Normal and Abnormal EMG
163-P
Normal and Abnormal EMG

• This class is part of Stage 1

Normal and Abnormal EMG

• The objectives of this lecture are:
  – Demonstrate a patient-centered and ethical approach in planning and conducting the EMG/NCS exam
  – Discuss techniques to optimize patient comfort and reduce anxiety during the EMG/NCS exam
  – Discuss Henneman's Size Principle in regards to recruitment of motor units.
  – Identify reasons for excess noise during EMG exam
Normal and Abnormal EMG

• The objectives of this lecture are (cont):
  – Explain and demonstrate the quadrant technique for EMG testing
  – Perform motor unit analysis during EMG testing - correctly identify motor unit amplitude, duration, morphology, and frequency.
  – State normal and abnormal values for motor unit amplitude, duration, and firing frequency
  – Discuss and demonstrate the four testing conditions during an EMG exam
  – Identify end-plate noise/end-plate spikes during an EMG exam

• The objectives of this lecture are (cont):
  – Recognize and explain the significance of the following:
    • Positive sharp waves and fibrillation potentials
    • Complex repetitive discharges
    • Smaller than normal and larger than normal motor unit potentials
    • Abnormal recruitment
    • Polyphasic potentials
  – Be able to differentiate acute, subacute, vs. chronic conditions based on EMG findings.
EMG Technique, Normal, and Abnormal Findings

EMG Parameters

Observe and Attempt to Quantify These:

• Insertional Activity
• Activity at Rest
• MUAP Morphology, Amplitude & Duration with slight contraction
• Recruitment Pattern with slight to maximal contraction
EMG Parameter: Insertional Activity (IA)

- Electrical Activity Due to Insertion or Movement of a Needle in Muscle
  - Normal: 50 msec after needle stops
  - Normal, Inc, Dec or Prolonged
- Inc IA Associated with Spontaneous Potentials.
- Dec IA Indicates Reduced # of Healthy Muscle Fibers
  - Due to Chronic Denervation (Fibrosis) or Muscle Necrosis = Poor Prognosis

EMG Parameter: Spontaneous Potentials

- Fibrillation Potentials (Fibs)
- Positive Sharp Waves (PSWs)
- Complex Repetitive Discharge (CRD)
- Myotonic Discharges
- Fasciculation Potentials (Fascics)
- Myokymic Discharges

**KEY POINT: These occur at rest**
Spontaneous Potentials

• Remember that NORMAL resting muscle should be electrically silent at rest
  – Exceptions:
    • End-plate spikes (initial upward- negative- deflection)
    • End-plate noise (sea-shell sound)

EMG Parameter:
Fibrillation Potentials

• Fibs and PSWs Generally Thought to be Physiologically the Same
• Generator: Single muscle fiber
• Due to Either Muscle Fiber Denervation
• Severity Graded +1 to +4 - Grossly Reflects Amount of Denervation
  – Amplitude: Acute = 100-1000 microvolts; Chronic < 20-50 microvolts
  – Shape: Biphasic (positive then negative). **Important to differentiate from end-plate spikes
  – Rate: 1-50 Hz
EMG Parameter: Positive Sharp Waves

- Generator: Single muscle fiber
- Due to Either Muscle Fiber Denervation
- Severity Graded +1 to +4 - Grossly Reflects Amount of Denervation
  - Amplitude: Acute = 100-1000 microvolts; Chronic < 20-50 microvolts
  - Shape: Positive deflection followed by rounded negative deflection
  - Rate: 1-50 Hz

Fibrillation Potentials and Positive Sharp Waves in the Tibialis Anterior Muscle
Grading of PSWs, Fibs

0  No PSWs or Fibs
1+ Persistent/unsustained single trains in at least two muscle regions
2+ Moderate numbers in 3 or more muscle areas
3+ Many in all muscle regions
4+ Baseline obliterated with potentials in all areas of muscle examined

EMG Worksheet: Report 3

<table>
<thead>
<tr>
<th>Electromyography</th>
<th>Motor Unit</th>
<th>Insertional Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle</td>
<td>Side Nerve</td>
<td>Nerve Root</td>
</tr>
<tr>
<td>Deltoid</td>
<td>Rt</td>
<td>Axillary C5,6</td>
</tr>
<tr>
<td>1st Dorsal Interosseous</td>
<td>Rt</td>
<td>Ulnar C8,T1</td>
</tr>
<tr>
<td>Deltoid</td>
<td>L</td>
<td>Axillary C5,6</td>
</tr>
<tr>
<td>1st Dorsal Interosseous</td>
<td>L</td>
<td>Ulnar C8,T1</td>
</tr>
<tr>
<td>Vastus Medialis</td>
<td>Rt</td>
<td>Femoral L2,3,4</td>
</tr>
<tr>
<td>1st Pedal Interosseous</td>
<td>Rt</td>
<td>Tibial S1,S2</td>
</tr>
</tbody>
</table>
EMG Parameter: Complex Repetitive Discharge

