Electromyography and Nerve Conduction Studies. Basic Understanding and Applications for the Ordering Provider

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Disclosures

• None
PRESENTATION OVERVIEW

Definition

Indications and NCS and EMG

Basic nerve and muscle anatomy and physiology

Components of the NCS and EMG evaluation

Clinical application of NCS and EMG

Basic interpretation of the NCS and EMG report
DEFINITION

EMG
- Study of muscle function through analysis of electrical activity both with the muscle at rest and during activation

NCS
- Study of motor and sensory nerve function by way of percutaneous electrical stimulation

Invented in the 19th Century
- With more sophisticated equipment is has been consistently used over the last 40+ years to diagnose muscle and nerve related disorders
INDICATIONS FOR NCS AND EMG

Evaluation of the nature of the pathophysiology of neurologic/muscular deficit
Quantification of the severity of involvement
Determine acuity/chronicity of injury
Detection of the level of a neurologic deficit
Determine prognosis
AXON AND MYELIN
BASIC ANATOMY AND PHYSIOLOGY
MOTOR UNIT

Definition: Alpha Motor Unit and all the Skeletal Muscle Fibers it Innervates

Size Varies by Muscle

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Number of Motor Axons</th>
<th>Number of Muscle Fibers</th>
<th>Innervation Ratio</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biceps</td>
<td>774</td>
<td>580,000</td>
<td>750</td>
<td>Buchtal, 1961</td>
</tr>
<tr>
<td>Brachioradialis</td>
<td>315</td>
<td>129,000</td>
<td>410</td>
<td>Feinstein et al</td>
</tr>
<tr>
<td>First dorsal interosseous</td>
<td>119</td>
<td>40,500</td>
<td>340</td>
<td>Feinstein et al</td>
</tr>
<tr>
<td>Medial gastrocnemius</td>
<td>579</td>
<td>1,120,000</td>
<td>1,934</td>
<td>Feinstein et al</td>
</tr>
<tr>
<td>Tibialis anterior</td>
<td>445</td>
<td>250,200</td>
<td>562</td>
<td>Feinstein et al</td>
</tr>
</tbody>
</table>
BASIC ANATOMY AND PHYSIOLOGY

Muscle → Peripheral Nerve → Plexus → Root(s) → Cord → Brain
COMPONENTS OF THE NCS AND EMG STUDY

- Sensory nerve conduction studies
- Motor nerve conduction studies
- F-waves
- H-reflexes
- Needle electromyography (EMG)
NERVE CONDUCTION STUDIES
SENSORY NERVE CONDUCTION STUDIES
THE SENSORY NERVE ACTION POTENTIAL (SNAP)

• Onset and Peak Latency
• Conduction Velocity
• Amplitude
SENSORY NERVE CONDUCTION STUDIES
THE SENSORY NERVE ACTION POTENTIAL (SNAP)

Typical nerves examined:
- Sural, ulnar, median, occasionally radial or superficial peroneal
MOTOR NERVE CONDUCTION STUDIES
THE MOTOR NERVE ACTION POTENTIAL (CMAP)

- Distal Latency
- Amplitude
- Proximal conduction velocity
MOTOR NERVE CONDUCTION STUDIES
THE MOTOR NERVE ACTION POTENTIAL (CMAP)

Typical nerves examined:
- ulnar, median, peroneal, tibial
F-WAVES AND H-REFLEX

Useful for identifying proximal segmental demyelination

H-reflex

- Essentially a recording of the calcaneal reflex
NEEDLE ELECTROMYOGRAPHY (EMG)
NEEDLE ELECTROMYOGRAPHY (EMG) TECHNIQUE

Small needle inserted into muscle (27 gauge)

Different muscles are sampled based on clinical question and findings during the exam
  - Root screen
    - Lower limb: medial gastroc, anterior tib, vastus medialis, TFL, Glut Max, Lumbar Paraspinals
    - Upper limb: FDI, APB, Pronator Teres, Biceps, Triceps, Deltoid, Cervical Paraspinals

Discomfort is usually minimal
NEEDLE ELECTROMYOGRAPHY (EMG)

