Fundamentals of Electromyography

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Importance of EMG Studies

- Diagnosis
- Localization
- Assist in further testing (i.e. identify potential biopsy sites)
- Prognosis
- Use in Research
Basic Tenets of Electromyography (EMG)

- EMG (even more than nerve conduction studies) is an extension of the physical exam.
- When in doubt, reexamine the patient (or check the equipment).
- When in doubt, do not overcall.
- Electrodiagnostic (EDX) findings should be reported in the context of the symptoms and referral doctor’s question.
- EDX are uncomfortable. Always stop when the patient asks.
Types of Needles

- Monopolar

Monopolar Needle Electrode

Picturess from www.casaengineering.com
Types of Needles

- Concentric

Pictures from www.casaengineering.com
The Anti-coagulated Patient

- Only 2 reported cases of anticoagulated (warfarin) patients with hematomas following EMG.
- 4 cases of incidental paraspinal hematomas found on MRI after EMG in non-coagulated patients (Caress et al. Neurology 1997).
- AANEM practice guidelines cite need for caution, examine small superficial muscles first and maintain pressure on needle sites.
- Recent survey of EMG Laboratories reported only 5 cases of hematomas after EMG requiring medical intervention in anticoagulated patients.
- No reports of significant bleeding in patients on anti-platelet therapy.
Technique

- Alcohol before skin puncture
- Identify muscle
- Introduce needle-ask patient to contract if necessary to confirm placement (Motor unit action potentials (MUAPs) should be crisp and sharp)
- Move needle 5-10 times, allow at least 3-5 seconds recording to identify spontaneous activity
- Ask patient to activate muscle minimally then increase force slowly to evaluate recruitment
- Remove needle
Morphology

- Motor unit action potential (MUAP) varies based on muscle, age
  - Duration often shorter in proximal muscles
  - Amplitude greater in adults than children (bigger fibers)
  - MUAP size larger in older individuals (probably from dropout of motor units with some “normal” reinnervation)

- Phases: # of baseline crossings plus 1
- Serrations (turns): # of changes in direction of potential not crossing baseline

10 msec/div, timebase
2MV/vertical segment
Duration

- One of the most important measurements
- Best reflects number of muscle fibers within a motor unit
- Typical duration between 5 and 15 ms
- Defined as time from initial deflection from baseline to final return of MUAP to baseline
- Correlates with pitch (shorter duration with higher pitch, longer duration with lower pitch)
Amplitude

- Most MUAPs have amplitude between 100 $\mu$V to 2 mV
- Larger in larger fibers (may not see large type II fiber MUAPs unless patient contracting forcefully)
- Depends greatly on needle and needle placement
  - Difficult to assess amplitude directly with monopolar needle
  - Further away the needle, the smaller the amplitude, less crisp the sound
- Amplitude correlated with volume (bigger the unit, louder the sound)
- Often (but not always) correlates with duration
Polyphasia

- Measure of synchrony: extent to which the muscle fibers within a unit fire at the same time
- Typically motor units have 2-4 phases
- Some degree of polyphasia normal (5-10% in any muscle, up to 25% in deltoid)
- Although abnormal, not specific
Firing pattern

- Can only be assessed in conscious patients
- Firing pattern important in differentiating spontaneous from voluntary discharges
- **During muscle contraction, to increase force you either fire more rapidly or recruit more units**
- Firing rate in normal muscle between 4 to 12 hz before second unit begins to fire
- Ratio of firing frequency measure of recruitment
  - Firing frequency to number of different MUAPs firing
  - Normally 5:1 (ie when rate reaches ~10 hz second unit starts firing, when 15 hz third unit firing)
- Easiest to assess when patient contracting less than full contraction
Recruitment

- Recruitment: Ability to add more units as firing rate increases
- Low recruitment: Ratio greater than 5:1 (ie a single unit firing 30 hz would be 30:1)
- Ratio increases as recruitment drops
- Most important in differentiating neurogenic from myopathic processes
- Be careful not to confuse activation with recruitment
Activation

- **Activation**: Ability to increase firing rate.
- Is a central process (i.e., abnormal secondary to upper motor neuron disorders, pain, poor cooperation/functional).
- **Does not affect ratio of firing frequency** (poor activation in normal subject will have ratio of 5:1).
Interference Pattern

- Interference pattern: Maximum voluntary contraction when no single motor unit can be distinguished (typically 30-50 hz)

- If abnormal either from reduced recruitment or from reduced activation
Pattern of EMG changes in Neuropathic Disorders

- Immediate: Morphology normal, recruitment decreased or absent (depending on severity of injury)
- Same pattern seen in demyelinating disorders with conduction block
- 10-14 days: Spontaneous activity present (wallerian degeneration has taken place)
- After 6 weeks morphology becomes more neuropathic (remodeling has occurred):
  - Decreased recruitment, larger amplitude, polyphasic
  - Satellite potentials: small, short duration, unstable units time locked to another larger unit
  - Nascent units: Small amplitude short duration units with decreased recruitment (recruitment distinguished from myopathic units)
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MUAP, motor unit action potential

Table adapted from Preston and Shapiro, 2nd edition
Pattern of EMG changes in Myopathic Disorders

- Myopathy: number of functioning muscle fibers decreased—units smaller, shorter duration.
- Abnormal firing causes polyphasia
- Acute: short duration, small amplitude units with normal or early recruitment
- Chronic: (some denervation often occurs) long-duration, high amplitude MUAPS can be seen (often with short-duration, small units)
- Recruitment is still normal or early until end stage
Spontaneous activity

- **Normal:**
  - Insertional activity: brief depolarization no longer than 300 ms
  - Endplate noise (seashell noise): low amplitude negative potentials firing irregularly at 20 to 40 hz. = MEPPs
  - Endplate spikes: muscle fiber action potential firing irregularly up to 50 hz
Abnormal Spontaneous Activity

- Fibrillation potentials: spontaneous depolarizations
- Positive sharp waves: same significance as fibrillation potentials
- Complex repetitive discharges: depolarization of a single fiber followed by ephaptic spread (muscle membrane to muscle membrane)
- Myotonic Discharge: spontaneous discharge of muscle fiber with waxing and waning of amplitude and frequency (rate between 20 and 150)
- Fasciculation: Single, spontaneous, involuntary discharge (slow rate 1-2 hz)
Videos of Spontaneous Activity
Videos of Spontaneous Activity
Videos of Spontaneous Activity
Conclusions

- Use your ears (more sensitive than your eyes)
- EMG is only as good as the electromyographer