PainWeek®

The Referral Loop: A Guide for Frontline Clinicians on Electromyography and Nerve Conduction Studies

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Title & Affiliation

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Disclosures

- No financial relationship to disclose
- I work for the Department of Veterans Affairs and my presentation does not represent the views of the VA or the US Federal Government

Learning Objectives

- Describe the basic techniques used in electrodiagnostic testing in order to educate patients about these tests when referred
- Formulate indications for electrodiagnostic studies in painful syndromes
- Summarize the limitations of electrodiagnostic studies in painful syndromes

What are electrodiagnostic studies?

- Physiologic studies of the lower motor and sensory neuron unit (nerve roots, plexus, peripheral nerves and muscles)
- Used to determine if there are any problems along this “pathway”
- Type of problem, where is it, its extent, and its chronicity

Dillingham T, et. Al. Ch. 8 in Braddom’s. Physical Medicine & Rehabilitation 5th Ed 2015

Who perform these?

- Generally Physiatrists and Neurologists
- Also technicians and others
- Know your people; these tests are highly operator-dependent

Why do we do these?

- “Objective" diagnostic tool / Mostly quantitative
- Like any diagnostic tool, should be utilized when results will affect treatment
- Serve to guide treatment and provide prognosis

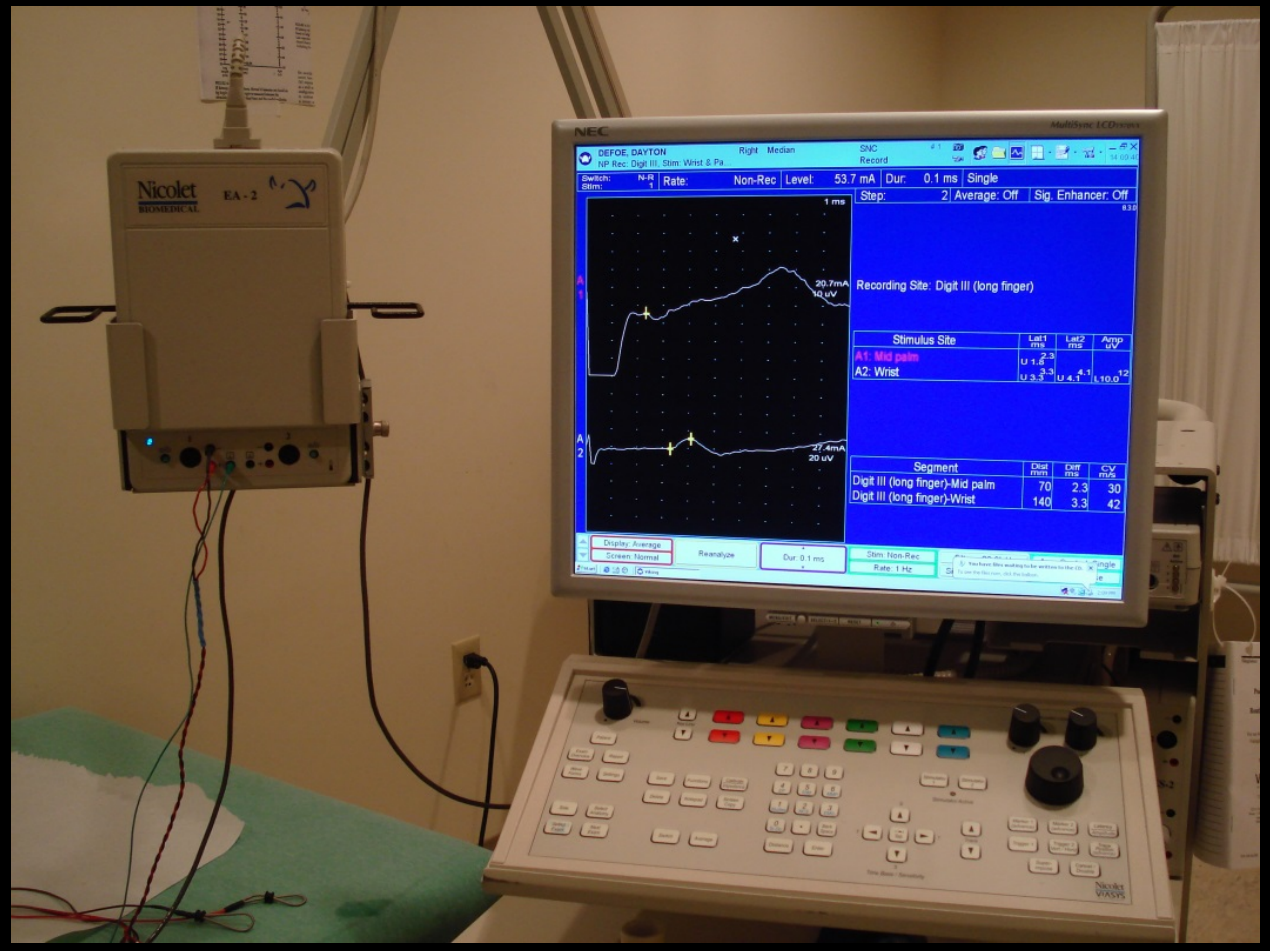
Equipment

… that was then

Equipment

… this is now

- EMG Machine – screen, computer, pre-amplifier
- Stimulator
- Surface recording electrodes
- Needle electrodes



