

# CLINICAL NEUROPHYSIOLOGY

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## Objectives:

1. Know the role of EMG/NCS in evaluating nerve and muscle function
2. Recognize common EEG findings and their significance
3. Understand VEP changes common in multiple sclerosis

## I. Electromyography & nerve conduction study (EMG/NCS)

The term EMG is often used loosely to refer to both the needle EMG examination and the nerve conduction study, as the two are usually performed together.

The needle electromyographic (EMG) examination employs a needle electrode (26 or 27 G) to record electrical activities from muscles. It is useful for evaluating weakness, denervation, reinnervation, and myopathic disorders of muscles, each of these conditions are associated with characteristic EMG patterns.

Nerve conduction study (NCS) uses electrical stimuli to evoke responses from sensory or motor nerve fibers. It measures the speed of nerve conduction (nerve conduction velocity) and the size of the sensory and motor responses (amplitude of the response from muscles or nerves). These values are then compared with normative values of the laboratory. The pattern of any abnormality present provides important clues to underlying disease. NCS is most commonly used to evaluate neuropathies, both focal and generalized neuropathies. It may identify sites of nerve entrapment (eg, carpal tunnel syndrome or ulnar neuropathy), or may help to confirm or characterize a diffuse nerve disorder (i.e. polyneuropathy). A variant of the technique -repetitive nerve stimulation -is used to assess neuromuscular junction disorders (eg, myasthenia gravis).

### Clinical Use:

1. Confirm or establish diagnosis / localize lesion: e.g., entrapment neuropathies or other focal neuropathies, radiculopathies, polyneuropathies, myopathies or neuromuscular junction D/O.
2. Characterize disease (e.g., demyelinative or axonal neuropathy), narrow differential Dx.
3. Assess severity: Therefore, useful in longitudinal follow-up (e.g., during treatment of neuropathy, such as carpal tunnel).
4. Assess prognosis: The amplitudes of sensory and motor responses reflect the number of functional or surviving nerve fibers and are useful prognostic indicators ( e.g., prognosis after nerve injuries).

### Limitations:

- I. Assess only large-diameter nerve fibers. (Autonomic function testing may be more useful in assessment of occasional neuropathy affecting predominantly small-diameter fibers.)

2. Uncomfortable. Though most patients find the procedure tolerable, occasional patients are unable to finish the testing.
3. Requires physician specially trained in neuromuscular diseases and the electrodiagnostic procedure. Results obtained by unqualified personnel are all too often misleading.
4. Expensive. These procedures are time consuming and therefore expensive.

## II Electroencephalography (EEG)

An EEG is a recording of electrical activity generated in the cerebral cortex that is most commonly recorded from the scalp. Each line of an EEG represents the comparison of electrical potential between two points on the head. Activity is described by the frequencies of the activity in hertz or Hz, which = 1/sec. They can be remembered by the mnemonic "D-TAB" and the Rule of 4's where Delta = 1-4 Hz (1 x 4), Theta = 4-8 Hz (2 x 4), Alpha = 8-12 Hz (3 x 4), and Beta = 12-16 Hz (4 x 4).

- Types of abnormalities:

- 1- Too slow, or encephalopathic, indicating lack of normal function. Normal awake adults have posterior dominant activity in the Alpha range, and frontal activity in the Theta range. Delta activity while awake is abnormal. Slowing can be focal or generalized indicating regional or global brain dysfunction.
- 2- Paroxysmal epileptiform activity include spikes or sharp waves, which are consistent with a risk for seizures. Epileptiform discharges can be focal or generalized, indicating a risk for partial or generalized seizures.

Epilepsy - sensitivity of a single interictal EEG about 40%. Repeated EEGs with special recording techniques increase sensitivity to 65-85%. False positive rate for paroxysmal abnormalities is less than 2%.

- Assist in diagnosis of encephalopathies/dementia/psychiatric illness.

