Electrodiagnostic Assessment: An Introduction to NCS and EMG

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Objectives

• Understand technique and role of Nerve Conduction Studies

• Understand Basics of Electromyography

• Clinical Application
Nerve Conduction Studies and Electromyography (NCS/EMG)

• An extension of the clinical neurological evaluation
• Useful whenever there is clinical suspicion of generalized or focal nerve pathology or muscle pathology
NCS/EMG provide information about:

- Site of pathology
- Type of pathology
- Severity of pathology
- Age of pathology
- Rule out Concomitant disease
Indications for NCS/EMG

- Numbness or Tingling
- Pain or Cramping
- Weakness
- Fatigue
Indications for NCS/EMG

• Numbness in Fingers/Arms
• Trouble Holding onto Things
• Pain in Hands/Arms/Neck
• Cramping in Hands
Indications for NCS/EMG

- Numbness in Toes/Feet
- Trouble Moving Ankles
  - Dragging Toes/Feet
  - Can’t Stand on Toes
- Pain in Calves/Legs/Buttocks/Low Back
- Cramping in Legs
Indications for NCS/EMG

- Trouble with Walking
- Trouble Lifting Arms Over-head
- Generalized Fatigue/Weakness
- Trouble Swallowing
- Trouble Keeping Eyes Open
- Trouble moving or focusing eyes
Indications for NCS/EMG

• a. Generalized Neuropathy
  • 1. Axonal
  • 2. Demyelinating
    – a. Acquired
      » 1. Acute; GBS
      » 2. Chronic; CIDP
    – b. Hereditary
Indications for NCS/EMG

• b. Focal Neuropathy
  – 1. Carpal Tunnel Syndrome
  – 2. Ulnar Neuropathy
  – 3. Peroneal Nerve Palsy
  – 4. Mononeuritis multiplex
  – 5. Brachial Plexus Lesions
  – 6. Other: meralgia paresthetica, posterior interosseous nerve syndrome, tarsal tunnel syndrome, etc.
Indications for NCS/EMG

• c. Radiculopathy
  – 1. Cervical
  – 2. Lumbar

• d. Motor Neuron Disease
  – 1. Amyotrophic lateral sclerosis (ALS)
  – 2. Spinal muscular atrophy (SMA)
Indications for NCS/EMG

• e. Muscle Disease
  – 1. Inflammatory
    • a. Polymyositis
    • b. Dermatomyositis
    • c. Inclusion Body Myositis
Indications for NCS/EMG
Muscle Disease

– 2. Metabolic

– 3. Hereditary or Congenital
  • a. Muscular Dystrophy- Duchenne or Becker
  • b. Muscular Dystrophy- Limb-Girdle, FSH, etc.
  • c. Congenital Myopathy- nemaline rod, central core, etc.
Indications for NCS/EMG

- f. Neuromuscular Junction Disease
  - 1. Myasthenia Gravis
  - 2. Lambert Eaton Myasthenic Syndrome
  - 3. Botulism
  - 4. Medications
What to Expect from an EMG Report

- Legibility
- Indication that the electrodiagnostic consultant is addressing the question being asked by the referring physician
- Comments regarding any pertinent information that should be given to the referring physician:
  - Need for re-evaluation in the future
  - Urgent need for medical intervention

EMG1
What to Expect from an EMG Report

• Data obtained during the study: (NCS)
  – Amplitude
  – Distal latency
  – Distance
  – Conduction velocity
  – Normal 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)
  – Motor unit recruitment
  – Motor unit morphology
  – Fibrillation potentials
  – Positive sharp waves
  – Fasiculations
What to Expect from an EMG Report

• A clinically and physiologically relevant interpretation with internal consistency
• An outline of the localization, severity, and acuity of the process
• Notation of other diagnoses that are excluded
• Explanation of any technical problems
Nerve Conduction Studies (NCS)

- Motor NCS
- Sensory NCS
- F waves
- H reflexes
Motor NCS

• 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
Normal Median Motor Study

<table>
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<tr>
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<th>DL (msec)</th>
<th>CV (m/s)</th>
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Sensory NCS

• Antidromic or orthodromic
• 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