Parts of a Study

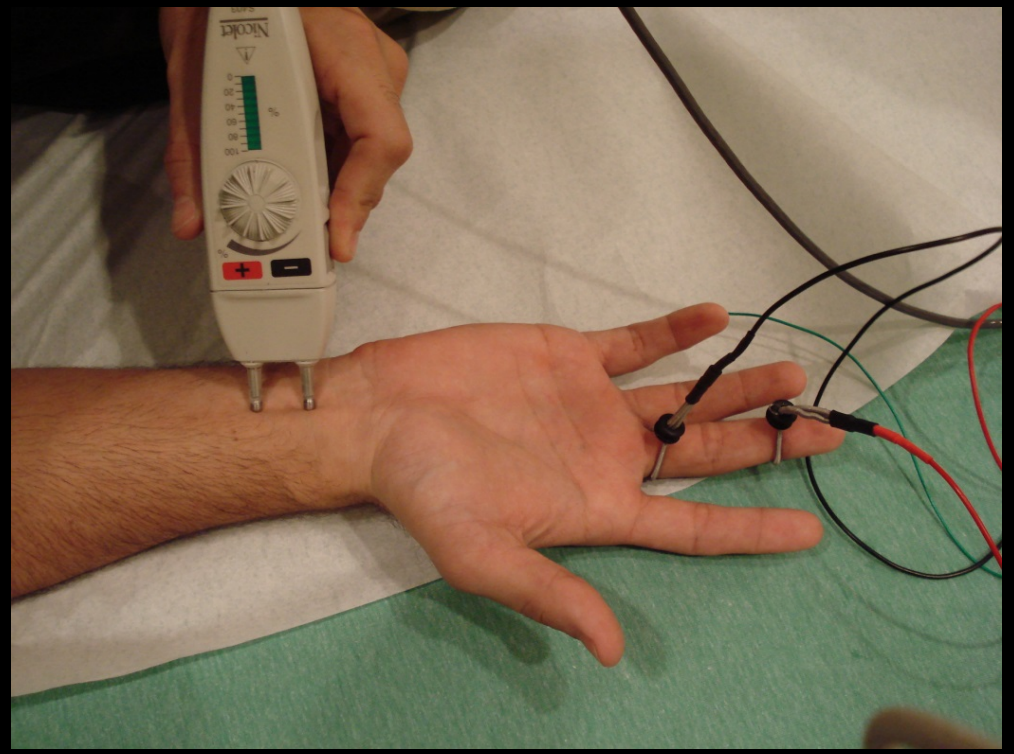
- 2 separate but equally important parts; separate or combined
  - Nerve Conduction Studies (NCS)
  - Electromyography (EMG)