COMPONENTS

Insertional Activity (muscle is quiet)
- Increased
- Sharp waves
- Fibrillation Potentials
NEEDLE ELECTROMYOGRAPHY (EMG) COMPONENTS

Have patient activate the muscle

Motor Unit Evaluation

- Morphology
  - Complexity
  - Amplitude
  - Duration
- Recruitment
  - Normal
  - Reduced
  - Rapid

Figure 44-8
Single voluntary motor unit potentials. A. Normal. B. Prolonged polyphasic potential seen with reinnervation. C. “Giant unit”—normally shaped but of much greater amplitude than normal. D. Brief, low-amplitude “myopathic” units. Calibrations: 5 ms (horizontal) and 1 mV in A and B; 5 mV in C; 100 μV in D (vertical).

Adams and Victor, 1981
WHEN TO ORDER AND EMG/NCS

Radiculopathy
Mononeuropathy
Plexopathy (Brachial or Lumbosacral)
Peripheral Neuropathy
Myopathy
Neuromuscular junction disorder
Anterior Horn Cell Disease
Cranial neuropathies
WHEN **NOT** TO ORDER AN EMG/NCS

Suspected Central Nervous System Disorder
- Stroke
- TIA
- Encephalopathy
- Spinal cord injury
- Multiple Sclerosis

Diffuse Body Pain
- Fibromyalgia, etc.

Joint Pain

Unexplained weakness
GOALS OF EMG/NCS

Localization of injury

- Nerve conduction studies are more precise than needle examination
GOALS OF EMG/NCS

Differentiating acute vs. chronic injuries

- Needle examination more helpful for this
  - Insertional activity
    - Increased insertional activity
    - Sharp Waves
    - Fibrillation Potentials
  - Activation
    - Reduced recruitment
    - Polyphasic motor unit potentials
    - Giant Motor Unit Potentials
GOALS OF EMG/NCS

Prognosticating Outcome

Monitoring progression of disease
LIMITATIONS OF EMG/NCS

- Cannot detect central nervous system disease
- Does not test the small fibers
- While it is highly specific, especially in cases of radiculopathy, it is not 100% sensitive
  - Unable to determine exact sensitivity because there is no gold standard to compare it against
- May not be able to detect exact level of pathology
  - Reasons to follow
- Examiner expertise
LIMITATIONS OF EMG/NCS
CONTINUED

Explanation for reduced sensitivity in radiculopathy

- Pure sensory radiculopathy
- Subtotal nerve root involvement
DIFFICULTY DETECTING THE LEVEL OF INVOLVEMENT

Imprecision of the myotomal maps

Difficulty with precision of upper lumbar radiculopathies

Difficulty with precision of lower lumbar radiculopathies

- Multiple roots involved depending on location of disc pathology
EXAMINER EXPERTISE

6 cases of lumbar radiculopathy
- 46.9% agreement on diagnosis
- Compared residents and faculty
  - Faculty twice as likely to agree on the diagnosis
NOTE

RADICULOPATHY
• NEUROGENIC CHANGE OCCURS FIRST IN THE PROXIMAL MUSCLES
• PARASPINALS ARE NOT RELIABLE IN THE SETTING OF SURGICAL INTERVENTION (POSTERIOR APPROACHES)
EMG/NCS is a diagnostic tool that can aide in the diagnosis of nerve and muscle disorders

- Should be used in addition to, and not in lieu of a solid physical exam, imaging (if indicated), and other necessary workup.

Before ordering an EMG/NCS it is best to have a specific question that needs to be answered based on the differential diagnosis

- i.e. Peroneal neuropathy vs. L5 radiculopathy, peripheral neuropathy, CTS vs. C6 radiculopathy, etc....

EMG/NCS performed within three weeks of the injury may be normal, even if there is true pathology (Wallerian degeneration).
WHAT SHOULD YOU EXPECT FROM THE PROVIDER PERFORMING THE STUDY

Include Raw Data in Faxed Report

- Are temperatures documented?
- Were F-waves performed?
- Was it a complete Study?

Actual Report

- Findings
- Interpretation
THANK YOU

QUESTIONS