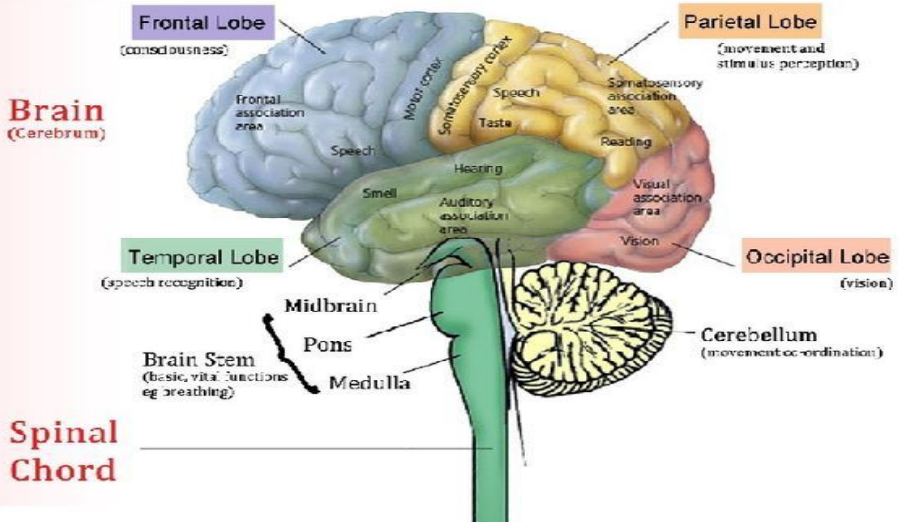
Introduction to EMG for Anesthesiologists and Pain Control Physicians

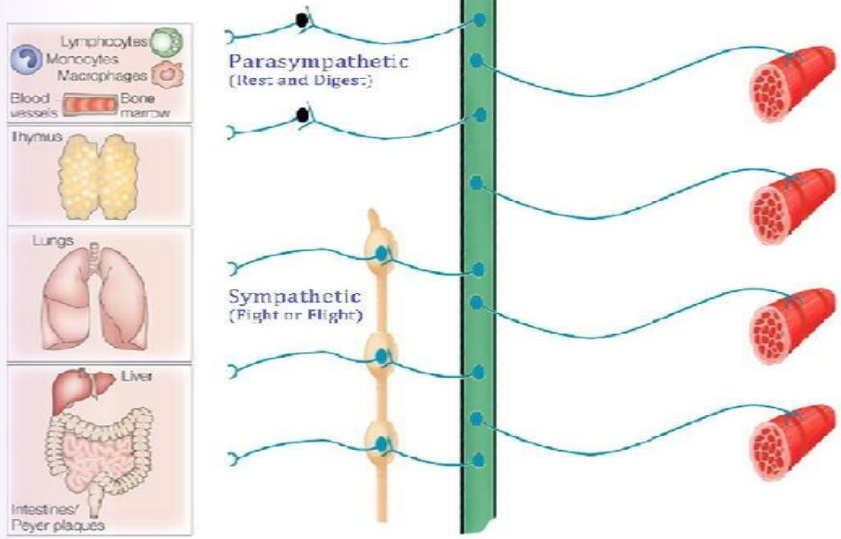
The Nervous System

Central Nervous System

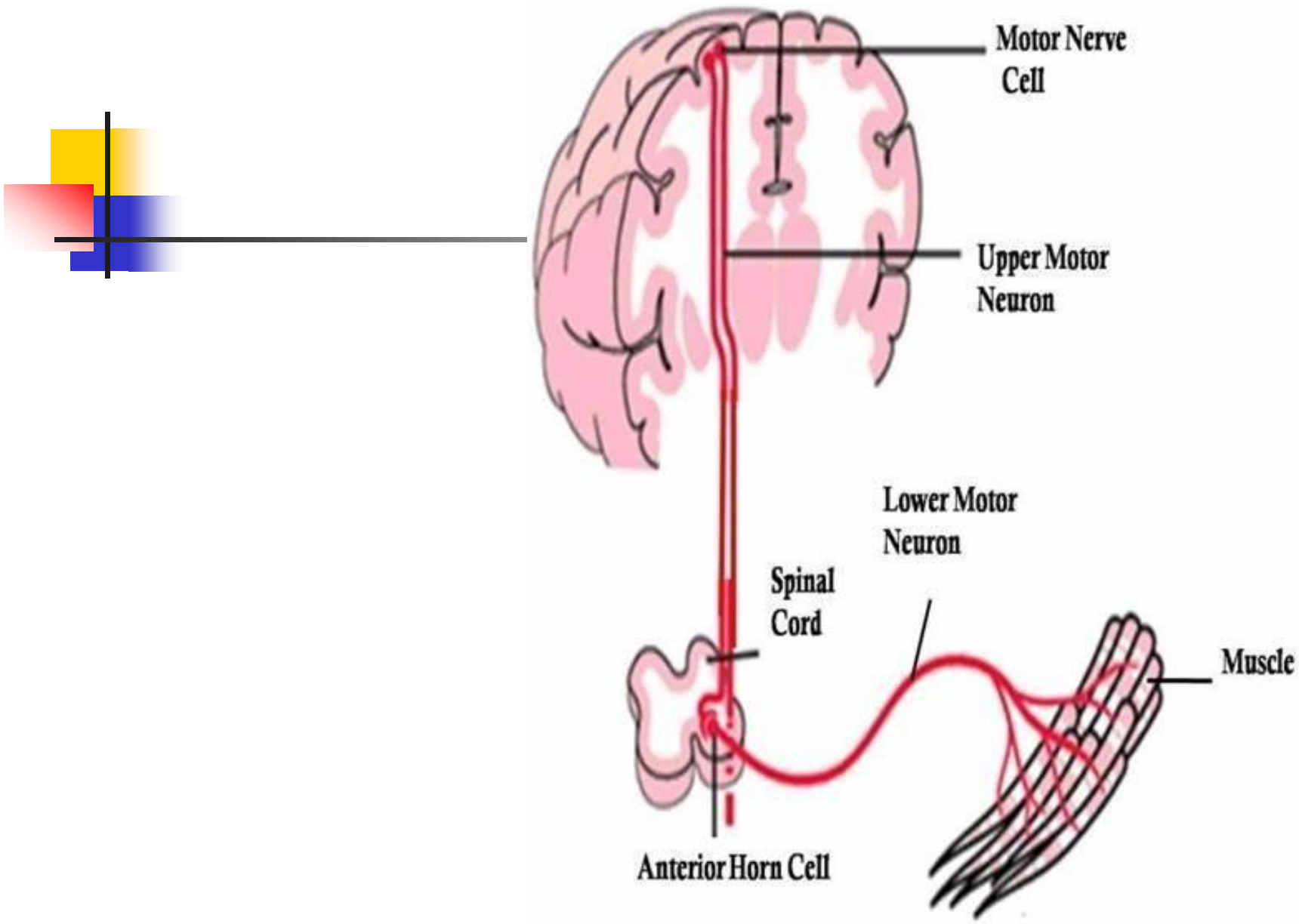


The central nervous system (CNS) consists of the Brain and the Spinal Cord. It plays the role of intergrating and processing the information it recieves from the outside.

Peripheral Nervous System



The Peripheral Nervous System (PNS) connects the CNS to the major organs and limbs. It is made up of the Automomic Division, which controls involuntary actions and impulses, and the Somatic Division which consists of the neurons that control voluntary actions.


Motor Nerve Cell
Upper Motor Neuron
Lower Motor Neuron
Spinal Cord
Muscle
Anterior Horn Cell

EMG and Nerve Conduction Studies

- **An extension of the Physical Examination**
- **Quantitates nerve and/or muscle injury**
- **Provides Useful Data Regarding Nerve Injury**
  - Site
  - Type
  - Severity
  - Duration
  - Prognosis

Importance of EDX Studies

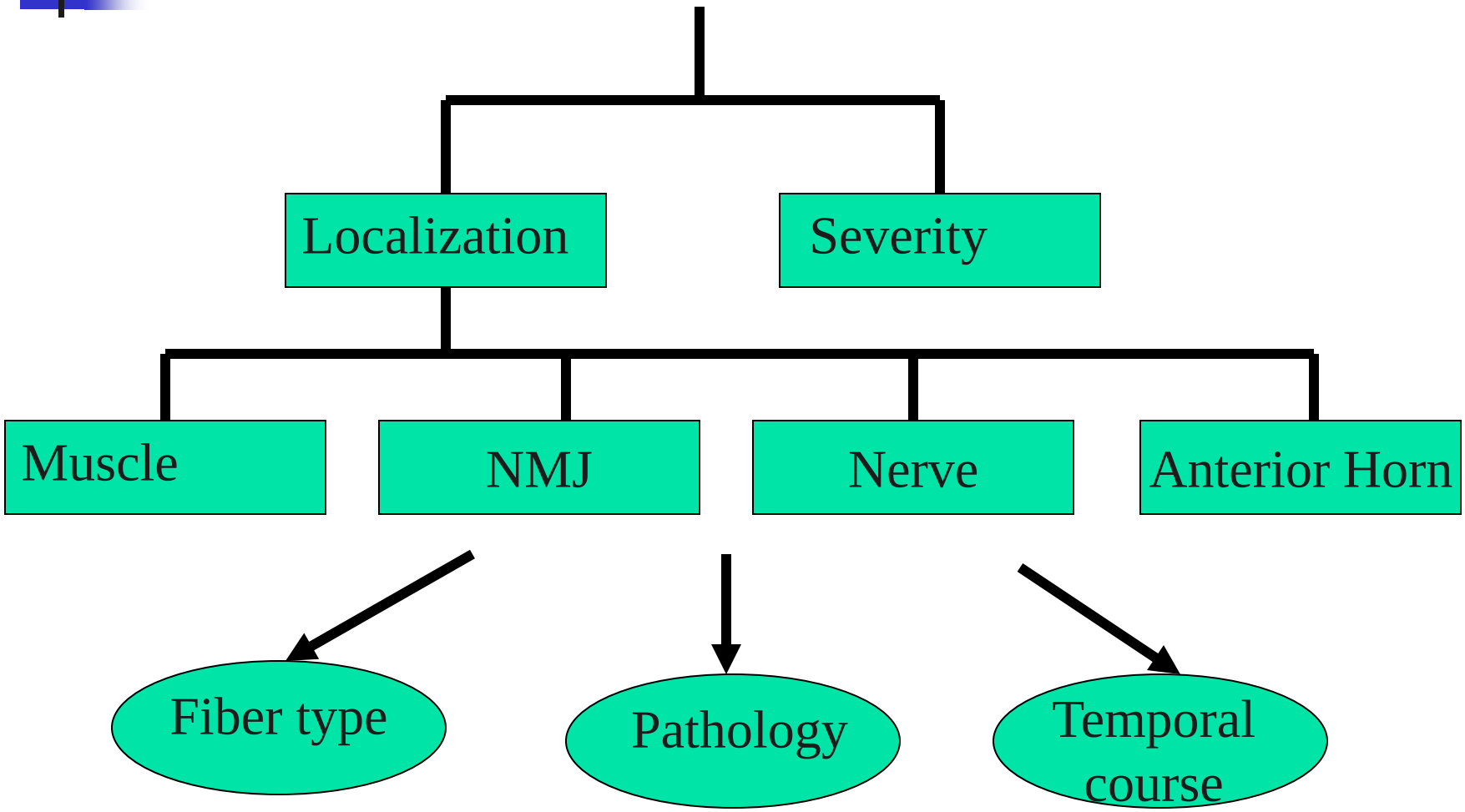
- Diagnosis
- Localization
- Assist in further testing (i.e. identify potential biopsy sites, imaging studies, spinal fluid analysis, blood work)
- Prognosis
- Use in Research

