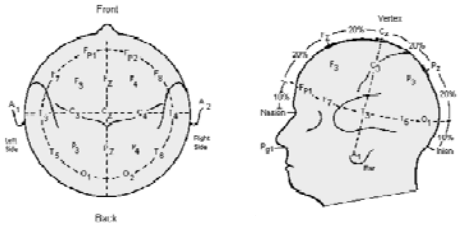
Electroencephalogram (EEG)

- Graphical depiction of cortical electrical activity, usually recorded from the scalp.
- Advantage of high temporal resolution but poor spatial resolution of cortical disorders.
- EEG is the most important neurophysiological study for the diagnosis, prognosis, and treatment of epilepsy.

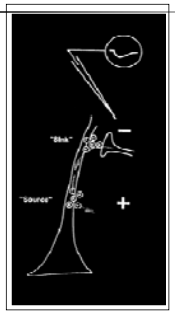
B-Slide 1

10/20 System of EEG Electrode Placement



B-Slide 2

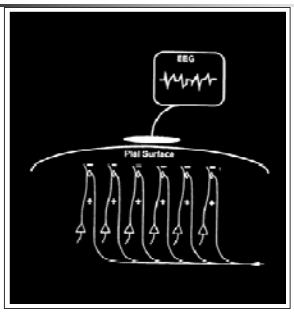
Physiological Basis of the EEG



- Extracellular dipole generated by excitatory post-synaptic potential at apical dendrite of pyramidal cell

B-Slide 3

Physiological Basis of the EEG (cont.)



- Electrical field generated by similarly oriented pyramidal cells in cortex (layer 5) and detected by scalp electrode

B-Slide 4

Electroencephalogram (EEG)

- Clinical applications
  - Seizures/epilepsy
  - Sleep
  - Altered consciousness
  - Focal and diffuse disturbances in cerebral functioning

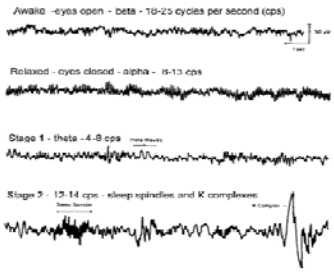
B-Slide 5

EEG Frequencies

- Gamma: 30-60 Hz
- Beta: 13-30 Hz
- Alpha: 8 to ≤ 13 Hz
- Theta: 4 to under 8 Hz
- Delta: < 4 Hz

B-Slide 6

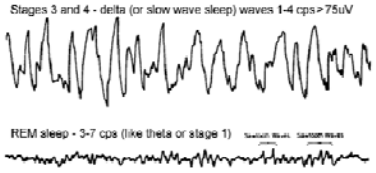
EEG Frequencies



Radtke, in Ebersole and Pedley, 2003

B-Slide 7

EEG Frequencies



Radtke, in Ebersole and Pedley, 2003

B-Slide 8

EEG Abnormalities

- Background activity abnormalities
  - Slowing not consistent with behavioral state
    - May be focal, lateralized, or generalized
  - Significant asymmetry
- Transient abnormalities / Discharges
  - Spikes
  - Sharp waves
  - Spike and slow wave complexes
  - May be focal, lateralized, or generalized

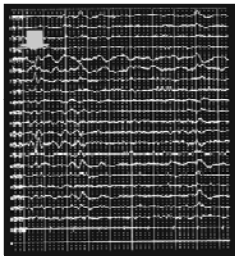
B-Slide 9

Focal seizure generation

- Seizure initiation
  - burst of action potentials, i.e. paroxysmal depolarizing shift
  - hypersynchronization of neighboring cells
- Propagation
  - activation of nearby neurons
  - loss of surrounding inhibition

B-Slide 10

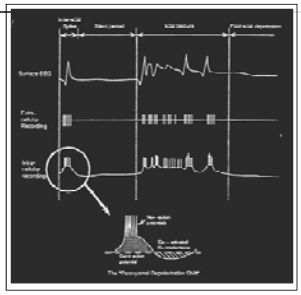
Sharp Waves



- An example of a left temporal lobe sharp wave (arrow)