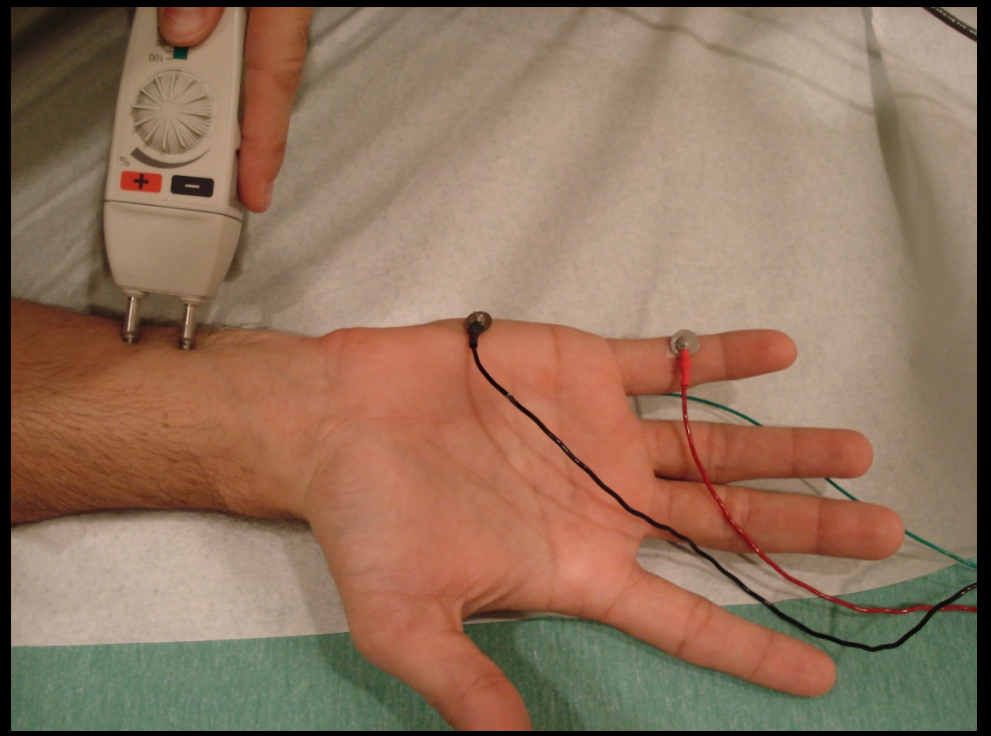
Basic concepts of NCS

- Nerve stimulated at a point along its pathway – depolarization evokes an action potential that travels along the nerve and is recorded by electrodes at a specific distance along that nerve's territory (skin or muscle)
- Stimulation by application of electrical current (1-100 mA)

Basic concepts of NCS

⑩No needles





Basic concepts of NCS

Information obtained

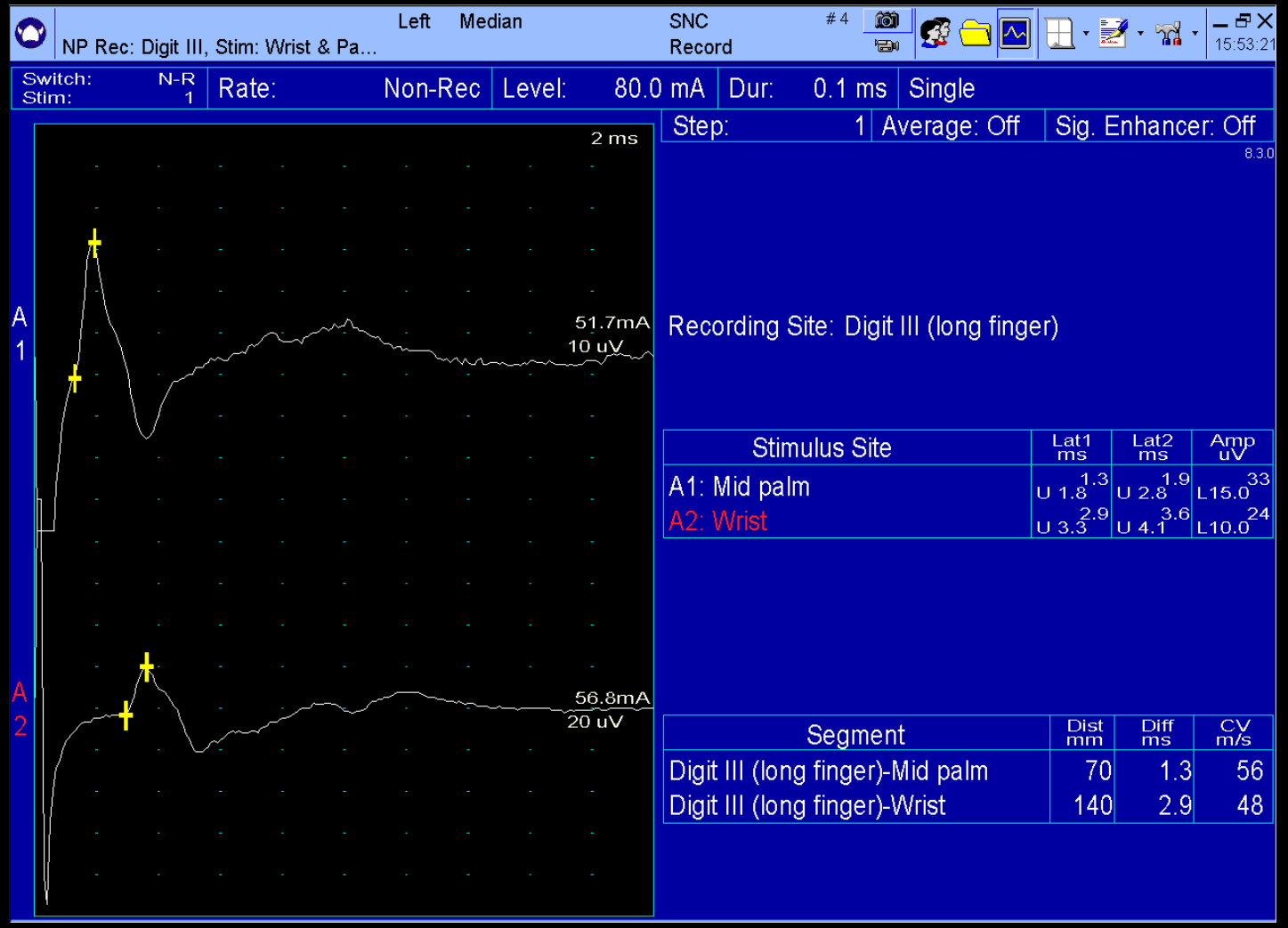
- **Latency** – time from delivery of the stimulus to the resulting recordable potential; mostly a function of integrity of the nerve's faster fibers myelin sheath
- **Amplitude** – displacement of the action potential (in mV or μV) from the baseline; mostly a function of the number & integrity axons
- **Conduction velocity**