NCSs and EMG

Points to Remember

- NCSs and EMG: assess physiology of nerve and muscle
- Not all radiculopathies are structural
- Neurologic consultation is best obtained before the testing is ordered
- If NCSs and EMG normal or non-contributory, justification for neurologic consultation is greater than before testing

Goals of EDX Testing



Adapted from fig 1-2, Preston and Shapiro

When to order NCSs and EMG

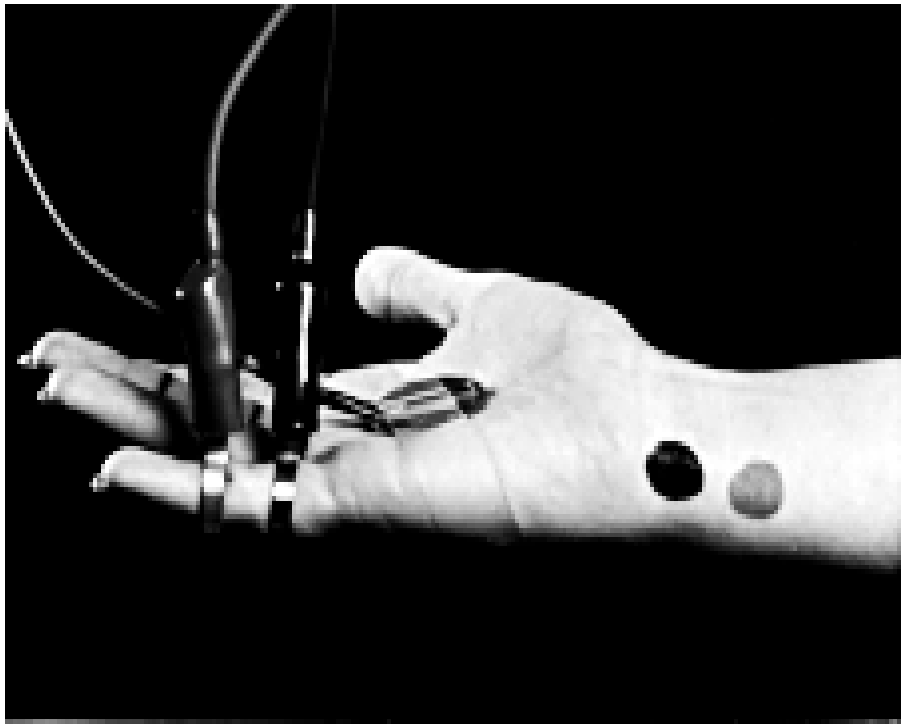
- Mononeuropathy
- Mononeuropathy Multiplex
- Radiculopathy
- Plexopathy (Brachial or Lumbosacral)
- Anterior Horn Cell Disorders
- Diffuse neuropathies
- Cranial neuropathies
- Neuromuscular Junction Disorders
- Myopathy

When Not to order NCSs and EMG

- Central Nervous System Disorders (Stroke, TIA, Encephalopathy, spinal cord injury)
- Multiple Sclerosis
- Total body fatigue, fibromyalgia
- Joint pain
- Unexplained weakness (without a neurologic consultation)
- Failed back, S/P multiple neck and low back surgeries

Types of nerve conduction studies

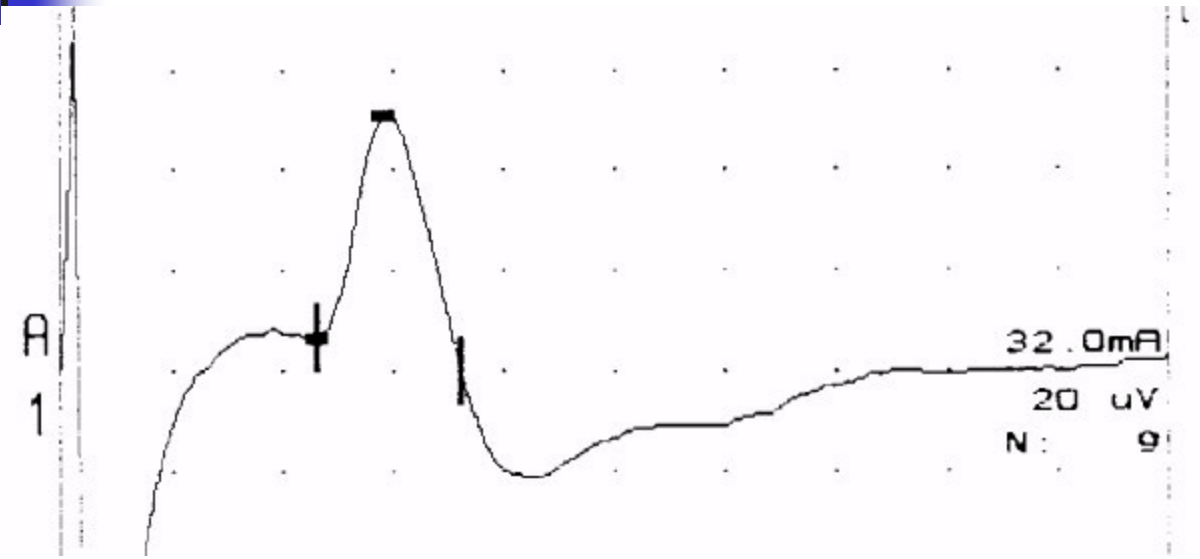
- Sensory: typically antidromic
- Typical nerves examined: Sural, ulnar, median, occasionally radial or superficial peroneal



Sensory NCS Parameters

- 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

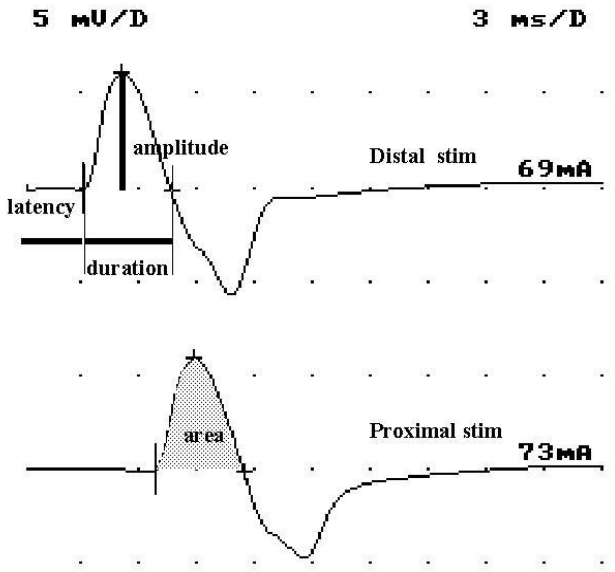
	Latency (msec)	CV (m/s)	Amp (uV)
Wrist-D2	2.2	58	44.1

Motor NCS Parameters

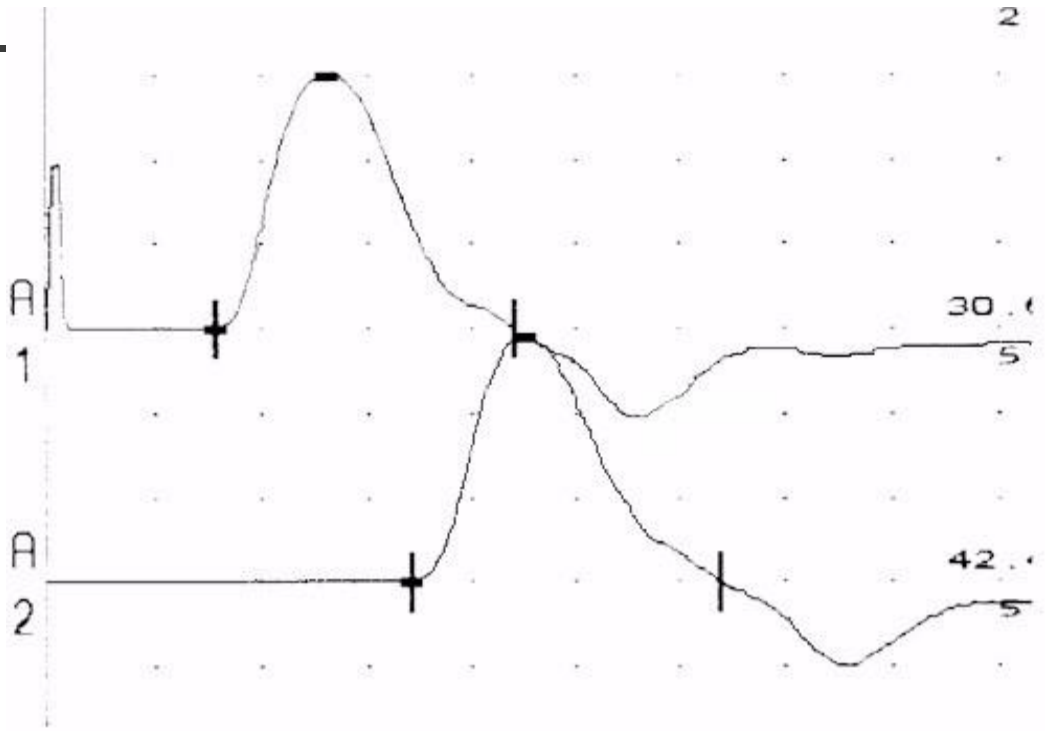
- Distal Latency
  - determined by conduction velocity of the nerve, neuromuscular junction & muscle
- Amplitude
  - determined by number of muscle fibers activated
- Proximal conduction velocity
  - determined by conduction velocity of the fastest fibers

Motor Nerve Conductions

- Vital part of EDX as this important for identifying demyelination, compression
- Need to do proximal and distal studies to evaluate for conduction velocity, conduction block, temporal dispersion
- Typical nerves: ulnar, median, peroneal, tibial.
- Less common: radial, femoral, phrenic, spinal accessory, facial

