Gli Artefatti in Elettroneurografia

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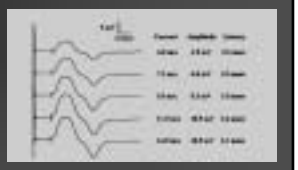
Artifacts in nerve conduction studies

Stimulus-related issues

A. Stimuli should be supramaximal

Generally the intensity recommended is 25% above what appears to be supramaximal based on plateauing amplitude with an incremental increase in stimulus intensity.



Supramaximal Stimulation

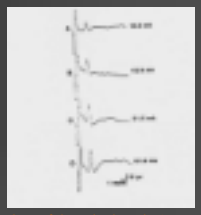
As stimulus intensity is increased, amplitude increases and distal latency decreases.

Artifacts in nerve conduction studies

Stimulus-related issues

B. Submaximal stimuli

1. Single submaximal stimuli when delivered at a distal stimulation site will produce APs of smaller amplitude and thereby simulate axon loss.
2. Single submaximal stimuli when delivered at a proximal stimulation site will produce APs of smaller amplitude and thereby simulate conduction block
3. Repetitive submaximal stimuli may produce erroneous decrements or increments.



Change of the amplitude on the CNAP with change of stimulus intensity

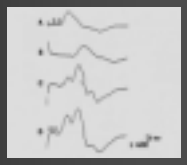
Artifacts in nerve conduction studies

Stimulus-related issues

C. Co-stimulation

1. With stimulus intensities way above supramaximal there is co-stimulation of adjacent nerves.

This can be a major problem when there is prominent axon loss in the nerve stimulated, but not in the co-stimulated nerve.



Spread effect

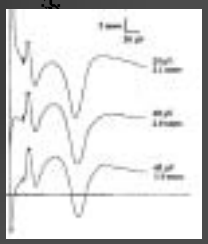
Stimulation of wrong nerve

Artifacts in nerve conduction studies

Stimulus-related issues

D. Stimulus Artifact

1. The stimulus artifact is of course essential to latency measurements.
2. The artifact becomes a problem when it obscures the onset of the potential of interest, and is mainly an issue for recording of relatively small signals (eg. sensory potentials) when the distance between the stimulating and recording electrodes is short.



Artifacts in nerve conduction studies

Stimulus-related issues

D. Stimulus Artifact

3. Artifact can be diminished by:
   a. placement of the ground between the stimulating and recording electrodes
   b. reducing the impedance to current flow at the stimulus site by skin preparation (decreasing with solvents, removing callous) and use of electrode jelly or saline on stimulus electrodes
   c. reducing impedance mismatch between the recording electrodes by skin preparation and use of electrode jelly
   d. decreasing the distance between the active and reference recording electrodes (if possible)
   e. increasing the distance between the recording and stimulus electrodes (if possible)
   f. keeping the stimulus intensity as low as possible
   g. keeping the stimulus remote from the recording electrode cables

Artifacts in nerve conduction studies

Stimulus-related issues

E. Bridging and Virtual Cathode

1. Electrical stimuli bring nerve to action potential at the node directly under the cathode. Exceptions:
   a. When stimulus spreads along low resistance paths (eg. excessive saline, electrode jelly on the skin) resulting in delivery of current to adjacent nerve segments
   b. With high currents, stimuli may be of sufficient magnitude to bring more distal nodes to action potential

Artifacts in nerve conduction studies

Recording-related issues

A. Signal to noise ratio

1. A high signal to noise ratio is particularly important for the recording of small sensory or mixed nerve potentials.

This problem is typically addressed as follows:

a. High frequency (low pass) filtering out of high frequency noise

b. Pre - amplification near recording electrodes

c. Averaging

Artifacts in nerve conduction studies

Recording-related issues

B. Placement of recording electrodes

The recorded wave forms result from differential amplification of the active minus the referential electrode.

Hence, for motor potentials, the electrodes are usually placed in a "belly-tendon" montage with the recording electrode over the motor point of the muscle in question and the reference over a relatively indifferent site, the tendon.

