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Fundamentals of NCS and NMJ Testing

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Disclosure

Potential Conflict of Interest

- I have no financial relationships to disclose that are relative to the contents of this presentation.
Goals of EDX Testing

- Localization
  - Muscle
  - NMJ
  - Nerve
  - Anterior Horn

- Severity
  - Fiber type
  - Pathology
  - Temporal course

Adapted from fig 1-2, Preston and Shapiro
What are the indications for electrodiagnostic consultation/testing?

• Suspected neuromuscular disease
  – Anterior Horn Cell Disorders
  – Nerve root pathology
  – Peripheral nerve/plexus pathology
  – Neuromuscular junction pathology
  – Muscle pathology
Value of NCSs/EMG

• When neuromuscular disease is present, electrodiagnostic testing can:
  • Clarify the type of pathology (i.e. AHC, root, neuropathy, NMJ, or myopathy)
  • Determine severity & extent of pathology
  • Confirm site of pathology
  • Estimate chronicity of pathology
Disorders Diagnosed/Evaluated by NCSs/EMG

- Generalized Neuropathies
  - Axonal (Many etiologies)
  - Demyelinating
    - Acquired
      » Acute: GBS
      » Chronic: CIDP
    - Hereditary
  - Mixed
    - Diabetic sensorimotor neuropathy
    - Uremic neuropathy
Polyneuropathies

Continued

• Polyneuropathies associated with many medical conditions
• Multiple investigations often needed
• NCSs/EMGs: best initial test to clarify underlying pathophysiology (i.e., axonal vs demyelination)
• Results may help focus rest of work-up
Disorders Diagnosed/Evaluated by NCSs/EMG

• Focal Neuropathies
  – Carpal Tunnel Syndrome (median neuropathy at the wrist)
  – Ulnar Neuropathy
  – Peroneal Nerve Palsy
  – Others: brachial plexus lesions, tarsal tunnel syndrome, etc.
Disorders Diagnosed/Evaluated by NCSs/EMG

- Radiculopathy
  - Cervical
  - Lumbar
- Motor Neuron Disease
  - Amyotrophic lateral sclerosis (ALS)
  - Spinal muscular atrophy (SMA)
Disorders Diagnosed/Evaluated by NCSs/EMG

• Muscle Disease
  – Inflammatory
    • Polymyositis, Dermatomyositis
  – Metabolic
  – Hereditary or Congenital
Disorders Diagnosed/Evaluated by NCSs/EMG

- Neuromuscular Junction Disease
  - Myasthenia Gravis
  - Lambert Eaton Myasthenic Syndrome
  - Botulism
  - Medications
Nerve Conduction Studies (NCSs) Technical Information

• Peripheral nerves are stimulated with an controlled electrical stimulus
• Responses recorded
  – Compound motor action potential (CMAP)
  – Sensory nerve action potential (SNAP)
  – F wave
  – H- reflex
Nerve Conduction Studies

• **Motor Latency**
  – Measure of conduction time from nerve segment through neuromuscular junction to muscle fibers

• **Sensory Latency**
  – Measure of conduction time of action potential across a nerve segment

• **Conduction Velocity**
  – Measure of the velocity of the fastest conducting axons

• **Motor Amplitude**
  – Measure of the number of activated axons and muscle fibers

• **Sensory Amplitude**
  – Measure of the number of activated axons
Nerve Conduction: Late Responses

• F Wave Latency
  – Retrograde “rebound” motor impulse
  – Travels full length of motor axon and back
  – Information about proximal segments
  – Limited sensitivity/specificity

• H Reflex
  – **Afferent Path:** Sensory axons (group Ia fibers)
  – **Efferent Path:** Motor Axons (alpha motor neurons)
  – Follows muscle stretch reflex arc
  – Side to side latency most valuable
Normal Median Motor Study

<table>
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<tr>
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<th>DL (msec)</th>
<th>CV (m/s)</th>
<th>Amp (mV)</th>
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<td>Wrist-APB</td>
<td>3.2</td>
<td></td>
<td>15.0</td>
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<tr>
<td>Elbow-Wrist</td>
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AANEM
Types of nerve conduction studies

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

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

Latency  CV      Amp
(msec)  (m/s)  (uV)
Wrist-D2  2.2   58   44.1

1 msec/div
F Waves

• Useful to assess proximal nerve conduction
• Helpful in the evaluation of:
  – Radiculopathy
  – Guillian-Barre Syndrome
  – Peripheral neuropathy
  – Other demyelinating neuropathies
F Waves: Normal Median
H Reflexes

• Useful to assess proximal nerve conduction
• Helpful in the evaluation of:
  – Polyneuropathy
  – S1 radiculopathy
  – Upper Motor Neuron lesions
F-waves and H-reflex

- Useful for identifying proximal segmental demyelination
- Can only be done when motor amplitude is > 1 mV
- Height-dependent
Neuromuscular Junction Testing

• Repetitive Nerve Stimulation
  – Stimulate nerve with train of supramaximal stimuli before and after exercise
  – Record from muscle
  – Attention to technical factors important
  – More sensitive recording from proximal muscles
Repetitive Nerve Stimulation: Normal

3Hz stimulation
Myasthenia Gravis

Repetitive Nerve Stimulation

2 Hz

[Diagram showing repetitive nerve stimulation at 2 Hz]
Repetitive Nerve Stimulation
Myasthenia Gravis
Single Fiber EMG

Model of Potential Pairs

Dahlback, Ekstedt, Stålberg, 1970

[Graph showing membrane potential changes in normal and Myasthenia Gravis conditions]
Limitations of NCSs/EMG

• Generally not helpful in the evaluation/diagnosis of:
  – Pain from joint disease
  – Fibromyalgia or myofascial pain syndromes
  – Central nervous system disorders
  – Disorders that do not arise from the neuromuscular system
What to Expect From an EMG Report

• The reason for the referral is addressed
• 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
What to Expect From an EMG Report

• Data obtained during the study: (NCS)
  – Amplitude
  – Distal latency
  – Distance
  – Conduction velocity
  – Normal (Reference) data
  – Side-to-side comparison (when appropriate)
  – Limb temperature during the study
What to Expect From an EMG Report

• Data obtained during the study: (EMG)
  – Presence & type of abnormal spontaneous activity
  – Motor unit recruitment
  – Motor unit morphology
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.
Pitfalls of nerve conduction studies

- Temperature effect and cold limb
- Sloppy measurement of distances
- Anatomic abnormalities of patient
- Technical factors: edema, large limbs, long limbs
- Too few nerve conduction studies, lack of comparisons
- Too many nerve conduction studies: Interpretation of non-existing abnormality