- Additional techniques:

Sleep deprivation is an activation procedure that increases the yield of epileptiform D/Cs.

Special electrodes: sphenoidal record from the anterior/mesial temporal lobe).

Photic stimulation- occasionally activates generalized epileptiform D/Cs.

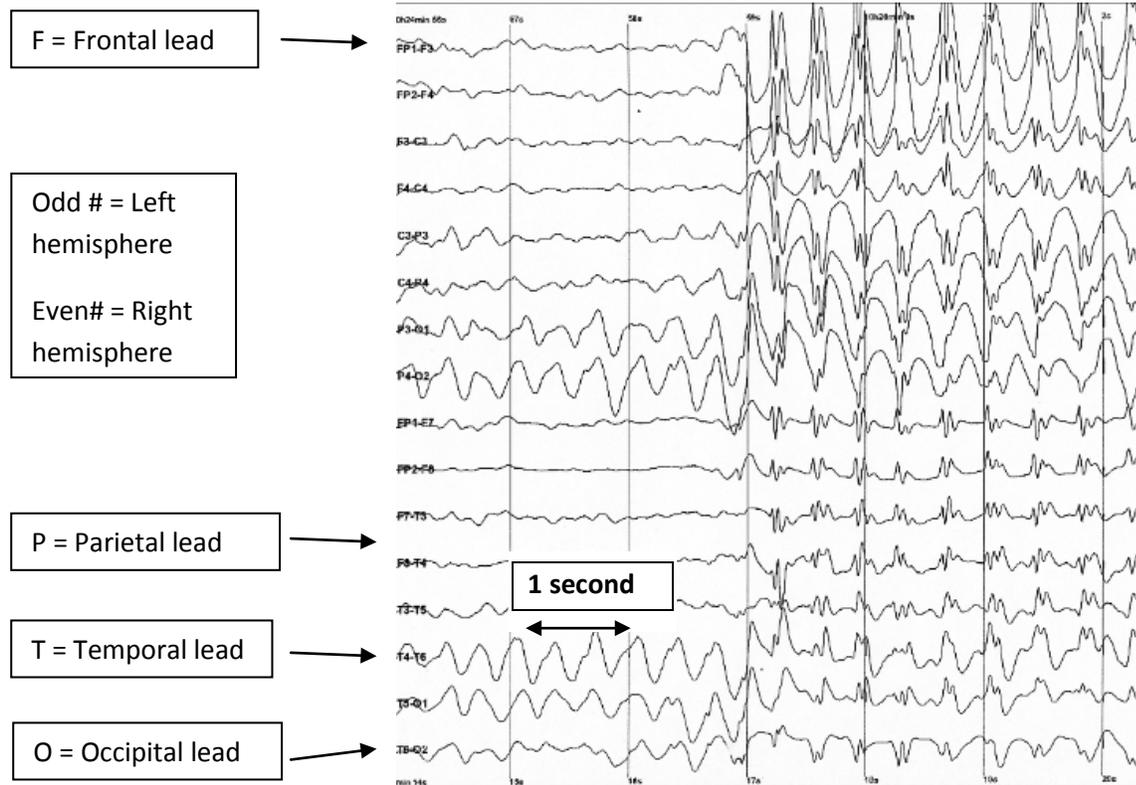
Hyperventilation- often elicits absence seizures.

Ambulatory EEG (prolonged recording to increase chance of recording paroxysmal activities).