B-Slide 11

Paroxysmal Depolarization Shift"



Intracellular and extracellular events of the paroxysmal depolarizing shift underlying the interictal epileptiform spike detected by surface EEG

Ayala et al., 1973

B-Slide 12

Generalized Spike Wave Discharge

B-Slide 13

EEG: Absence Seizure

B-Slide 14

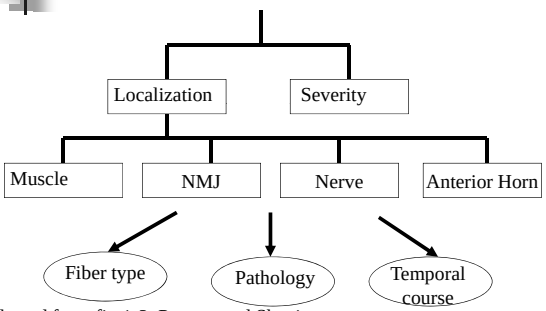
EMG and Nerve Conduction Studies

- **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

Goals of EDX Testing



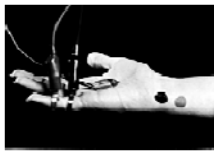
Adapted from fig 1-2, Preston and Shapiro

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

Types of nerve conduction studies

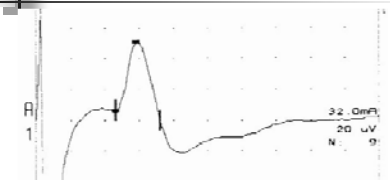
- Sensory: typically antidromic
- Typical nerves examined: Sural, ulnar, median, occasionally radial or superficial peroneal



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



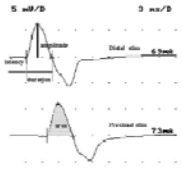
	Latency (msec)	CV (m/s)	Amp (uV)
Wrist-D2	2.2	58	44.1

Motor NCS Parameters

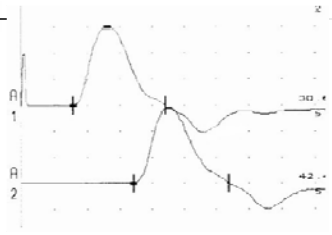
- Distal Latency
  - determined by conduction velocity of the nerve, neuromuscular junction & muscle
- Amplitude
  - determined by number of muscle fibers activated
- Proximal conduction velocity
  - determined by conduction velocity of the fastest fibers

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

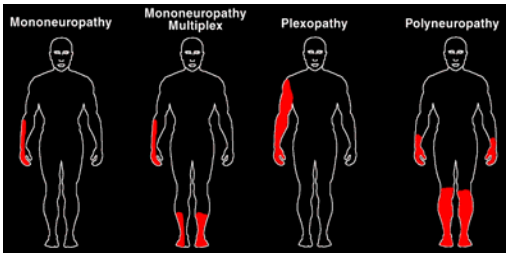


Normal Median Motor Study

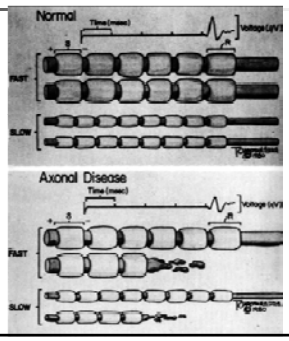


	DL (msec)	CV (m/s)	Amp (mV)
Wrist-APB	3.2		15.0
Elbow-Wrist		55	14.8

What is Peripheral Neuropathy?