A Few Trace Examples

Ulnar Motor


Right Ulnar
MNC
Record
2
NP Rec: ADM, Stim: Wr, B.Elb, A...
15:34:00
Switch: N-R
Stim: 1
Rate: Non-Rec
Level: 80.3 mA
Dur: 0.1 ms
Single
Step: 3
Average: Off
Sig. Enhancer: Off
8.3.0
5 ms
A 1
100mA
5 mV
A 2
100mA
5 mV
A 3
100mA
5 mV
Recording Site: Abductor digiti minimi (manus)
Stimulus Site | Lat1 ms | Dur ms | Amp mV | Area mVms
A1: Wrist | U 3.6 3.0 | 5.3 | L5.00 9.3 | 28.6
A2: Below elbow | 6.8 | 5.6 | 8.6 | 27.4
A3: Above elbow | 8.6 | 4.8 | 9.2 | 27.1
Segment | Dist mm | Diff ms | CV m/s
ADM m-Wrist | 80 | 3.0 |
Wrist-Below elbow | 215 | 3.8 | L48.0 57
Below elbow-Above elbow | 110 | 1.8 | L48.0 61

Median Sensory



Radial Sensory

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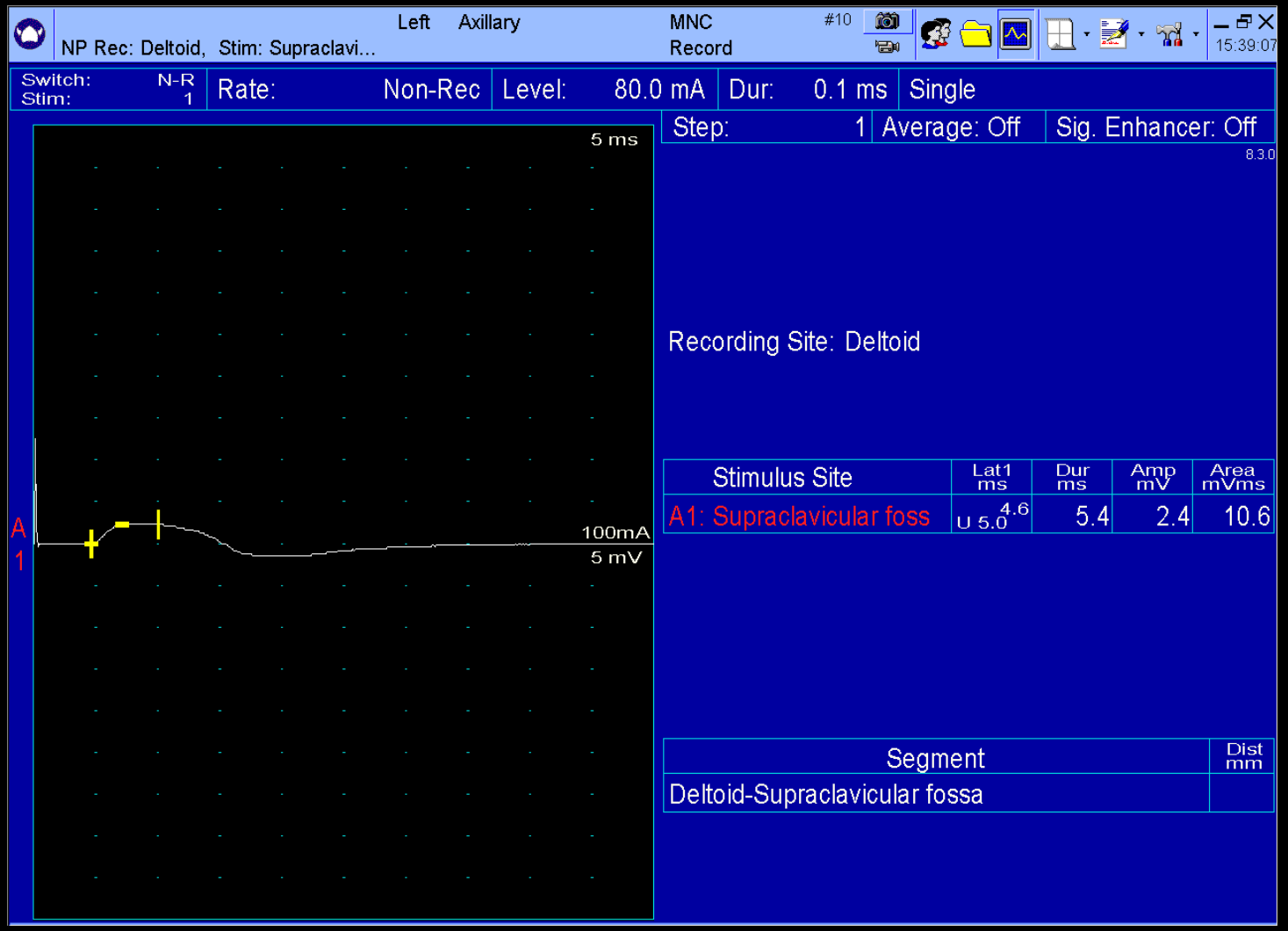
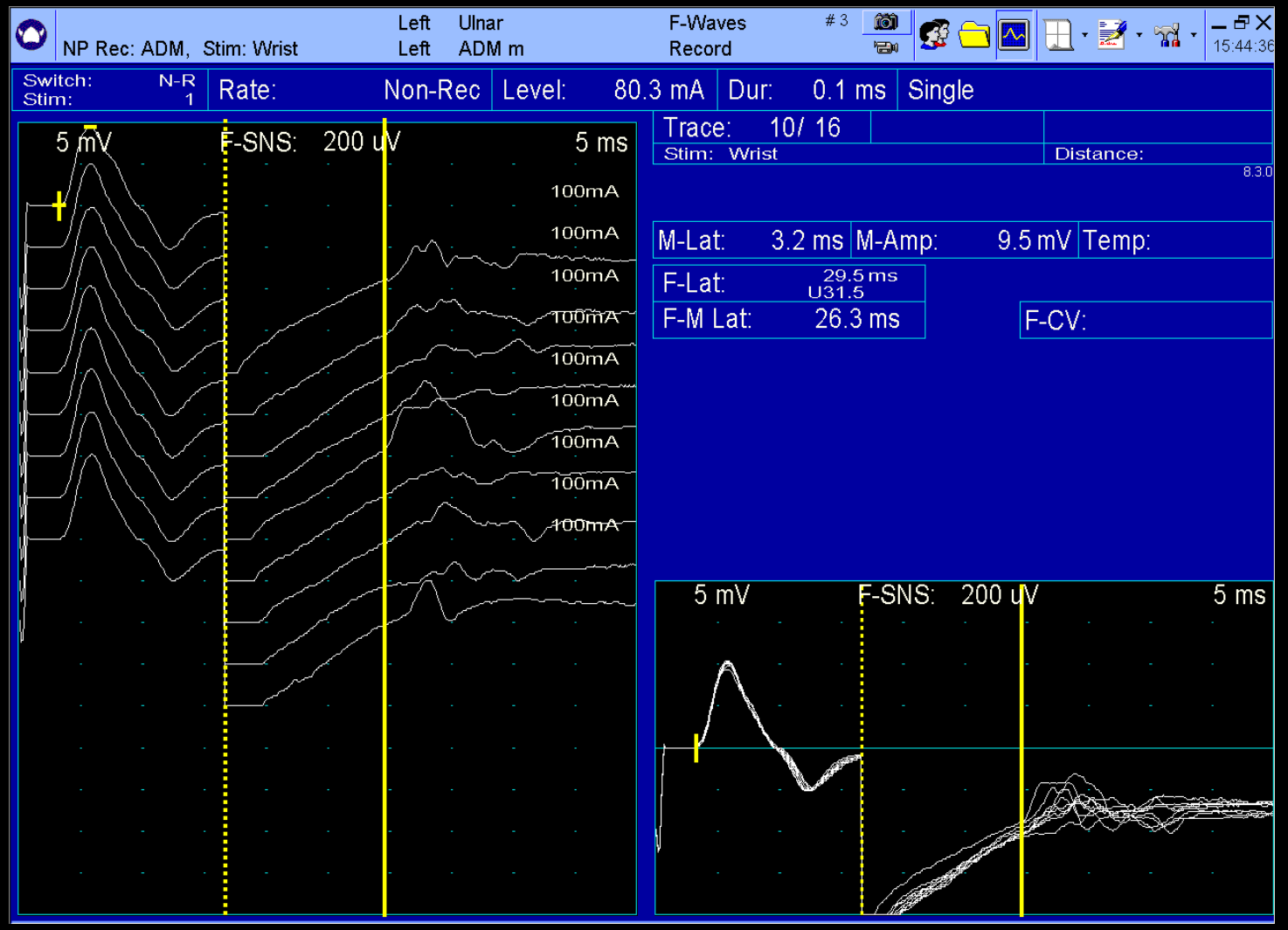
Axillary Motor