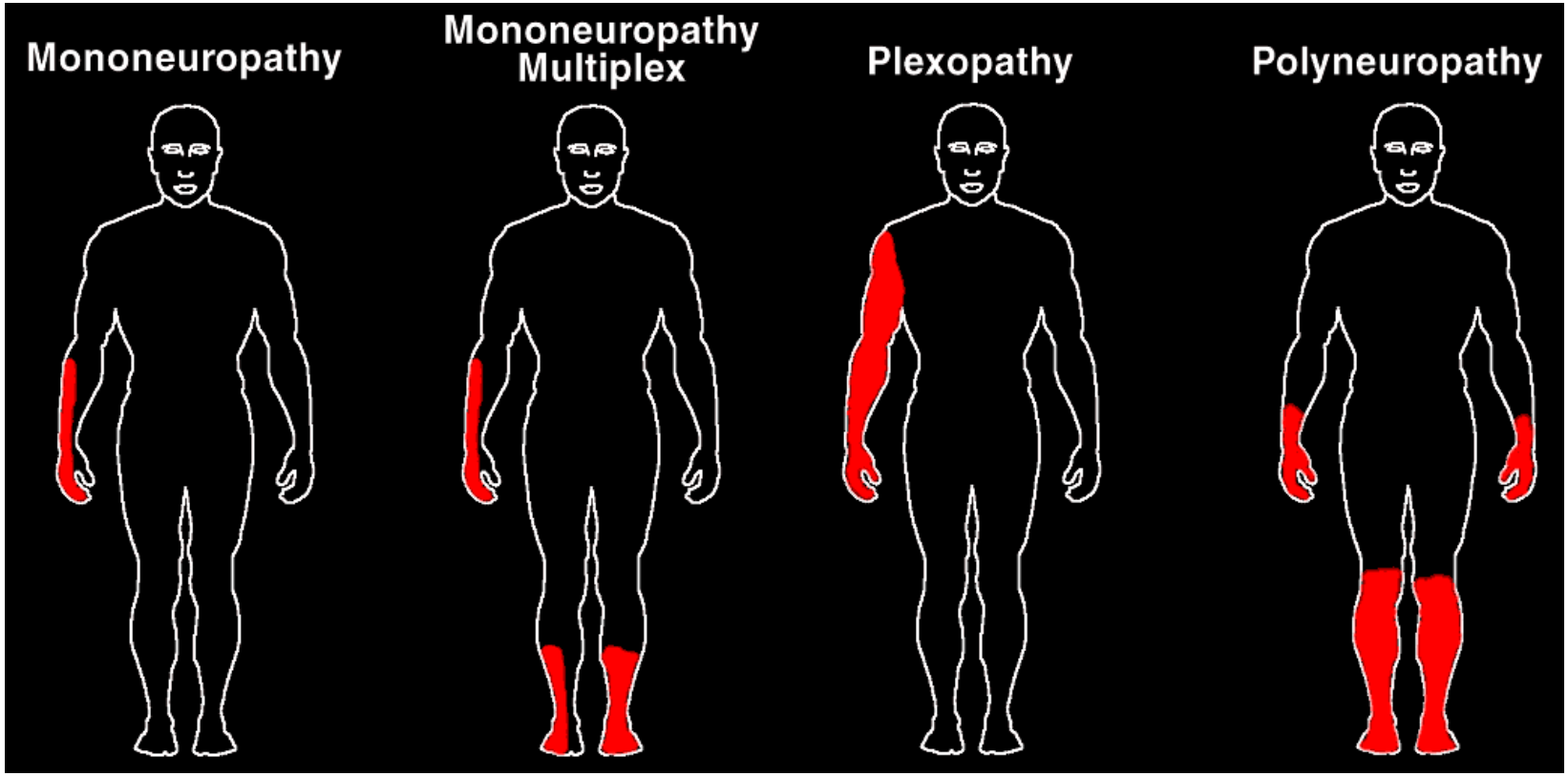


Normal Median Motor Study

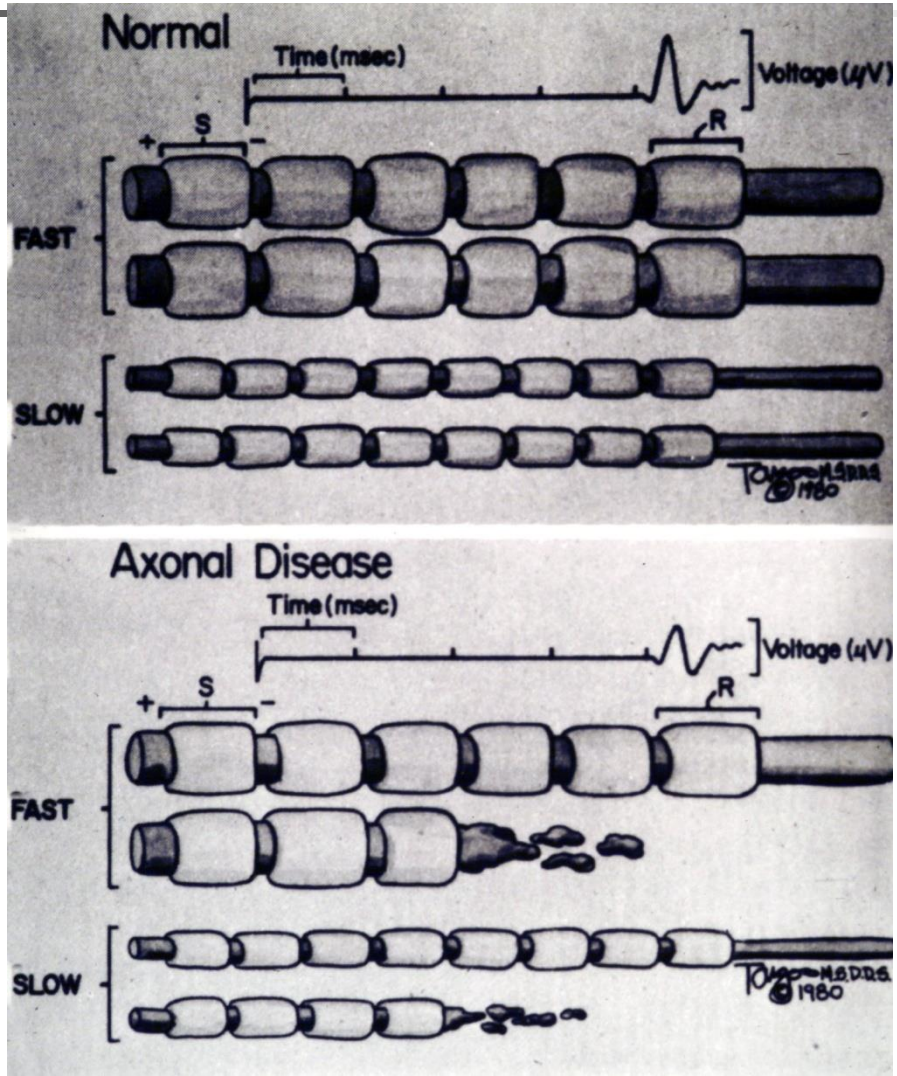


	DL (msec)	CV (m/s)	Amp (mV)
Wrist-APB	3.2		15.0
Elbow-Wrist		55	14.8

What is Peripheral Neuropathy?