- Occur in a Wide Variety of Chronic, Progressive Neurogenic and Myopathic Disorders
  - To Include some Chronic Denervating Conditions
- Generator: Ephaptic muscle fiber conduction (we think)
  - Amplitude: 100-1000 microV
  - Shape: Polyphasic or serrated
  - Abrupt stop/start (**differentiate from myotonic)
  - Rate: 5-100 Hz

Complex Repetitive Discharge in the Infraspinatus Muscle
EMG Parameter:
Myotonic Discharges

- Occur in Disorders of Myotonia (*Delayed Muscle Relaxation*)
  - Can occur in other myopathic or chronic neuropathic disorders
  - Generator: Muscle fibers
  - Rhythm: Waxes and wanes in amplitude and firing rate (**differs from CRDs**)
  - Amp: 10-1000 microV
  - Rate: 20-100 Hz
- Most Common Due to the Myopathic Form:
  - Myotonic Dystrophy - Most Common of All Myotonias

EMG Parameter:
Fasciculation Potentials

- Most Commonly Seen in Chronic Neurogenic Disorders Esp. Lower Motor Neuron Diseases
  - ALS, Jakob-Cruetzfeldt, Chronic Root Compression, Peripheral Neuropathy, or NORMAL
- Generator: Motor Unit
- Spontaneous intermittent firing (1 Hz to several per minute)
  - **Characterized by the “company they keep”**
**EMG Parameter:**
**Myokymic Discharges**

- Vermicular (worm-like) discharges  
  - Rare. May occur in chronic nerve Dz
- Bursts of 2-10 normal appearing motor units firing at 20-150 Hz
- Generator: Ephaptic axonal discharges of groups of motor units (we think)
- Rate: .1-10 Hz semi-rhythmic for each burst
- Amp: >300 microV
Motor Unit Analysis

• **Technique:**
  - Gentle contraction
  - Identify and “hone in on” first few Motor Unit Potentials (MUPs) by slightly moving needle
    - Good location if rise time <1 msec for monopolar or <.5 msec for concentric needle
    - Listen for “crisp” sound

Motor Unit Analysis

• Normal parameters vary widely based on particular muscle and needle type:
  • Amp (peak to peak): 300-8000 microV
  • Duration: 7-12 msec on avg.
  • Phases (baseline crossings): <4*
  • Recruitment: Small to large MUPs. First MUP initiates at 5 Hz. Subsequent MUPs occur at about every 5 Hz increase in firing rate.
  • **Note: <20% polyphasic MUPs is normal**
Motor Unit Analysis

• **Machine Settings:**
• Start at gain 200uV/sweep 5-10 - evaluate first few units, firing rate, small to large recruitment, morphology - submax contraction
  – (may need to increase the gain to 500uV if waves are off the screen)

![Normal Motor Unit Potential](image-url)
Motor Unit Reinnervation

• Two Means of Reinnervation:
  – Collateral Sprouting
  – Direct Regeneration of the Original Nerve Terminal

Collateral Sprouting

Terminal Branches of an Intact Axon Sprout to Reinnervate Motor Fibers of Another Degenerated Axon/Motor Unit
Direct Reinnervation

Axons of a Degenerated Motor Unit Regenerate to Directly Reinnervate Its Same Motor Fibers

EMG Parameter: Phases, Amplitude & Duration

- Polyphasicity, Amplitude and Duration Relate to the Type and Amount of Reinnervation
  - Large Amp, Long Duration, Polyphasic MUP = Reinnervation Via Collateral Sprouting
  - Small Amp, Short Duration, Polyphasic MUP = Direct Regeneration, Early Collateral Sprouting or Myopathic Disorders (Fiber Splitting)
Collateral Sprouting

Terminal Sprouts Conducting Slower than Normal

Polyphasic Motor Unit Potential Larger Amp and Duration

Polyphasic MUAPs
Direct Regeneration

Terminal Sprouts Conducting Slower than Normal

Polyphasic Motor Unit Potential Smaller Amp Short Duration

Giant MUP = Matured Collateral Sprouting

Mature Terminal Sprouts Conducting at Normal Speed

Giant Motor Unit Potential > 12,000 microvolts (Non-Polyphasic, Long Duration)
Mature Direct Regeneration Leads to Normal MUP

- Mature Regenerated Terminal Nerve Endings
- Normal Motor Unit Potential
- Normal Amp and Duration

Recruitment

- Next at gain 500uV/sweep 30-50 msec
- Have patient perform a mild to mod to max contraction (gradually increasing)
  - Look for gradually increasing amplitude of motor units
  - Recruitment of new motor units
  - Frequency of firing
How does the nervous system increase force of contraction?
EMG Parameter: Recruitment Pattern