F-wave <ulnar>



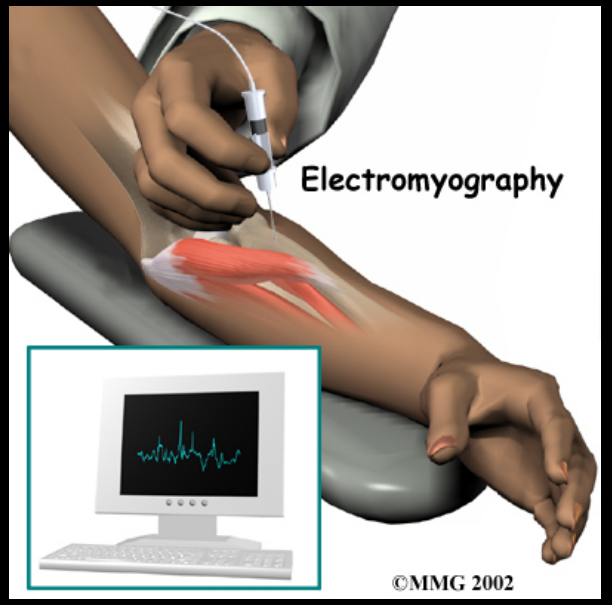
Basic concepts of NCS

- Results are compared to pre-determined normal general population values; also compared (whenever possible) to the patient's own value (i.e. side-to-side/other comparable nerves)

- Absolute and relative differences or deviations are noted

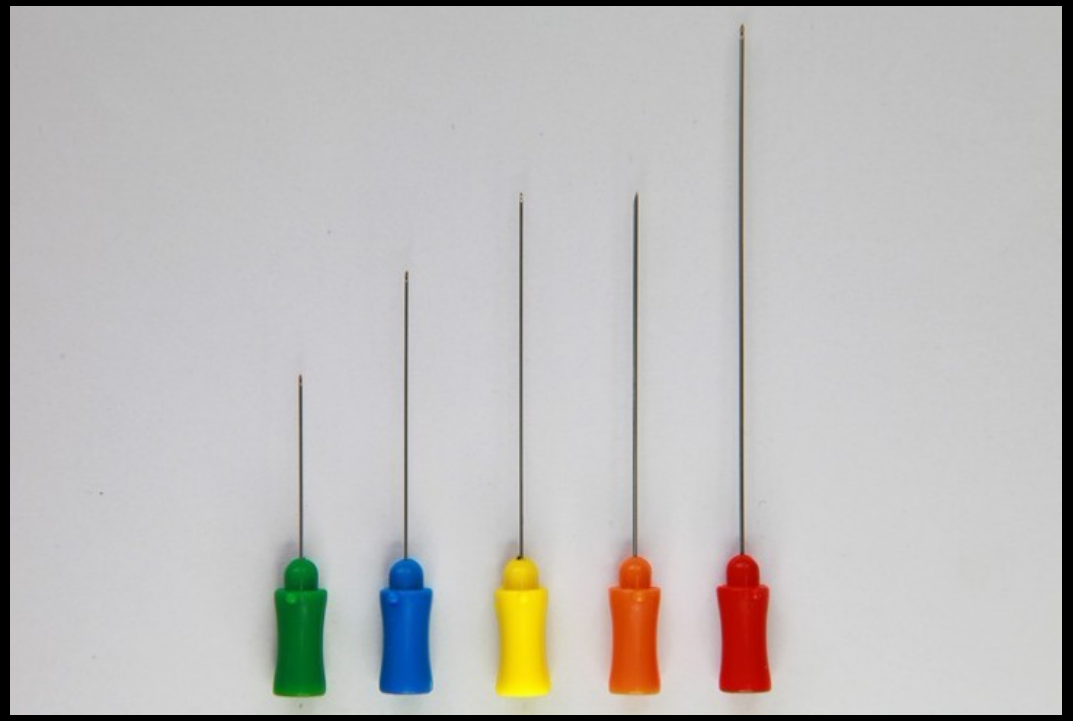
EMG

- Involves no electrical stimulation
- Recording of muscle-generated electrical potentials (voluntary and spontaneous) via a needle electrode inserted into the muscle tissue



Basic concepts of EMG

- Needle electrodes – many types but general concept: teflon coated (electrically isolated) except at tip with a very small area of recording
- Typical length – 25, 37, 50, 75 mm / 27G