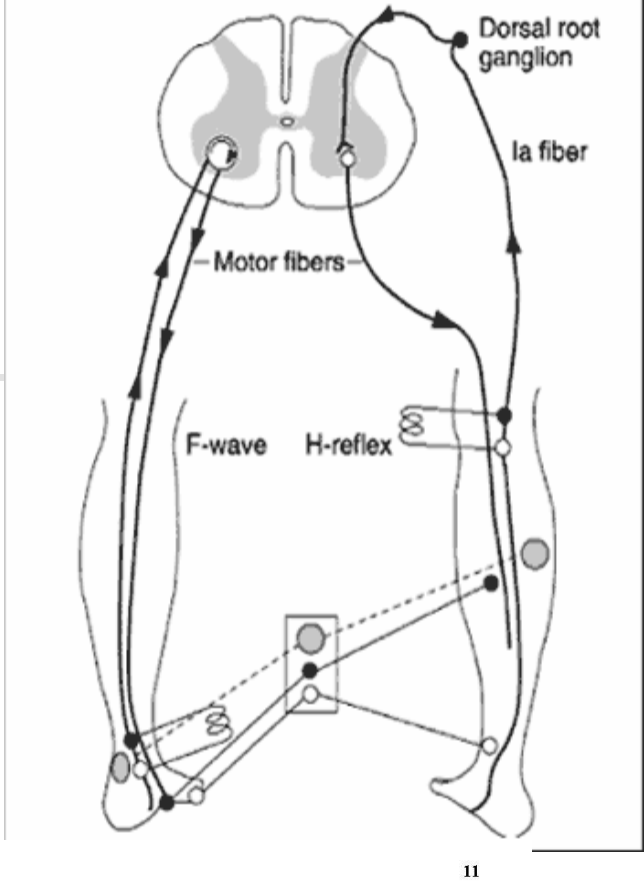


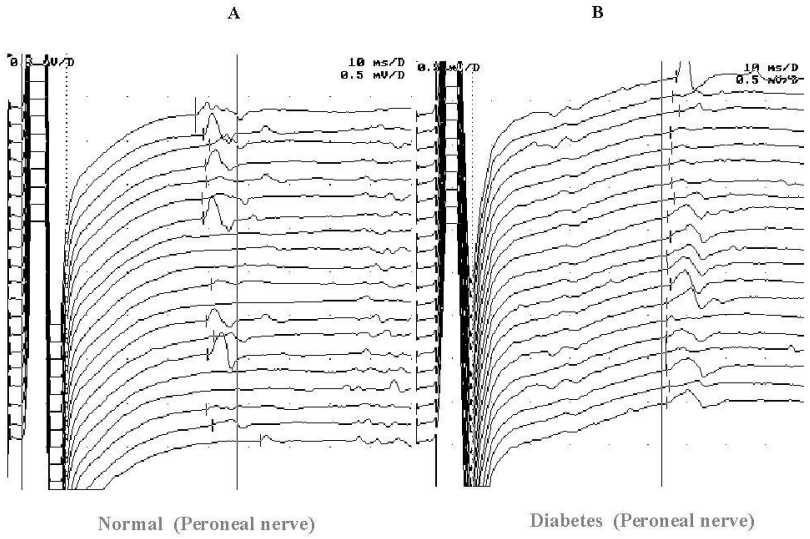
Nerve conduction responses after injury



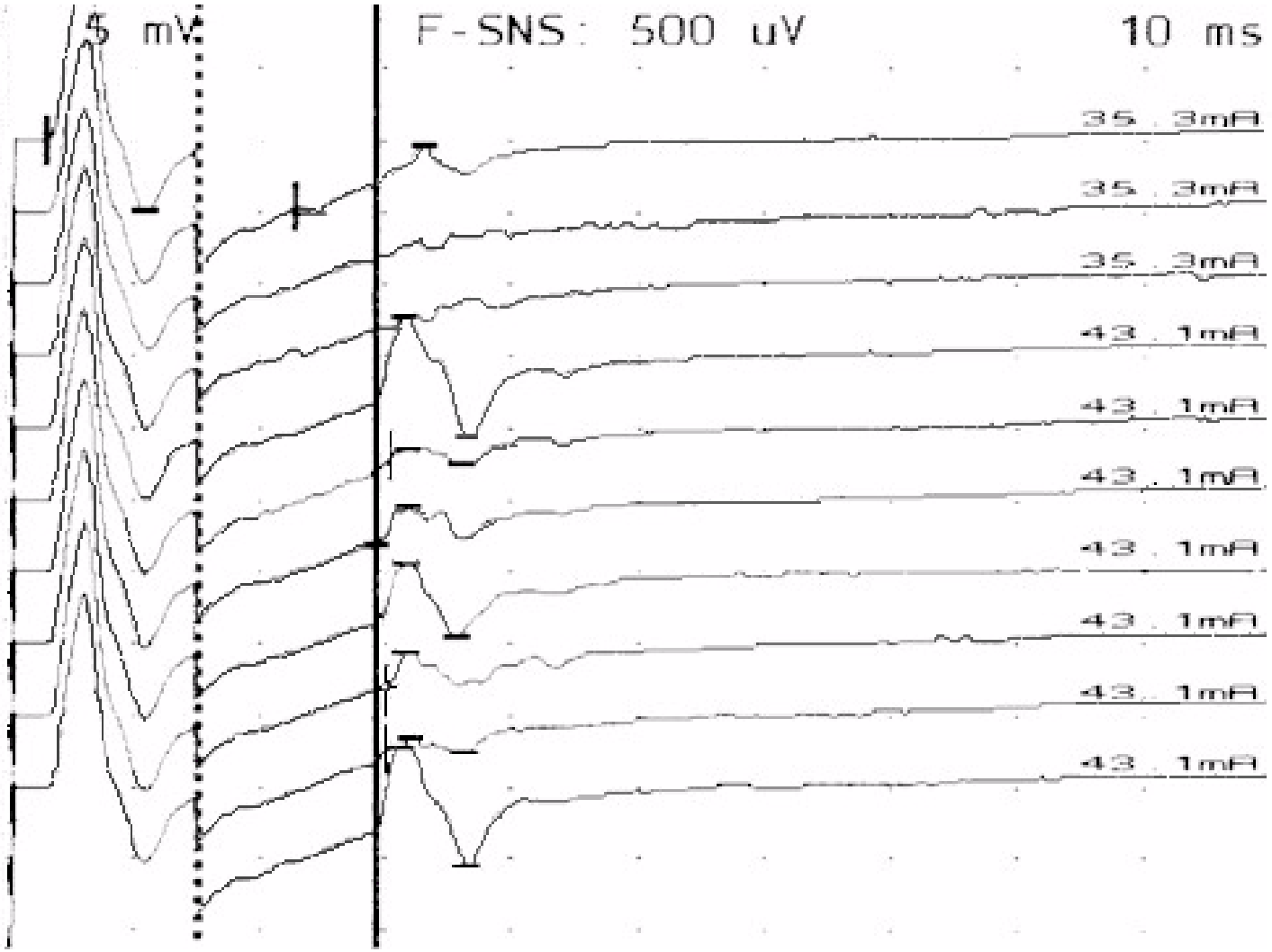
F-waves and H-reflex

- Useful for identifying proximal segmental demyelination
- Can only be done when motor amplitude is > 1 mV
- Extremely height-dependent





F Waves: Normal Median



Needle Electromyography: Techniques

- **Needle electrode is inserted into the muscle**
  - Needle is disposable, single use
- **Multiple muscles are accessible for examination**
- **Combination of muscles tested**
  - Dependent upon clinical question
- **Level of discomfort is mild**

Needle Electromyography: Data

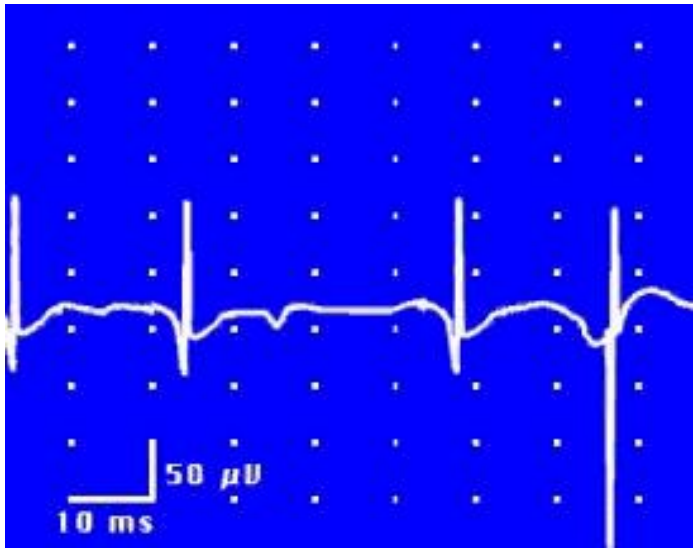
- Insertional Activity
- Spontaneous Activity
- Motor Unit Configuration
- Motor Unit Recruitment
- Interference Pattern

Needle Electromyography: Data

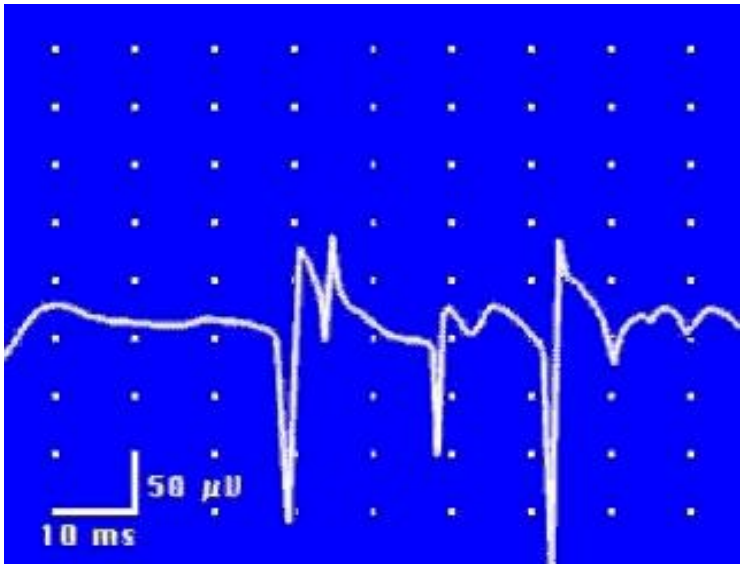
- **Motor Unit Configuration**
  - **Single motor unit:** A motor axon and all its muscle fibers
  - **Motor Unit Configuration:** Amplitude, Duration, Morphology
  - **Muscle is volitionally activated at different force levels**
  - **Needle recording properties enable assessment of single MUs**
- **Motor Unit Recruitment**
  - **Pattern of motor unit activation with increasing volitional activation**
- **Interference Patterns**
  - **Motor unit pattern with full voluntary activation**

