WHAT EMG CAN TELL YOU AND WHAT IT CAN'T

Anthony Chiodo, MD, MBA
Michigan Medicine
Department of Physical Medicine
and Rehabilitation

Purpose of Nerve Conduction Studies

- Make diagnosis of nerve injury
- Identify pattern of nerve conduction studies that are abnormal to make diagnosis; i.e. sural, peroneal motor, and tibial motor amplitude loss in lumbosacral plexopathy
- Identify pattern of abnormalities in nerve conduction studies to make diagnosis; i.e. sensory amplitude loss in dorsal ganglionopathy
- Rule out diagnoses

Keys to Diagnosis

- Pattern of abnormality
- Sites of abnormality
- Areas of normal function

Nerve Conduction Study Measurements

- Amplitude: a measure of the number of axons
- Distal latency: a measure of the speed of the fastest fibers distally
- Conduction velocity: a measure of the speed of the fastest fibers between two points

Nerve Conduction Study Slowing

- Slowing does not always equal demyelination: the exception is in large fiber axonal loss
- Demyelination noted by slowing across a segment (>20% reduction), proximal amplitude decrement (motor responses > 20% reduction), and temporal dispersion (distal response < 70% proximal response duration)
- Key again is pattern of abnormality: focal vs. multi-focal vs. diffuse, proximal vs. distal, motor vs. sensory

Other Ways to Utilize Nerve Conduction Studies

- Repetitive nerve stimulation
- F-response latency: alpha-motor neuron response
- H-reflex: tibial mono-synaptic reflex arc

Types of Studies

- Sensory: stimulate nerve, recording electrode over nerve, reference electrode 3-4 cm distal
- Motor: stimulate nerve, recording electrode over motor endplate, reference electrode over electrically neutral site
- Mixed: midpalmar responses: stimulate nerve, recording electrode over nerve, reference electrode 3-4 cm distal

Influences on Nerve Conduction Studies

- Height/Length
- Temperature
- Display Gain
- Stimulus Intensity
- Measurement Errors
- Age
- Volume conduction
- Distance from endplate in Motor NCS

Variation in Nerves and Segments

- Longer nerves conduct more slowly
- Conduction velocity faster in proximal segments: larger fibers, warmer temperatures, increased internodal distances

Upper Extremity Studies

- Median: sensory, motor, and mixed
- Ulnar: sensory(2), motor, and mixed
- Radial: sensory and motor
- Lateral antebrachial cutaneous: sensory
- Musculocutaneous: motor
- Medial antebrachial cutaneous: sensory
- Accessory: motor
- Others: axillary, suprascapular, long thoracic

Lower Extremity Studies

- Sural: sensory
- Peroneal: sensory and motor(2)
- Tibial: motor
- Saphenous: sensory
- Lateral femoral cutaneous: sensory
- Femoral: motor

Other Nerve Conduction Studies

- Phrenic: motor

Needle Examination

- Discover the pattern of motor axonal loss
- Need to evaluate a pattern of muscles that will make the diagnosis and exclude likely alternative diagnoses
- So, need to have experience in needle sampling a variety of muscles to make the diagnosis

What to look for on Needle EMG

- What does the muscle feel like when you enter the muscle?
- What is the spontaneous activity of the muscle?
- Is spontaneous activity the same throughout the muscle?

Spontaneous Activity

- Normal: muscle should be at rest
- Evidence of muscle fiber denervation: fibrillation and positive waves
- Evidence of motor unit excitability: fasciculations and myokymic discharges
- Evidence of muscle fiber irritability: complex repetitive discharges, myotonic discharges

Insertional Activity

- Look for the same responses as on spontaneous activity
- Motor fiber and unit excitability in response to an injury current

Motor Unit Evaluation

- Recruitment
  - *Number of units firing per unit of strength generated*
  - *Rate of firing (next order fires at less than 10 Hz)*
  - *Full interference pattern*
- Appearance

Motor Unit Appearance

- Percent polyphasia (less than 20%)
  - *Motor unit variability*
- Amplitude (large or small dependent on muscle)
  - *Motor unit variability*
- Duration

Appearance and Time Frame in Axonal Disorders

- Wallerian degeneration in 1-3 weeks depending on length of nerve
- Initially NCS will be normal but recruitment will be impaired (not necessarily demyelinating, just not completed Wallerian degeneration)
- Begin to see motor unit polyphasia and duration changes in 4-6 weeks
- Begin to see motor unit amplitude changes in 3 months

INTERRATER RELIABILITY OF THE NEEDLE EXAMINATION IN LUMBOSACRAL RADICULOPATHY

Kendall and Werner, Muscle and Nerve, 2006.

- Unblinded electromyographer using clinical and EMG data
- Blinded electromyographer using needle examination data
- 6 cases reviewed by 66 examiners
- 21 faculty and 10 residents
- Diagnostic agreement was 46.9%
- 60.5% faculty level
- 28.5% resident level

Results

- Faculty-level examiners: twice as likely to agree on the final diagnosis as resident-level examiners
- Odds ratio, 1.9; *P* 0.019
- Correct diagnosis were more confident in their diagnostic decision than those who chose the incorrect diagnosis
- Mean 7.2/10 certainty with correct diagnosis vs. 4.8 certainty with incorrect diagnosis, *P* 0.0004

Conclusion

- Extensive training is necessary for electromyographers
- Abnormal spontaneous activity and MUAP analysis

The clinician effect on “objective” technical components of the electrodiagnostic consultation

Yamakawa, Haig, et al, 2007.

- 150 subjects (55-79): controls, back pain or lumbar stenosis and 88 follow-up studies
- Blinded electromyographer (5 muscles and paraspinal mapping)
- Unmasked physiatrist performed a very limited electromyogram of a single paraspinal level randomly chosen ahead of time by an assistant

Results

- If the unmasked thought the patient had stenosis, they scored higher ($p < .001$)
- Bias was related to degree of training (most trained/experienced had significantly less subjectivity when unmasked)

Issues in Training

- Experience in surface anatomy and needle placement
- Experience in working with patients in an anxiety provoking environment
- Experience with nerve conduction studies
- Experience with machine
- Experience in waveform analysis
- Experience in clinical application
- Experience with maintaining objectivity

Putting it all Together: Summary

- Pattern of nerve conduction studies: abnormal and normal
- Pattern of needle examination studies: abnormal and normal

Putting it all Together: Interpretation
What EMG Can Tell You

- Normal or abnormal study?
- Electrodiagnostic evaluation of what disorder?
- Severity
- Focal or diffuse
- Demyelination (focal or diffuse) or axonal loss
- What time frame for the axonal loss?
- Ruled out what other pertinent conditions?
- Clinical correlation statement

Condition	Sensitivity	Specificity
Carpal Tunnel Syndrome	80	90
AIDP	72	64
CIDP	75	75
Mild lumbar stenosis	48	100
Severe lumbar stenosis	90	100
Radiculopathy	55-80	90
Myasthenia Gravis	76	100

What EMG Can't Tell You

- Normal study does not mean that the problem is not there.
  - *Radiculopathy*
  - *Compression neuropathies*
  - *Early demyelinating neuropathies*
  - *Non-necrotizing myopathies (steroids, statins)*
  - *Was enough of a study done (NMJ disorders, ALS)*
- Normal study does not mean that the patient's problem is not physiological
  - *Although commonly used in medico-legal situations*
- Abnormal study does not always help you with etiology.

Questions?