** to order NCSs and EMG

- Central Nervous System Disorders (Stroke, TIA, Encephalopathy, spinal cord injury)
- Multiple Sclerosis
- Total body fatigue, fibromyalgia
- Joint pain
- Unexplained weakness (without a neurologic consultation)
- Failed back, S/P multiple neck and low back surgeries
- In place of a neurologic consultation

Types of nerve conduction studies

- Sensory: typically antidromic
- Typical nerves examined: Sural, ulnar, median, occasionally radial or superficial peroneal
Sensory NCS Parameters

- Onset and peak latencies
- Conduction velocity
  - determined by velocity of a very few fast fibers
- Amplitude
  - determined by the number of large sensory fibers activated

Normal Median Sensory Study

<table>
<thead>
<tr>
<th></th>
<th>Latency</th>
<th>CV (msec)</th>
<th>Amp (uV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrist-D2</td>
<td>2.2</td>
<td>58</td>
<td>44.1</td>
</tr>
</tbody>
</table>
Motor NCS Parameters

- **Distal Latency**
  - determined by conduction velocity of the nerve, neuromuscular junction & muscle

- **Amplitude**
  - determined by number of muscle fibers activated

- **Proximal conduction velocity**
  - determined by conduction velocity of the fastest fibers

Motor Nerve Conductions

- Vital part of EDX as this important for identifying demyelination, compression
- Need to do proximal and distal studies to evaluate for conduction velocity, conduction block, temporal dispersion
- Typical nerves: ulnar, median, peroneal, tibial.
- Less common: radial, femoral, phrenic, spinal accessory, facial
Normal Median Motor Study

<table>
<thead>
<tr>
<th>DL</th>
<th>CV</th>
<th>Amp</th>
</tr>
</thead>
<tbody>
<tr>
<td>msec</td>
<td>m/s</td>
<td>mV</td>
</tr>
<tr>
<td>Wrist-APB</td>
<td>3.2</td>
<td>15.0</td>
</tr>
<tr>
<td>Elbow-Wrist</td>
<td>55</td>
<td>14.8</td>
</tr>
</tbody>
</table>

What is Peripheral Neuropathy?
Nerve conduction responses after injury

F-waves and H-reflex

- Useful for identifying proximal segmental demyelination
- Can only be done when motor amplitude is > 1 mV
- Extremely height-dependent
**Needle Electromyography: Techniques**

- **Needle electrode is inserted into the muscle**
  - Needle is disposable, single use
- **Multiple muscles are accessible for examination**
- **Combination of muscles tested**
  - Dependent upon clinical question
- **Level of discomfort is mild**
Needle Electromyography: Data

- Insertional Activity
- Spontaneous Activity
- Motor Unit Configuration
- Motor Unit Recruitment
- Interference Pattern

Needle Electromyography: Data

**Motor Unit Configuration**
- Single motor unit: A motor axon and all its muscle fibers
- Motor Unit Configuration: Amplitude, Duration, Morphology
- Muscle is volitionally activated at different force levels
- Needle recording properties enable assessment of single MUs

**Motor Unit Recruitment**
- Pattern of motor unit activation with increasing volitional activation

**Interference Patterns**
- Motor unit pattern with full voluntary activation
EMG: Spontaneous Activity

- Fibrillation Potentials
- Positive Sharp Waves
- Fasciculation Potential
EMG: Neurogenic Motor Unit

10 msec/div, timebase
2MV/vertical segment

EMG Motor Unit Changes

Figure 44d
Single voluntary motor unit potentials. A. Normal. B. Prolonged polyphasic potential seen with denervation. C. "Clear unit" - normally shaped but of much greater amplitude than normal. D. Brief, low-amplitude "myopathic" unit. Calibrations: 5 ms (horizontal) and 1 mV in A and B. 2 mV in C. 100 µV in D (vertical).

Adams and Victor, 1981
Common Mononeuropathies

- Median at the Wrist (CTS)
- Ulnar at the Elbow (Tardy Ulnar Palsy)
- Peroneal Palsy at the Fibular Head

Case 1

- 63 year old woman
- Numbness, tingling, pain of entire right hand X 4 months
- Awakens her at night.
- Drops objects from right hand
- Works as sander in furniture factory.
- Borderline diabetic
- Examination: Decreased cold entire right hand, normal strength, positive Tinel’s right wrist, normal reflexes in the RUE
Carpal Tunnel Syndrome
Atrophy of APB Muscle