1 msec/div

Latency  CV      Amp
  (msec) (m/s) (uV)
Wrist-D2  2.3  59  44.1
F waves

• Useful to assess very proximal conduction
  – Helpful in the evaluation of:
    Radiculopathy
    Guillian-Barre’ Syndrome
    Peripheral neuropathy
    Other demyelinating neuropathies
F waves

- Latency
  - determined by the conduction velocity of the antidromic stimulus to the motor neuron and returning orthodromic impulse to the recording muscle.
- Persistence
  - may not appear after each stimulus in a normal study; decreased persistence or absence may provide additional information
F waves - Normal Median Nerve
Median Nerve - F waves
in a patient with cervical radiculopathy

Minimum F Latency:
37.6 msec
normal minimum 32 msec
H Reflexes

• Useful to assess very proximal conduction
  – Helpful in the evaluation of:
    • Polyneuropathy
    • S1 radiculopathy
    • Upper Motor Neuron lesions
    • Brachial plexopathy
H Reflexes

- Latency
  - determined by the conduction velocity of an afferent arc via group Ia fibers from muscles spindles and an efferent arc from alpha motor fibers
  - the electrophysiologic equivalent of muscle stretch reflex (DTRs)

- Amplitude
  - side-to-side comparison of amplitude is expressed as a ratio
H Reflexes

Normal latency = 32 msec
(posterior tibial nerve)

Note decreasing amplitude of M response with increasing amplitude of H reflex
Neuromuscular Junction Testing

• 1. Repetitive Nerve Stimulation
  – Stimulate nerve with train of supramaximal stimuli before and after exercise
  – Record from muscle
  – Rate of stimulation:
    • 2-3 Hz for Myasthenia Gravis
    • 30-50 Hz for Lambert Eaton, Botulism
  – Sensitivity varies with site tested
Repetitive Nerve Stimulation: Normal

3Hz stimulation
Repetitive Nerve Stimulation: Myasthenia Gravis

3 Hz stimulation rate
EMG 1 - Basics

• A needle electrode is placed into the muscle
  – needle is sterile and disposable
• Muscles examined depends on the clinical problem
• Detailed knowledge of anatomy is necessary to identify specific locations
EMG 2 - Basics

• Muscle is studied at rest and at different levels of sustained, voluntary contraction
• At rest, the muscle should be silent- any activity may signal a nerve or muscle abnormality
• During activity, the electrical shape and pattern of the response can distinguish between nerve and muscle disease
EMG 3 - Resting EMG

• Fibrillation potential/Positive waves: A spontaneous muscle fiber action potential
  – indicates loss of muscle-nerve connection
  – provides information about the chronicity of the problem

• Fasciculation: A spontaneous motor unit potential is an indication of irritability in the motor nerve cell
Fibrillation Potentials and Positive Sharp Waves

Fibrillation Potentials

Positive Sharp Waves
Fasiculations
EMG 4 - The Motor Unit

• A single motor neuron and all the muscle fibers to which it is connected
• Number of muscle fibers varies with the muscle
• A single muscle fiber is connected to only one nerve fiber
EMG 5 - Motor Unit Potentials

- Morphology
  - Amplitude
  - Duration
  - Phases
Morphology of Motor Unit Potentials

From: Preston and Shapiro, 1998

Normal  Neuropathic  Myopathic
Enlarged, Polyphasic Motor Unit

10 msec/div
EMG 6 - Recruitment

- Recruitment is the pattern of motor unit firing when a muscle contracts
  - Reduced Recruitment - Neuropathy
  - Increased (early) Recruitment - Myopathy
  - Dependent on patient cooperation and effort
Normal Recruitment Pattern
Reduced Interference Pattern
Increased (Early) Recruitment
Specialized Testing

• Interference pattern analysis
• Quantitative motor unit analysis
• Single Fiber analysis
• Segmentation studies
• Cranial nerve testing
• Brainstem and somatosensory evoked potentials
• Pelvic Floor and Respiratory muscles
Case Presentation
Hand Numbness 4