Basic concepts of EMG

- Study will typically consist of evaluation of several muscles; from 1 to 10-15
- Muscles need to be observed fully relaxed/at rest; then patient asked to voluntarily activate/contract the muscle and signals analyzed
- Only assesses LMN – anterior horn cell, nerves, and muscle; **nothing sensory**

Usefulness of EDX

- **Peripheral Neuropathies**

- Diagnosis and characterization (demyelinating, axonal, mixed, motor, sensory)
- Most common: DM, EtOH, CRI, Hypothyroidism
- Others: toxic exposures – heavy metals, antineoplastics (vincristine)
- HIV, Vit B-12 deficiency
- Hereditary
- AIDP, CIDP

Fateh, et al. *J Diab Metab Dis* 2016; 15:8
Dillingham T, et. al. Ch. 8 in Braddom's. Physical Medicine & Rehabilitation 5th Ed 2015

Usefulness of EDX

- Focal neuropathies (CTS, Ulnar, TTS)
- Plexopathies
- Some Cranial Neuropathies (i.e. 7th)

Usefulness of EDX

Radiculopathies

- motor only by EMG
- ideally - abnormalities in several muscles supplied by the same spinal nerve but different peripheral nerves/branches

Callaghan B. *JAMA* 2016; 315(3):297-298

Usefulness of EDX

- Motor Neuron Disorders (i.e. ALS, PPS)[1]
- Myopathies (inflammatory vs. non-inflammatory)[2]

1. Morris. *Neurodiagnostic J* 2015; 3:180-194
2. Carvalho. *Clin Neurophysiol* 2016; 127(7): 2670-81

Usefulness of EDX

- NMJ disorders (MG, Lambert-Eaton)
- Miscellaneous:
  - neurogenic causes of anal sphincter dysfunction
  - laryngeal EMG for dysphonia/VC paralysis
  - dysfunction of the diaphragm

Geiger. Electrodiagnosis of NMJ Disorders 2018; 131-152

CTS

- Most sensitive means of diagnosis
- May not be as straightforward to diagnose clinically
- Key before surgery
- May co-exist with PN, worsening prognosis

Thompson *Lancet* 2017; 16(4): 263
Bland *Orthopedics* 2017; 40(4): 198-199
Masson *J Clin Rheum* 2016; 22(1): 45-46

Radiculopathy

- Usually in combination with clinical exam/hx and imaging
- Physiologic (functional) test vs. anatomic

Shoulder dysfunction scenario

- High velocity blunt trauma to shoulder with shoulder subluxation
- MRI - full thickness supraspinatus and infraspinatus tendon tear
- Repair considered but on exam there are discrete areas of numbness in the arm

Focal vs Radicular, etc.

- Unilateral leg pain, weakness (foot drop) and numbness
- L5 vs. peroneal palsy ???

Some Pitfalls

- Results are generally very useful but not always black and white
- Hence the importance of using it as an extension of the H&P, like other diagnostic tests (i.e. labs, imaging)

More Pitfalls to bear in mind…

Radiculopathies

- Pure Sensory >> Mixed >> Pure motor
- For sensory we can use special NCS techniques called late responses; H-Reflex for S1 and C6-7; abnormalities are not pathognomonic but may support dx
- Also SSEP's[1]

1. Eisen A. *Can J Neurol Sci* 1983; 10:178-182

More Pitfalls

Peripheral Neuropathies

- Will not detect small fiber neuropathies; better for compression than toxic/ischemic
- Painful small fiber neuropathies may be present and elude detection

Callaghan B. *JAMA* 2016; 315(3):297-298

Contraindications

- NCS – demand-type pacemakers; particularly when stimulating nearby
- EMG – coagulopathies, anticoagulation, infected/wound site

- Always evaluate benefit vs. risk ratio
- Generally uncomfortable but tolerable; sedation never used

Proper Utilization

- Longstanding diabetics with clear clinical PN for r/o diabetic neuropathy; may refer if other problems are suspected or superimposed

Proper Utilization

- Patients with pain complaints without objective neurological findings or at least anatomically-sound/concordant symptoms
- Yield is usually too low

Proper Utilization

Pure UMN syndromes (i.e. SCI, Stroke)