EMG: Spontaneous Activity

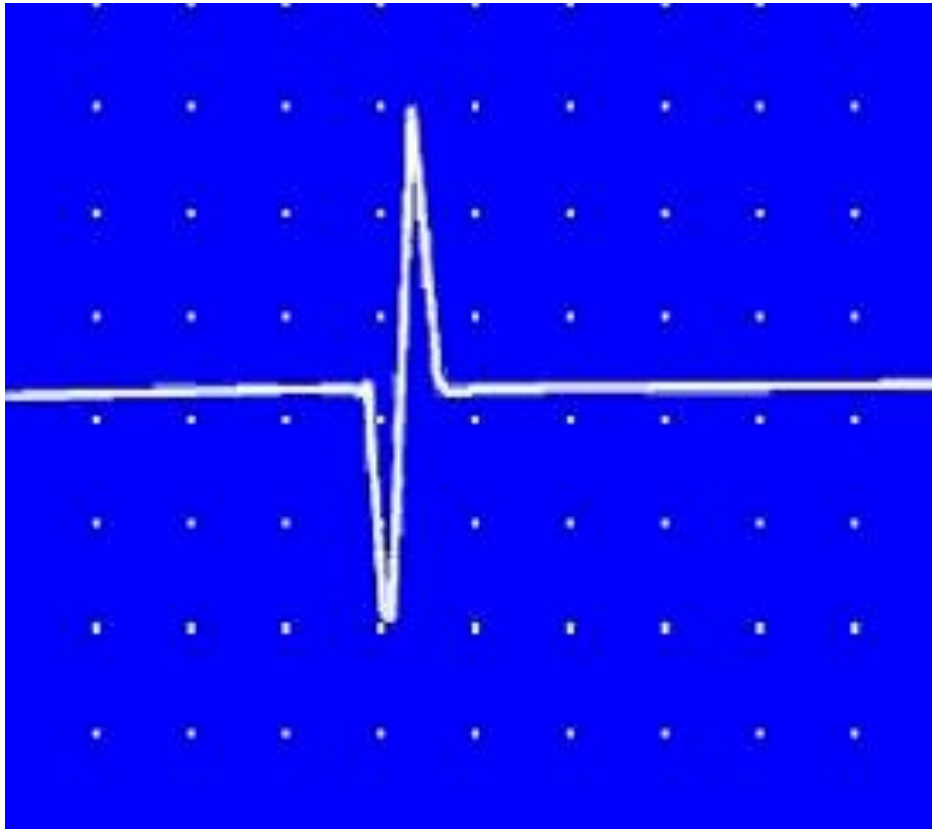
Fibrillation Potentials



Positive Sharp Waves

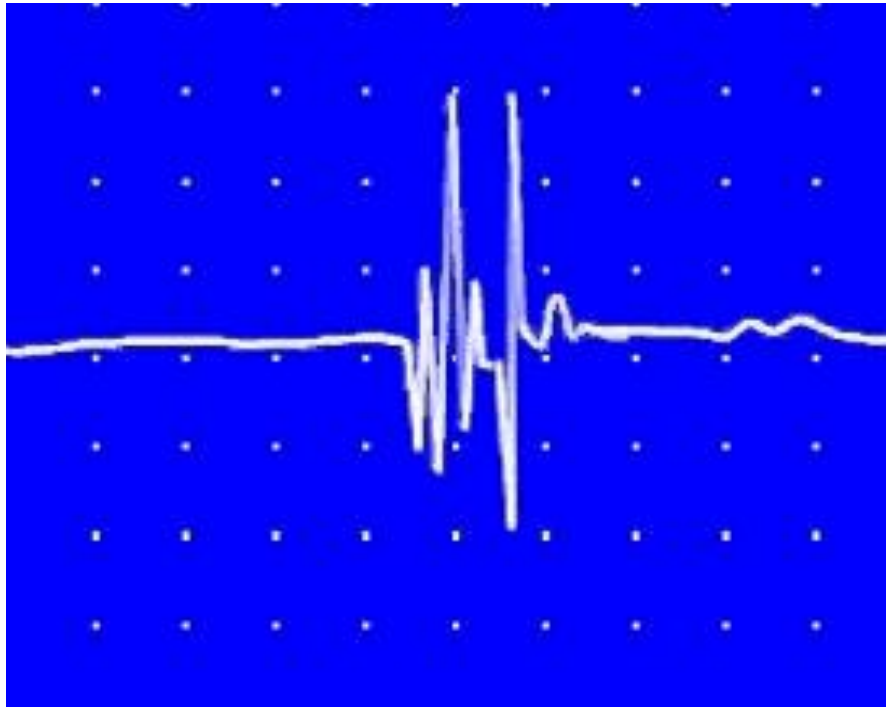


EMG: Spontaneous Activity



Fasciculation Potential

EMG: Neurogenic Motor Unit

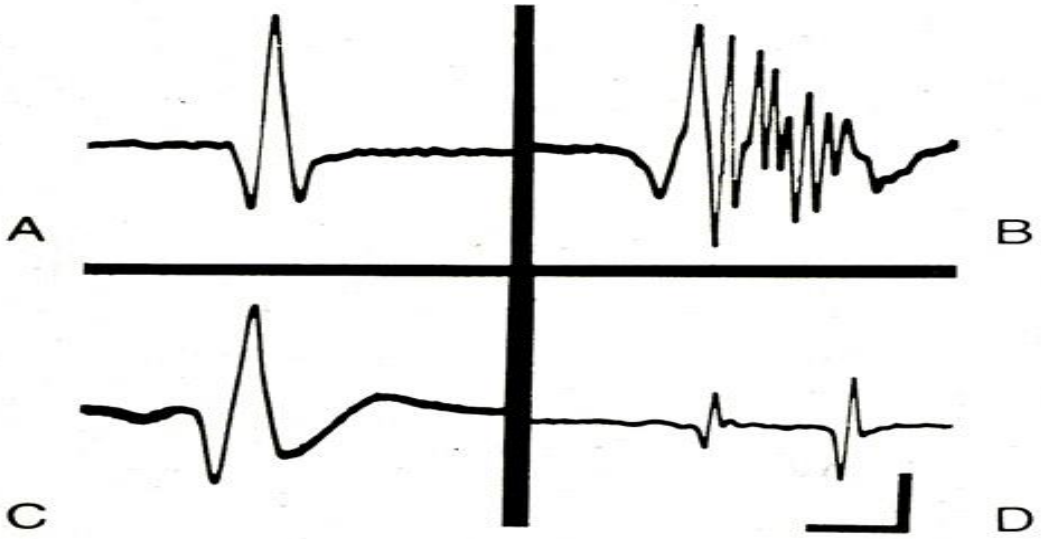


10 msec/div, timebase

2MV/vertical segment

EMG
Motor Unit Changes

Figure 44-8
Single voluntary motor unit potentials. A. Normal. B. Prolonged polyphasic potential seen with reinnervation. C. "Giant unit"—normally shaped but of much greater amplitude than normal. D. Brief, low-amplitude "myopathic" units. Calibrations: 5 ms (horizontal) and 1 mV in A and B; 5 mV in C; 100 μV in D (vertical).



Adams and Victor, 1981

Common Mononeuropathies

- Median at the Wrist (CTS)
- Ulnar at the Elbow (Tardy Ulnar Palsy)
- Peroneal Palsy at the Fibular Head

Case 1

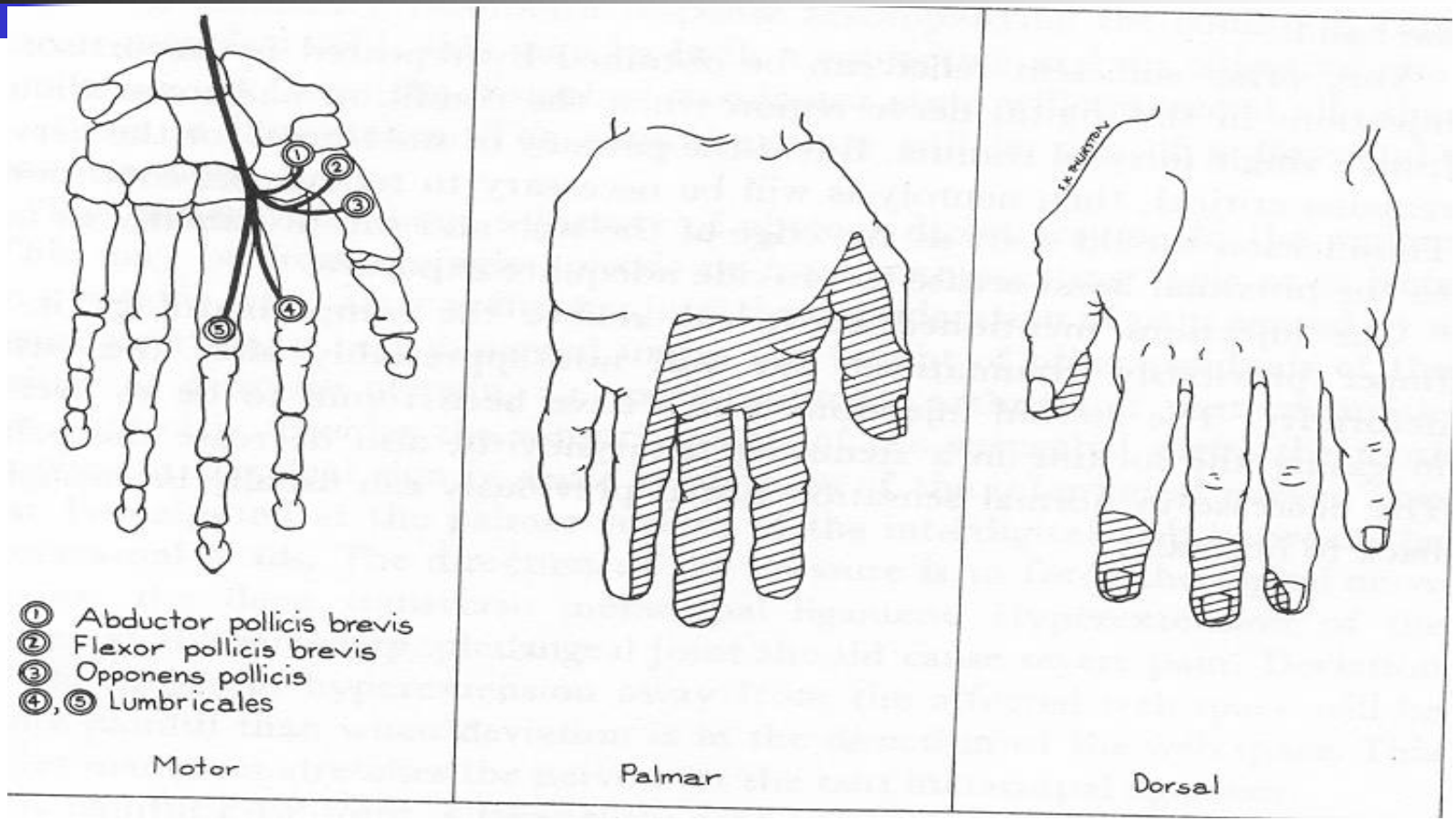
- 63 year old woman
- Numbness, tingling, pain of entire right hand X 4 months
- Awakens her at night.
- Drops objects from right hand
- Works as sander in furniture factory.
- Borderline diabetic
- Examination: Decreased cold entire right hand, normal strength, positive Tinel's right wrist, normal reflexes in the RUE

Carpal Tunnel Syndrome
Atrophy of APB Muscle

Dawson,Hallett, Millender, 1990

Median Nerve

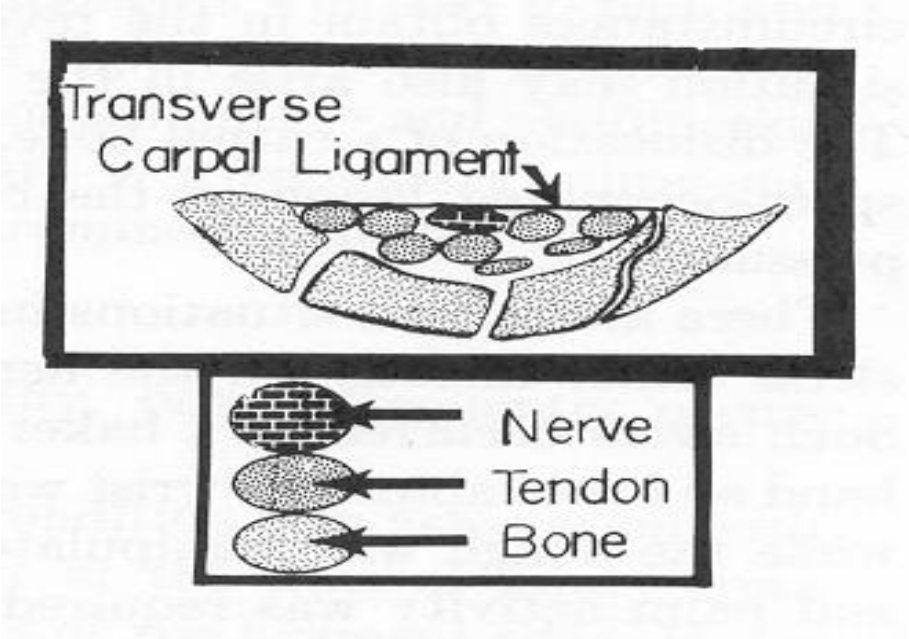
Innervation of the Hand and Sensory Loss



Kopell, Thompson, 1963

Carpal Tunnel Syndrome

X-Section View of Wrist



Kopell, Thompson, 1963

Case 1 continued

Sensory Conduction Studies

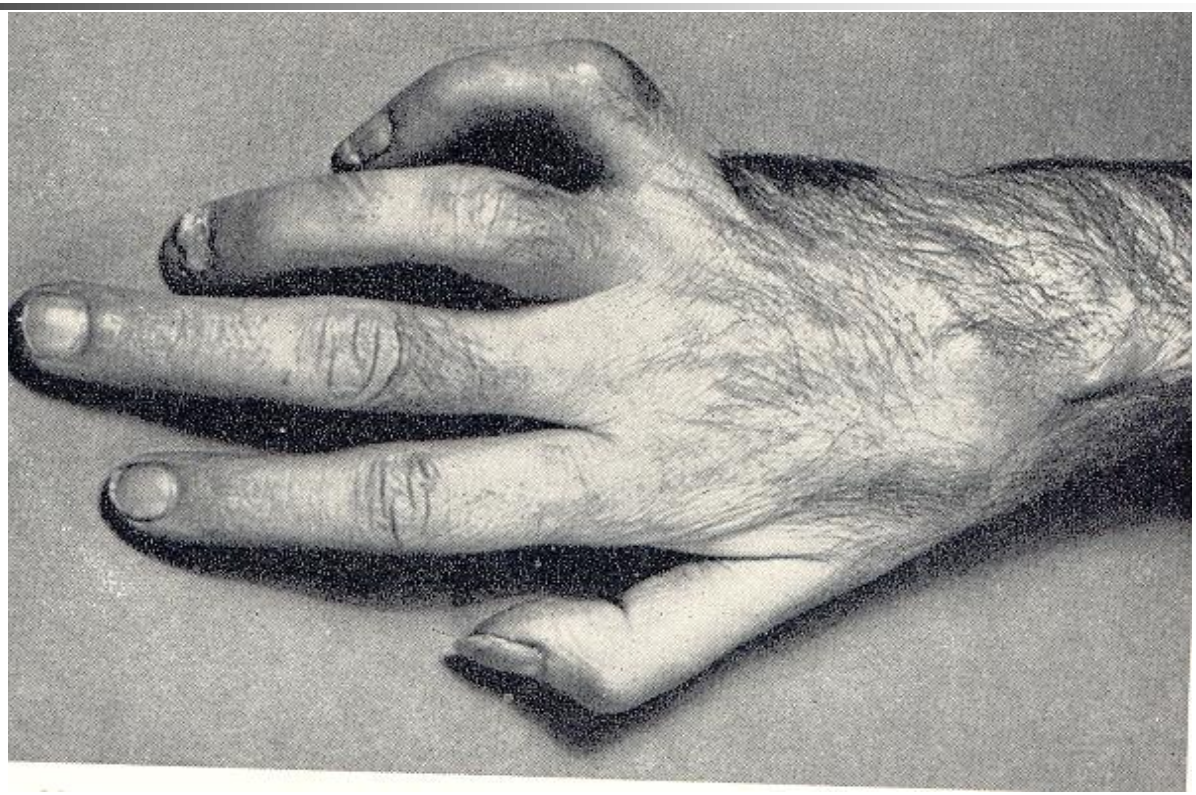
Side	Nerve	Recording Site	Stimulation site	Latency (ms)	Amplitude (mcv)	Cond. Velocity (m/s)
Right	Median	Digit 2	Wrist	4.2 (<3.5)	12 (>22)	
Right	Ulnar	Digit 5	Wrist	2.9 (<3.2)	21 (>10)	
Right	Radial	Dorsum thumb	Dorsum forearm	1.9 (<2.0)	23 (>21)	