History
A 43 year old pianist began noticing tingling and fatigue in the right 4th and 5th digits worsened with playing. The tingling increased slowly over about 6 months. On exam there was minimal weakness of ulnar hand intrinsic muscles with mild subjective loss of light touch over both the dorsal and ventral surfaces of digits 4 and 5.
Case Presentation
Hand Numbness 4

Signs and Symptoms

• Hypesthesias, paresthesias in ulnar distribution
• Pain in ulnar distribution
• Motor symptoms: difficulty writing, weak pinch, , clawing of hand, abducted D5 (Wartenberg’s sign)
Case Presentation
Hand Numbness 4

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Ulnar Neuropathy at the Elbow

Etiology

- Compression is often external (as opposed to CTS)
- Internal compression also occurs, usually distal to external sites
- Repeated stretch
- Ganglia, tumors, fibrous bands, etc.
Ulnar Neuropathy at the Elbow
Anatomy

• From the mid arm, the nerve travels distally superficial to medial head of the triceps.
• The epicondylar groove is formed by medial epicondyle and olecranon.
Ulnar Neuropathy at the Elbow
Anatomy

FIGURE 1. Elbow anatomy illustrating the relationship of the ulnar collateral ligament and flexor carpi ulnaris to the nerve.
Ulnar Neuropathy at the Elbow Anatomy

- The humeroulnar aponeurotic arcade (the roof of the cubital tunnel) joins the 2 heads of the flexor carpi ulnaris (FCU) and overlies the nerve as it exits the groove about 1 cm distal to the epicondyle.

- Branches to the forearm flexors (FCU and flexor digitorum profundus IV & V) come off distal to the epicondyle.
Summary

• Review basics of Nerve Conduction Studies

• Introduction to Electromyography

• Clinical Application

• Extension of History and Physical Examination
Case Presentation
Hand Numbness 5

History and Examination
A 39 year old mechanic noted sudden onset of numbness and paresthesias in Digit 4&5 while driving. Pain was present in the volar wrist, and his hand became weak. Exam 6 weeks later revealed reduced sensation over the medial palm and digits 4 and 5, with weakness of all ulnar hand intrinsic muscles.
### Case Presentation

**Hand Numbness 5**

- **Motor Studies to FDI and ADM**

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UNW 2
Ulnar Neuropathy at the Wrist

Most Common Patterns:
1. Isolated Deep Motor Branch
2. Deep Motor + Hypothenar Branch
3. All Branches
4. Pure Sensory
Ulnar Neuropathy at the Wrist
Anatomy

The major branches of the ulnar nerve in the forearm and hand.

DC = dorsal cutaneous branch
PC = palmar cutaneous branch
S = superficial branch
HM = hypothenar motor branch
DM = deep motor branch
Case Presentation
Weakness

History
A 52 year old man was evaluated for diffuse weakness: “rule out myopathy”. He notes weakness of his shoulder and hip girdle muscles, dry mouth, and sexual dysfunction that has gradually progressed over 4 months. He has been on antihypertensive medication for 10 years and has smoked 2 packs of cigarettes daily for 30 years.

LEMS 1
Case Presentation

Weakness

Examination

– Normal eye movements, speech, swallowing
– Marked neck weakness (grade 3 of 5 MRC)
– Moderate (grade 4) weakness proximal upper and lower extremities
– Reflexes absent
– Sensation normal
Case Presentation

Weakness

Electrodiagnosis

- Nerve conduction testing was abnormal
  - Borderline low amplitude motor evoked responses
  - Normal sensory responses
  - Normal distal latencies, conduction velocities
  - Compound motor potential amplitudes doubled in size after exercise (>100 % facilitation)
Case Presentation

Weakness

• Needle examination was normal
  – no evidence of denervation
  – no evidence of reinnervation
  – no evidence of myopathy

• Interpretation: evidence of a pre-synaptic neuromuscular junction defect, such as the Lambert Eaton myasthenic syndrome
Lambert Eaton Myasthenic Syndrome

- Electrodiagnostic consultant excluded questioned diagnosis of myopathy
- Accurately suggested alternative diagnosis
- CT scan demonstrated a mass which was pathologically confirmed as small cell lung carcinoma
- Timely localization of abnormality lead to rapid determination of malignancy

LEMS 5