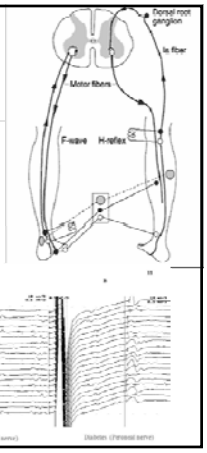


Nerve conduction responses after injury

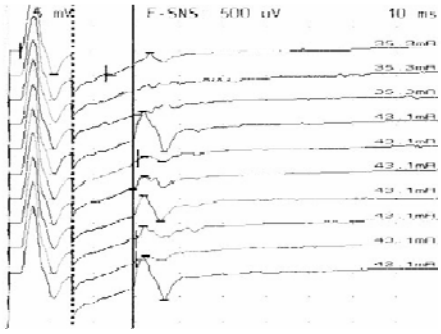


F-waves and H-reflex

- 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

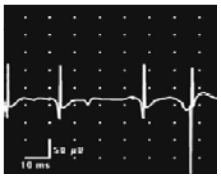
- **Insertional Activity**
- **Spontaneous Activity**
- **Motor Unit Configuration**
- **Motor Unit Recruitment**
- **Interference Pattern**

Needle Electromyography: Data

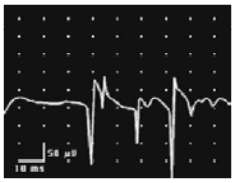
- **Motor Unit Configuration**
  - Single motor unit: A motor axon and all its muscle fibers
  - Motor Unit Configuration: Amplitude, Duration, Morphology
  - Muscle is volitionally activated at different force levels
  - Needle recording properties enable assessment of single MUs
- **Motor Unit Recruitment**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

EMG: Spontaneous Activity

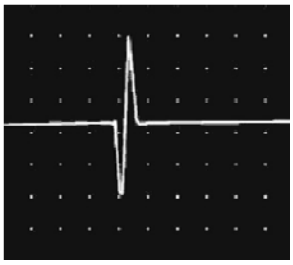
Fibrillation Potentials



Positive Sharp Waves

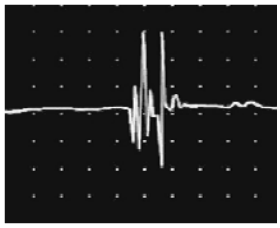


EMG: Spontaneous Activity



Fasciculation Potential

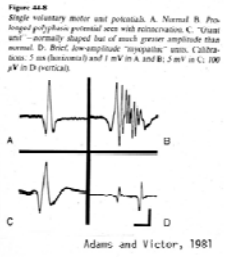
EMG: Neurogenic Motor Unit



10 msec/div, timebase

2MV/vertical segment

EMG
Motor Unit Changes



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

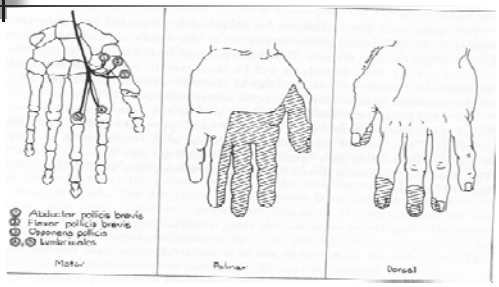
Carpal Tunnel Syndrome

Atrophy of APB Muscle

Dawson,Hallett, Millender, 1990

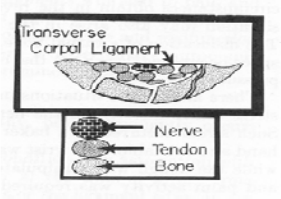
Median Nerve

Innervation of the Hand and Sensory Loss



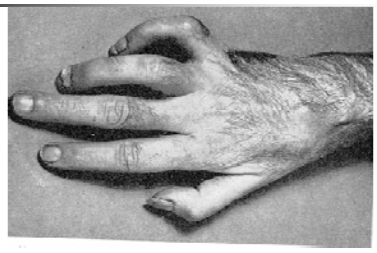
Kopell, Thompson, 1963

Carpal Tunnel Syndrome
X-Section View of Wrist



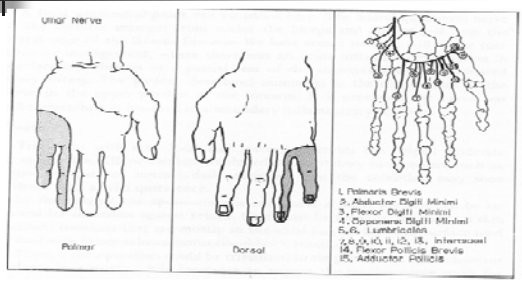
Kopell, Thompson, 1963

Ulnar Neuropathy
Claw Hand



Haymaker, Woodhall, 1953

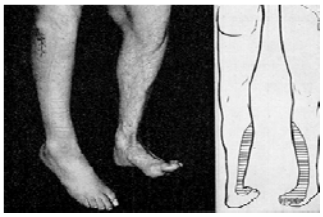
Ulnar Neuropathy
Sensory Loss, Nerve Innervation