Case 1 continued
Motor Conduction Studies

Side	Nerve	Recording Site	Stim. Site	Latency (ms)	Ampl. (MV)	Velocity (m/s)	F-wave (ms)
Right	Median	APB	Wrist	6.0 (<4.0)	2.9 (>4.0)		36
Right	Median	APB	Ante. Fossa		2.7	47 (>49)	
Right	Ulnar	ADM	Wrist	3.1 (<3.4)	7.3 (>6.0)		30.3
Right	Ulnar	ADM	B. Elbow		6.8	51 (>49)	
Right	Ulnar	ADM	A.		6.7	50	

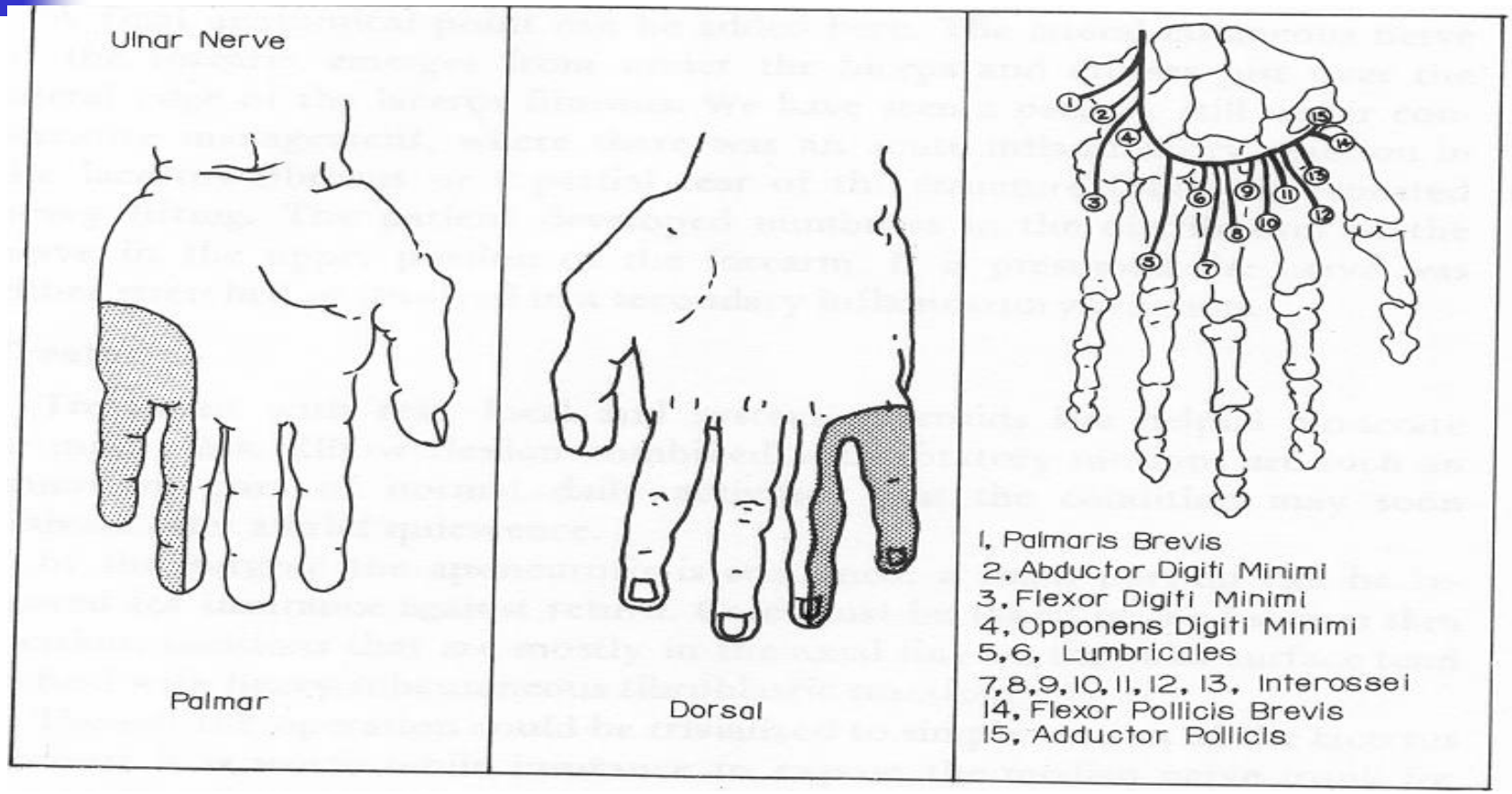
Ulnar Neuropathy

Claw Hand



Haymaker, Woodhall, 1953

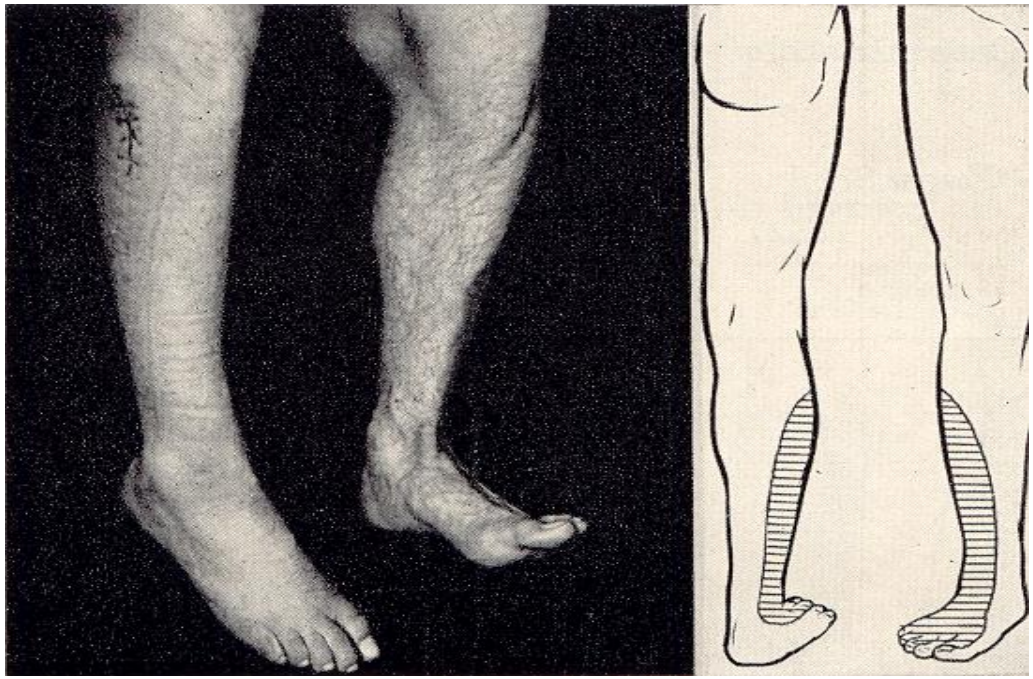
Ulnar Neuropathy
Sensory Loss, Nerve Innervation