Kopell, Thompson, 1963
Median Nerve
Innervation of the Hand and Sensory Loss

Kopell, Thompson, 1963
## Carpal Tunnel Syndrome
### X-Section View of Wrist

![X-Section View of Wrist](image)

Kopell, Thompson, 1963

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## Case 1 continued
### Sensory Conduction Studies

<table>
<thead>
<tr>
<th>Side</th>
<th>Nerve</th>
<th>Recording Site</th>
<th>Stimulation Site</th>
<th>Latency (ms)</th>
<th>Amplitude (mcv)</th>
<th>Cond. Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>Median</td>
<td>Digit 2</td>
<td>Wrist</td>
<td>4.2 (&lt;3.5)</td>
<td>12 (&gt;22)</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>Ulnar</td>
<td>Digit 5</td>
<td>Wrist</td>
<td>2.9 (&lt;3.2)</td>
<td>21 (&gt;10)</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>Radial</td>
<td>Dorsum thumb</td>
<td>Dorsum forearm</td>
<td>1.9 (&lt;2.0)</td>
<td>23 (&gt;21)</td>
<td></td>
</tr>
</tbody>
</table>
### Case 1 continued

**Motor Conduction Studies**

<table>
<thead>
<tr>
<th>Side</th>
<th>Nerve</th>
<th>Recording Site</th>
<th>Stim. Site</th>
<th>Latency (ms)</th>
<th>Ampl. (MV)</th>
<th>Velocity (m/s)</th>
<th>F-wave (ms)</th>
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</thead>
<tbody>
<tr>
<td>Right</td>
<td>Median</td>
<td>APB</td>
<td>Wrist</td>
<td>6.0 (&lt;4.0)</td>
<td>2.9 (&gt;4.0)</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>Median</td>
<td>APB</td>
<td>Ante. Fossa</td>
<td>2.7</td>
<td>47 (&gt;49)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>Ulnar</td>
<td>ADM</td>
<td>Wrist</td>
<td>3.1 (&lt;3.4)</td>
<td>7.3 (&gt;6.0)</td>
<td>30.3</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>Ulnar</td>
<td>ADM</td>
<td>B. Elbow</td>
<td>6.8</td>
<td>51 (&gt;49)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>Ulnar</td>
<td>ADM</td>
<td>A. Elbow</td>
<td>6.7</td>
<td>50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Ulnar Neuropathy**

**Claw Hand**

Haymaker, Woodhall, 1953
Ulnar Neuropathy
Sensory Loss, Nerve Innervation

Common Peroneal Injury
Right Foot Drop and Sensory Loss
Length Dependent Motor and Sensory Polyneuropathy

Plexopathy: Selected Etiologies

- Compression (CABG)
- Inflammatory (Parsonage-Turner Syndrome)
- Radiation Injury (Radiotherapy)
- Traumatic Injury (Traction, laceration, missile)
- Ischemia (Diabetic amyotrophy)
Guillain-Barre Syndrome
Conduction Block

Dermatomyositis
Eyelid and Facial Rash
Dermatomyositis
Hand Rash

Model of Neuromuscular Junction

Myasthenia Gravis (MG)

Calcium Channel (VGCC)

Receptor Terminal

Acetylcholine Vesicle

Acetylcholine Receptor

Acetylcholine Receptor Antibody (AChRAb) Assay
Myasthenia Gravis
Repetitive Nerve Stimulation

2 Hz

Myasthenia Gravis
Single Fiber EMG

Myasthenia Gravis
Lambert-Eaton Syndrome
Repetitive Nerve Stimulation

What to Expect From an EMG Report

- A clinically and physiologically relevant interpretation/diagnosis
- An outline of the localization, severity, and acuity of the process
- Notation of other diagnoses that are detected/excluded
- Explanation of any technical problems
Summary: Utility of EMG/NCS

- Highly sensitive indicator of early nerve injury
- Detects dynamic and functional injury missed by MRI
- Provides information regarding chronicity of nerve injury
- Provides prognostic data
- Highly localizing
- Clarifies clinical scenarios when one disorder mimics another
- Identifies combined multi-site injury, avoiding missed diagnoses
- Identifies more global neuromuscular injury with focal onset
- Provides longitudinal data for charting course, response to therapy
- ** All dependent on a reliable laboratory with full repertoire of techniques

EMG “Pearls”

- Electrodiagnostic studies are a supplement to, and not a replacement, for the history and physical examination
- Electrodiagnostic results are often time-dependent
- Electrodiagnostic studies are not “standardized” investigations and may be modified by the practitioner to answer the diagnostic question