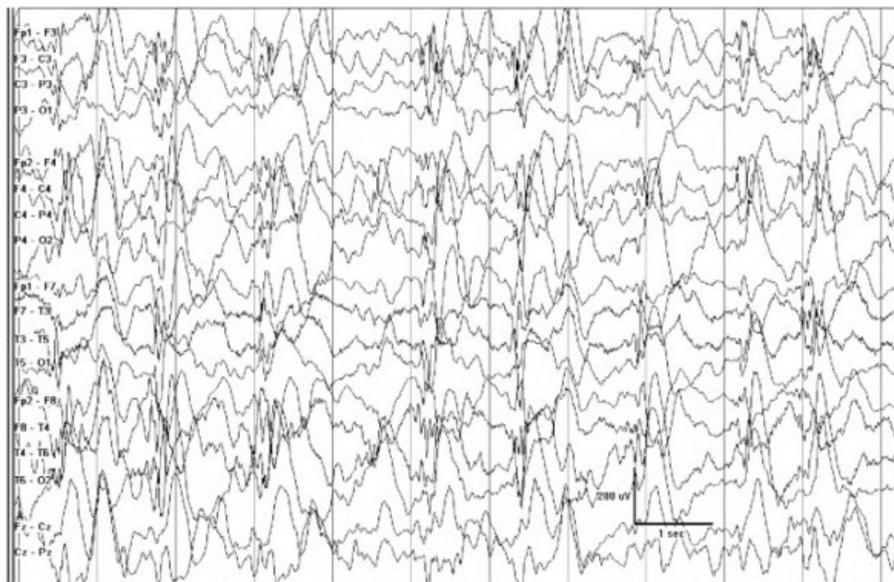
Video-monitoring (prolonged recording that additionally provides clinical/EEG correlates of ictal or other paroxysmal activities).

Polysomnographic recording (All-night sleep recording and multiple sleep-latency test (MSLT). These tests are used for evaluation of sleep disorders (e.g., sleep apnea and narcolepsy).

Confirmatory test for brain death – documentation of electro-cerebral silence (ECS).



Above: absence seizure that consists of 3 Hz spike and wave activity that is generalized and maximal bifrontally. From <http://commons.wikimedia.org/wiki/File:Spike-waves.png>



Above: Hypsarrhythmia = chaotic spikes and slow waves consistent with infantile spasms. Korff CM & Nordli DR Jr Epilepsy syndromes in infancy. *Pediatr Neurol.* 2006 Apr; 34(4):253-63.



Above: Burst-suppression in 1:3 ratio of time of burst to time of suppression, consistent with profound encephalopathy. Korff CM & Nordli DR Jr Epilepsy syndromes in infancy. *Pediatr Neurol.* 2006 Apr; 34(4):253-63.



Above: Right Frontal Periodic Lateralizing Epileptiform Discharges (PLEDs), consistent with a risk for seizures and focal brain injury. When temporal, often due to herpes encephalitis. D. Chong, L. Hirsch Which EEG Patterns Warrant Treatment in the Critically Ill? Reviewing the

Evidence for Treatment of Periodic Epileptiform Discharges and Related Patterns *J. Clin. Neurophysiology*, Apr 2005 22(2):79-91

### **III. Evoked Potentials (EPs)**

- What is an EP? An electrical potential generated in the peripheral or central nervous system following some stimulus that evaluates sensory conduction in the central or peripheral sensory pathways.
- Visual EP (VEP)- measures conduction from eye to visual cortex following visual stimulation, and is often slowed during and after optic neuritis.
- Brainstem auditory EP (BAEP)- measures conduction from ear to lower midbrain following auditory stimulation.
- Somatosensory EP (SSEP)- measures conduction from electrical stimulation of peripheral nerve (usually median in the arm and posterior tibial in the leg) to cortex.
- Other special EPs (motor, cognitive, movement-related)

Clinical applications:

- Multiple sclerosis (where exam and MRI do not generate a definite diagnosis)
- Assessment of hearing/visual impairment in infants
- Peripheral nerve/root diseases- in general, EMG/NCS is better than EPs
- Tumors
- Intraoperative neuro monitoring (IOM)
- Prognosis of coma

The utility of all clinical neurophysiologic techniques depends on the expertise of the neurologist/clinical neurophysiologist and the technologist as well as the ability of the referring physician to ask a specific question that can be answered with these techniques.