Kopell, Thompson, 1963

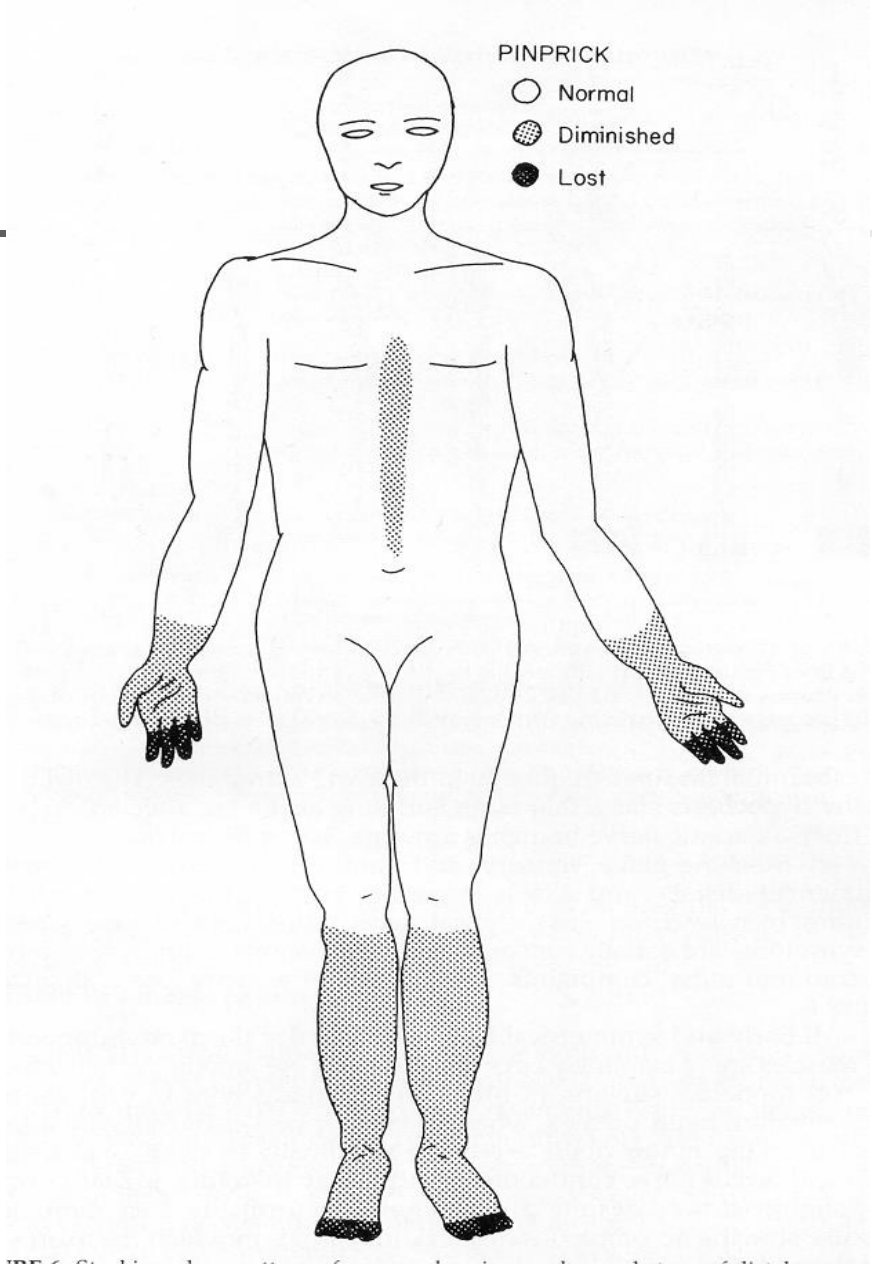
Common Peroneal Injury

Right Foot Drop and Sensory Loss



Haymaker, Woodhall, 1953

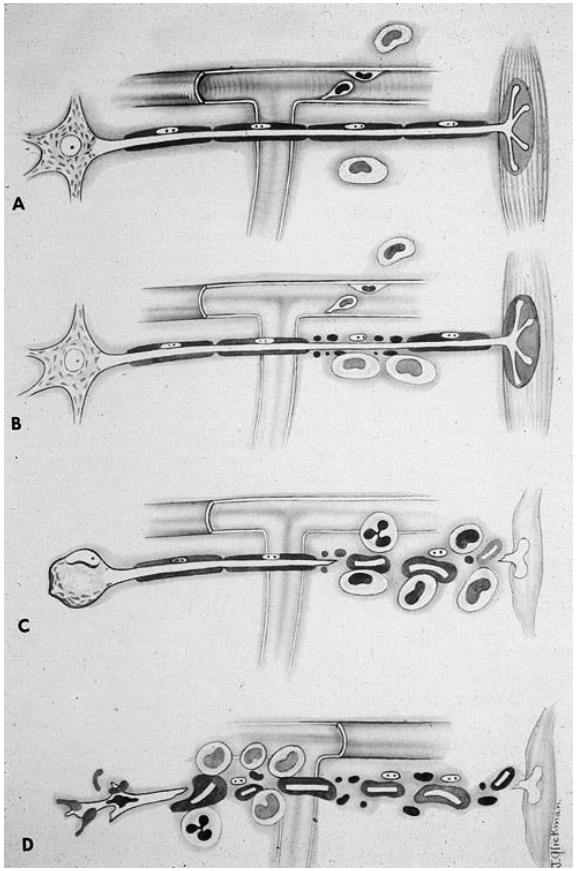
Length Dependent Motor and Sensory Polyneuropathy

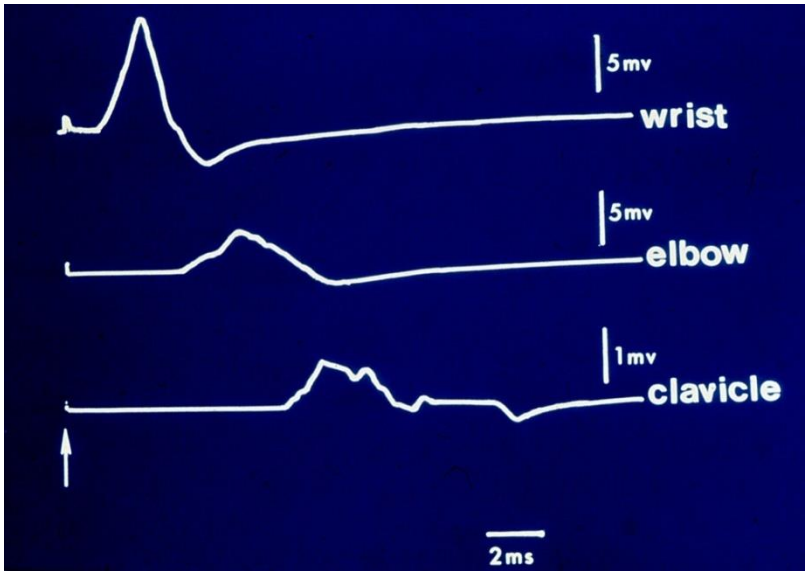


Plexopathy: Selected Etiologies

- **Compression** (CABG)
- **Inflammatory** (Parsonage-Turner Syndrome)
- **Radiation Injury** (Radiotherapy)
- **Traumatic Injury** (Traction, laceration, missile)
- **Ischemia** (Diabetic amyotrophy)

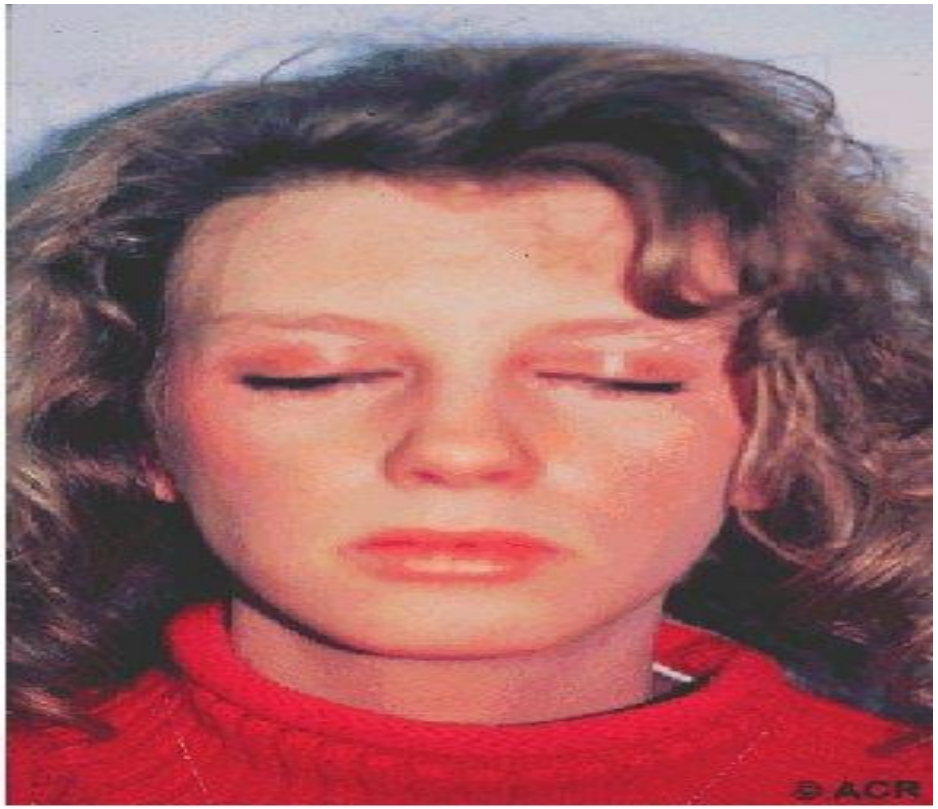
Guillain-Barre Syndrome
Conduction Block