Kopell, Thompson, 1963

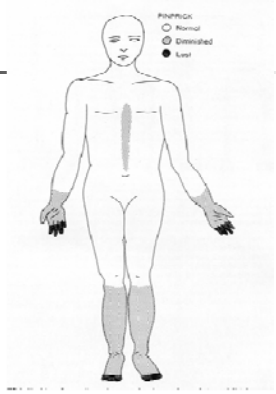
Common Peroneal Injury

Right Foot Drop and Sensory Loss



Haymaker, Woodhall, 1953

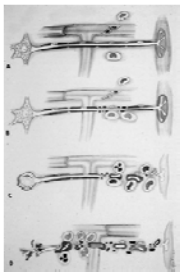
Length Dependent Motor and Sensory Polyneuropathy

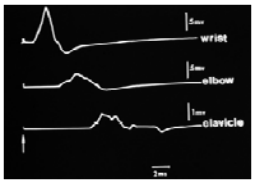


Plexopathy: Selected Etiologies

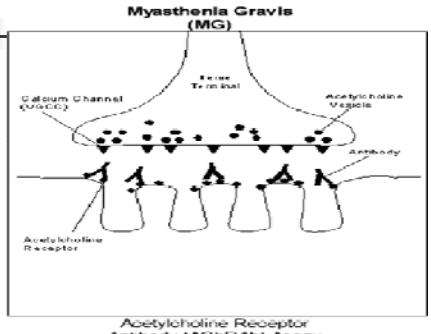
- **Compression** **(CABG)**
- **Inflammatory** **(Parsonage-Turner Syndrome)**
- **Radiation Injury** **(Radiotherapy)**
- **Traumatic Injury** **(Traction, laceration, missile)**
- **Ischemia** **(Diabetic amyotrophy)**

Guillain-Barre Syndrome
Conduction Block



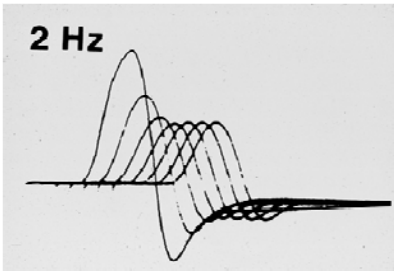


Model of Neuromuscular Junction

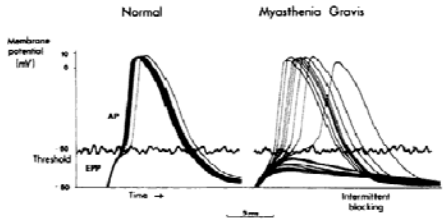


Acetylcholine Receptor
Antibody (AChRAb) Assay

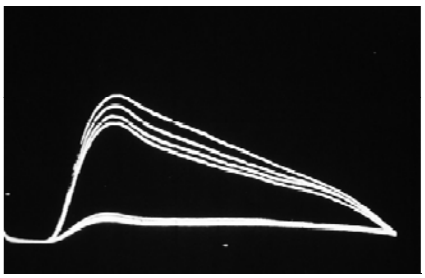
Myasthenia Gravis
Repetitive Nerve Stimulation



Single Fiber EMG
Myasthenia Gravis



Lambert-Eaton Syndrome
Repetitive Nerve Stimulation



Dermatomyositis
Hand Rash

Dermatomyositis
Eyelid and Facial Rash

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**
- **<u>** All dependent on a reliable laboratory with full repertoire of techniques</u>**