- UMN is affected and in most cases the LMN is intact

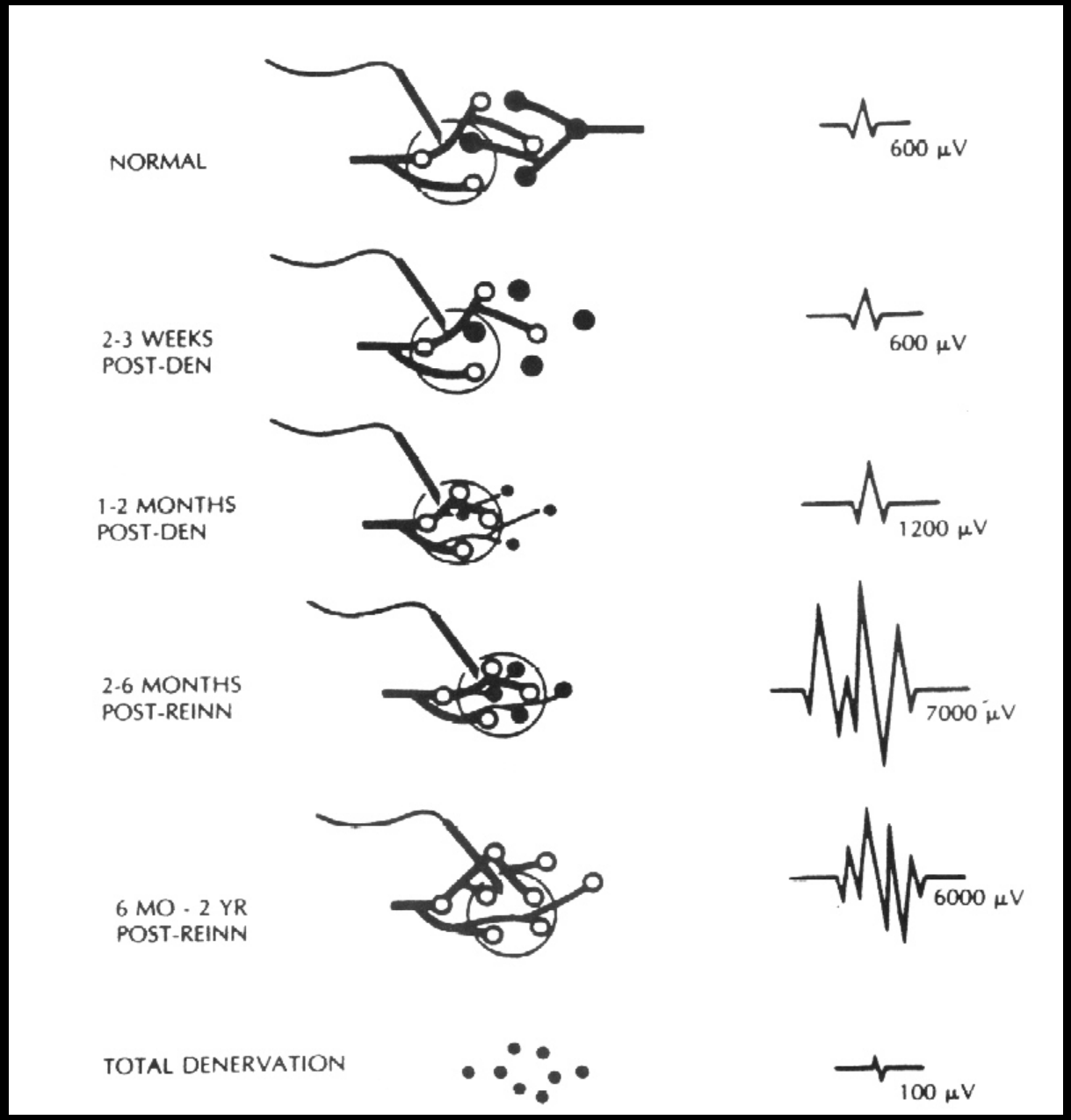
Almost done….

How to Prepare/Counsel Patients

- Wear loose comfortable clothing
- No body creams or lotions
- May or may not involve needles
- Usually minimally painful, well-tolerated
- Usually harmless / no expected complications
- Go well-hydrated, no need to fast or to hold medications*

Timeframes

- sooner is not always better…….
- some abnormalities may not be seen immediately but may become apparent in days, weeks, or months


NORMAL
600 µV
2-3 WEEKS
POST-DEN
600 µV
1-2 MONTHS
POST-DEN
1200 µV
2-6 MONTHS
POST-REINN
7000 µV
6 MO - 2 YR
POST-REINN
6000 µV
TOTAL DENERVATION
100 µV

Timeframes

- Study is dynamic at that point in time
- Having a clinical diagnosis dictates the basic protocol to follow; findings along the way prompt variations and modifications as the study progresses

Robinson L. *Muscle Nerve* 2015; 52:321-333

Timeframes

- Results from EMG cannot be reviewed later; analysis should happen in real time; to some extent true also for NCS
- Results are available immediately - the study is being interpreted as it is being done

Other Concepts

- Rarely an emergency
- Possible exception: case of suspected AIDP when dx is needed to implement therapy – i.e. plasmapheresis

Dillingham T, et. Al. Ch. 8 in Braddom's. Physical Medicine & Rehabilitation 5th Ed 2015

Thank you!

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