Dermatomyositis

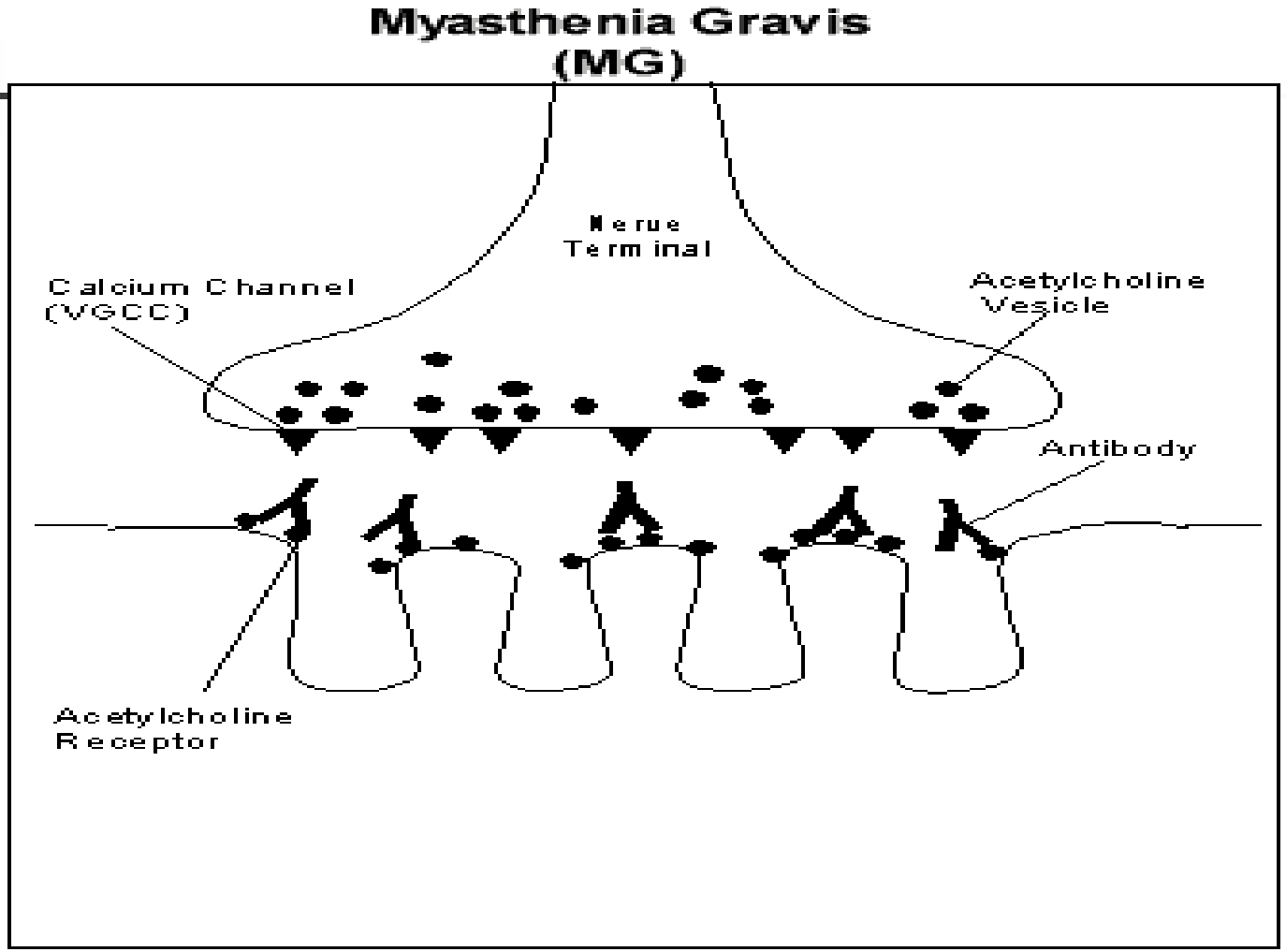
Eyelid and Facial Rash



Dermatomyositis

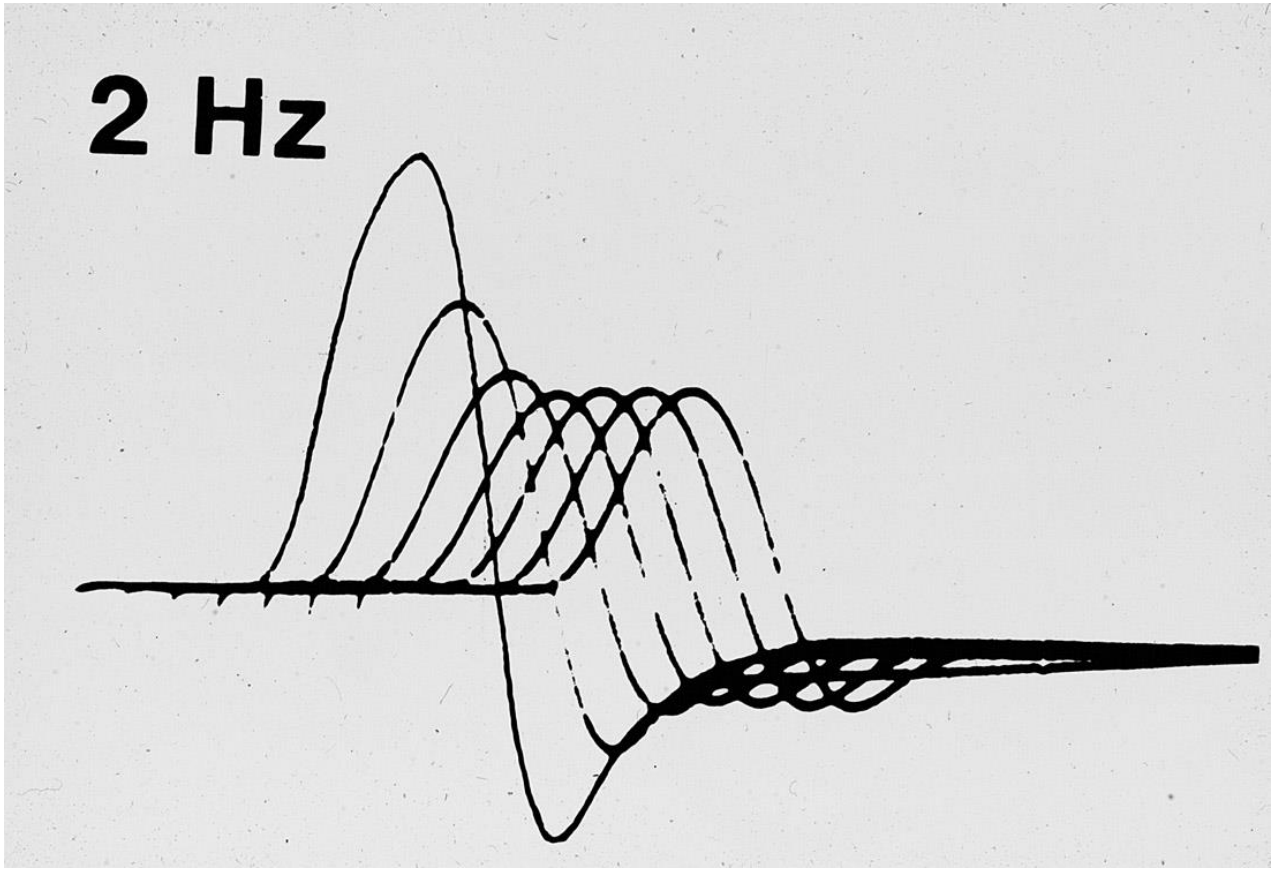
Hand Rash

Model of Neuromuscular Junction

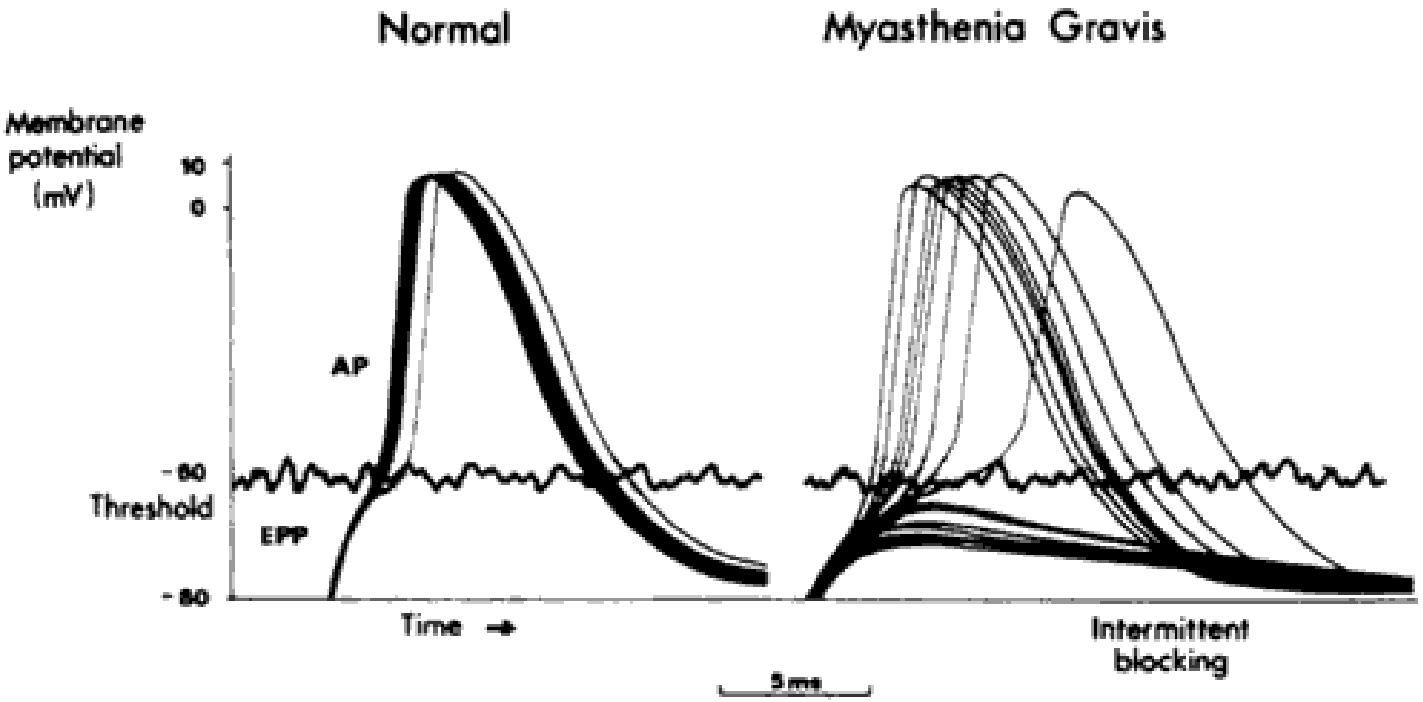


Acetylcholine Receptor
Antibody (AChRAb) Assay

Myasthenia Gravis
Repetitive Nerve Stimulation

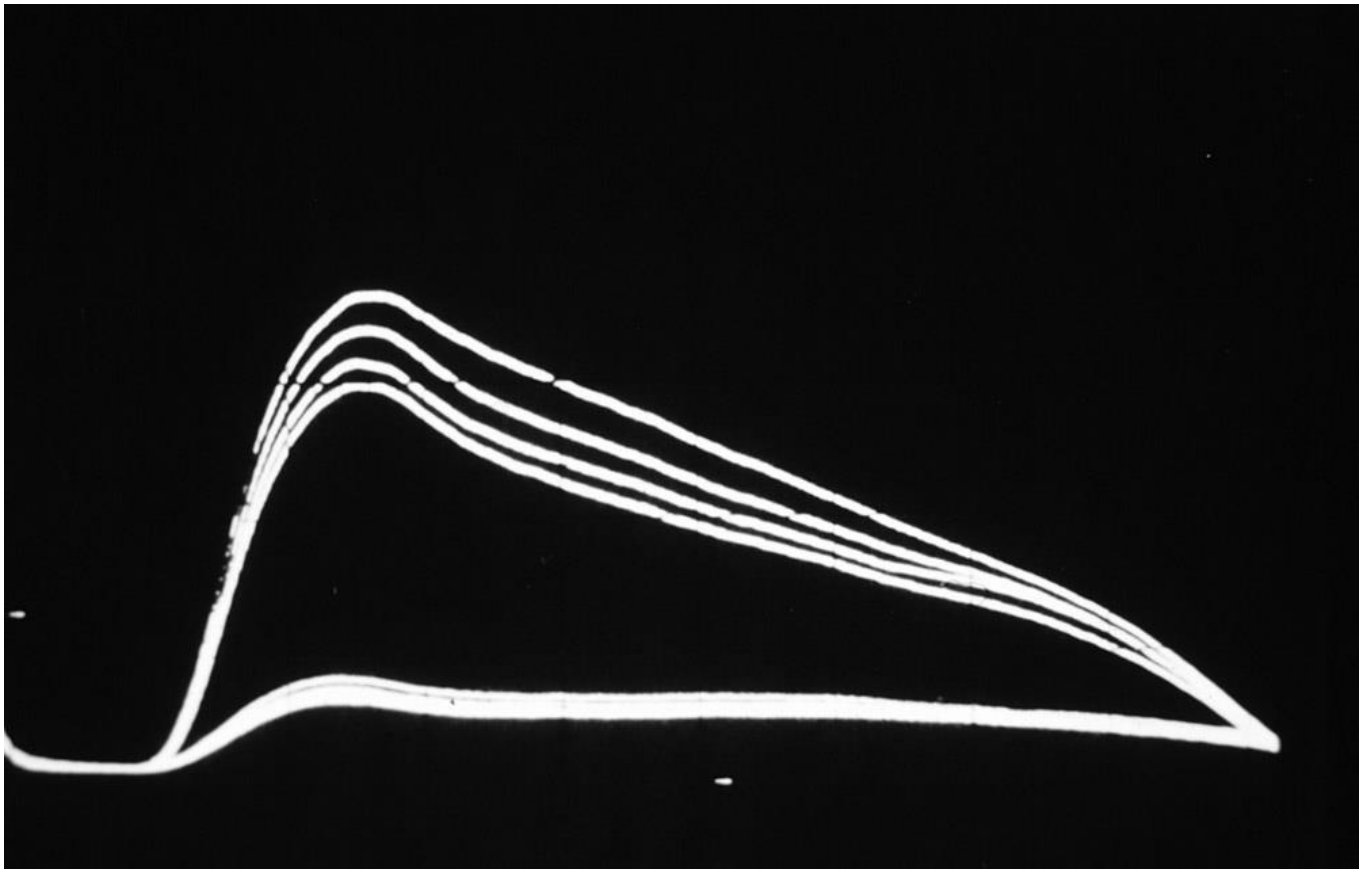


Single Fiber EMG
Myasthenia Gravis



Lambert-Eaton Syndrome

Repetitive Nerve Stimulation



What to Expect From an EMG Report

- A clinically and physiologically relevant interpretation/diagnosis
- An outline of the localization, severity, and acuity of the process
- Notation of other diagnoses that are detected/excluded
- Explanation of any technical problems

Summary: Utility of EMG/NCS

- Highly sensitive indicator of early nerve injury
- Detects dynamic and functional injury missed by MRI
- Provides information regarding chronicity of nerve injury
- Provides prognostic data
- Highly localizing
- Clarifies clinical scenarios when one disorder mimics another
- Identifies combined multi-site injury, avoiding missed diagnoses
- Identifies more global neuromuscular injury with focal onset
- Provides longitudinal data for charting course, response to therapy
- ** All dependent on a reliable laboratory with full repertoire of techniques

EMG "Pearls"

- Electrodiagnostic studies are a supplement to, and not a replacement, for the history and physical examination
- Electrodiagnostic results are often time-dependent
- Electrodiagnostic studies are not "standardized" investigations and may be modified by the practitioner to answer the diagnostic question