• The Gradual Increase in the Number of MUPs Recruited With In Relation to the Rate of Firing and the Increased Force of Contraction (i.e. Size Principle)
  – 1st: Small MUs Recruited and Fire at a Max Rate of ~ 5-10Hz
  – 2nd: Other Larger MUs Are Then Recruited at Same Rate

EMG Parameter: Recruitment Pattern Types

• Neurogenic = Reduced Recruitment
  – Rate of Individual MUs Firing will be out of Proportion to the Total Number That Are Firing
  – Fast firing rate (>20 Hz): look closely at first few MUPs
  – Fewer Units available and the Remaining Ones Increase Their Rate to Increase Force
  – Seen in Disorders of Axonal Destruction/Block
  – May Be Only Sign in Neurapraxia
EMG Parameter: Recruitment Pattern Types

• Myopathic = *Rapid Recruitment*
  – More MUs activated than suspected for the force of contraction.
  – Seen when the motor fiber can not generate normal force (i.e. in Myopathic Disorders)
  – Rate firing is normal but Amp is Small
  – Avg. Motor unit duration (non-polyphasics) is <6 msec

![EMG波形示意图](image)

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EMG Parameter: Interference

• Means By Which to Evaluate the Relationship Between the Number of Firing MUs and the Muscle Force Exerted With Maximal Effort
• **Full Pattern** - Baseline Is Obscured By MUPs With Max Effort
• **Discrete Pattern** - Individual MUPs Are Recognizable With Max Effort

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EMG Parameter: Interference

• **Neurogenic Disorder**
  – Reduced or Discrete Interference Pattern
• **Myopathic Disorder**
  – Full Interference Pattern
Full Interference

Discrete Interference with fast firing rate (>20 Hz)
Review
Neurogenic Disorders (Cont.)

• Insertional Activity
  – Acute - Increased
  – Chronic - Reduced

• PSWs/Fibs
  – Acute - Inc. and Larger Amplitude
  – Chronic - Dec. Compared to Acute Stage and Small Amplitude
  – Go away with reinnervation

Review
Neurogenic Disorders (Cont.)

• CRD
  – Chronic Denervating Conditions

• Fasciculations
  – In Chronic LMN Disorders
Review
Neurogenic Disorders (Cont.)

• EMG Polyphasia, Amplitude and Duration
  – *Large Amp, Long Duration, Polyphasic MUP* = Reinnervation Via Collateral Sprouting
  – *Small Amp, Short Duration, Polyphasic MUP* = Direct Regeneration, Early Collateral Sprouting
  – Amp & Dur Inc and Polys Dec With Chronicity for Both of These Situations

Review
Neurogenic Disorders (Cont.)

• Recruitment Pattern - Reduced, fast firing rate

• Interference Pattern - Reduced or Discrete
Review
Myopathic Disorders

• PSWs/Fibs
  – Inc in inflammatory myopathies, muscular dystrophy's and some other primary muscle Dx

• CRD
  – Inc in inflammatory myopathies, muscular dystrophy's and some other primary muscle Dx

• Myotonic Discharges
  – Myotonias

Review
Myopathic Disorders (Cont.)

• EMG Polyphasia, Amplitude and Duration
  – *Small Amp, Short Duration (<6 msec), Polyphasic MUP* = Myopathic Disorders (Fiber Splitting)

• Rapid Recruitment Pattern

• Full Interference Pattern
<table>
<thead>
<tr>
<th>Insertional Activity</th>
<th>Normal</th>
<th>Increased</th>
<th>Normal</th>
<th>Normal/ increased</th>
<th>Myotonic Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting Activity</td>
<td>Silent</td>
<td>Fibs, PSWs</td>
<td>Silent</td>
<td>Fibs, PSWs or Silent</td>
<td>Fibs, PSWs, myotonic discharges, or Silent</td>
</tr>
<tr>
<td>Minimal Contraction</td>
<td>300-5000 µV, 5-15 ms</td>
<td>Large amplitude, Polyphasic</td>
<td>Normal</td>
<td>Low amplitude, early recruitment</td>
<td>Myotonic Discharge</td>
</tr>
<tr>
<td>Maximal Contraction</td>
<td>Screen fill</td>
<td>Reduced, fast firing rate</td>
<td>Reduced, slow firing rate</td>
<td>Full, low amplitude</td>
<td>Full, low amplitude</td>
</tr>
</tbody>
</table>

**Summary/Questions**

- Remember to examine 3 depths at 4 quadrants
- You may have to examine multiple sites within the same muscle depending upon your clinical judgement and the suspected pathology
- Take your time, be safe and methodical
- Questions ????????????
Normal and Abnormal EMG

- There will be a quiz on this lecture
- There will also be video clips uploaded with abnormal and normal EMG findings – review these.