There are 2 major sources of error:

a. When the recording electrode is not optimally placed, the amplitude of the wave form is sub-maximal. (for motor studies, such potentials may be preceded by a positive deflection).

b. The reference electrode may in fact not be over an indifferent site, and the resultant wave form in the case of CMAPs may be a composite from more than 1 muscle

Changing recording sites

Near nerve technique

Artifacts in nerve conduction studies

Recording-related issues

C. Impedance mismatch

Differential amplification results in useful data only when the recording and referential electrodes are matched for impedance.

If one of the electrodes is defective or more commonly if the skin is not carefully prepared under both electrodes, the resultant traces will be contaminated by various artifacts even when the patient is properly grounded.

Again, this will be more of a problem with high amplification as in the recording of sensory potentials.

Artifacts in nerve conduction studies

Recording-related issues

D. Side-to-side symmetry of SNAP amplitude

Reduction of SNAP amplitude is an indication of post-ganglionic axon loss. In patients with unilateral symptoms, side-to-side comparison of SNAP amplitude is commonly performed.

The ratio of smaller to larger amplitude SNAP in normals is as low as 0.5 for median and ulnar nerves, and 0.4 for radial, musculo-cutaneous, sural and superficial peroneal nerves.

Artifacts in nerve conduction studies

Anatomy-related Issues

A. Measurements

Calculation of segmental conduction velocities relies on surface distance measurements to estimate neural distance from one stimulus site to another.

There are several sources for error:

1. Nerve may be redundant in its course around various joints (eg. ulnar nerve around elbow), and the distance measurements will be an underestimate, unless the joint is flexed.
2. Proximal nerve segments (plexus, root) are particularly difficult and are usually measured with calipers.
3. The greatest chance for error is with very short distances between stimulating sites, since mistakes of ± 1 cm in estimating the exact stimulus sites will have greatest impact when the total distance is small (eg. less than 5 cm). Hence, for routine calculation of segmental conduction velocities with surface techniques, on try to keep the inter-stimulus distance at least 10 cm.

Artifacts in nerve conduction studies

Anatomy-related Issues

B. Anomalous Innervation

1. Forearm median to ulnar anastomoses (MUAs) occur in about 20% to 30% patients, and occur bilaterally in about 2/3 of them. In most (80%) of the patients, the MUA innervates ulnar intrinsic hand muscles in (or near) the thenar (FDI, Add Poll) and hypothenar (ADQ) areas in about 17%, only ADQ fibers are involved.

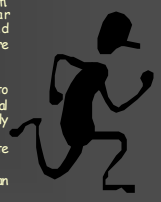
There are at least 4 important consequences of such anomalies:

a. In CTS, the presence of MUA may make it impossible to calculate a true forearm conduction velocity without using special techniques. Without them, the calculated velocity is spuriously fast.

b. The presence of a MUA to hypothenar muscles can simulate conduction block in the ulnar nerve in the forearm.

c. In the presence of a MUA, injuries to the proximal median nerve may result in denervation of ulnar hand muscles.

d. In a complete MUA (eg. median hand), complete lesions of the proximal ulnar nerve will spare all ulnar-innervated intrinsic hand muscles.



Artifacts in nerve conduction studies

Anatomy-related Issues

B. Anomalous Innervation

2. The other common anastomosis is the accessory peroneal innervation of the EDB.

Normally, this muscle is supplied by the deep peroneal branch, but in about 20-30% of patients is supplied by the superficial peroneal branch of the peroneal nerve.

Deep peroneal neuropathies in the presence of this anomaly will be atypical by virtue of EDB sparing clinically. It can also obscure the electrodiagnosis of conduction block at the fibular head when recording from EDB.

Artifacts in nerve conduction studies

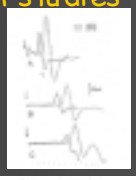
Physiological Issues

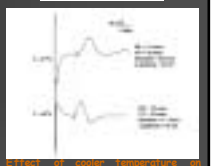
A. Temperature

There is great inter-individual variation in limb temperature even when ample time is allowed to equilibrate in a warm lab. Moreover, there is marked variation of neural temperature over the course of a given nerve with a gradual trend toward cooler temperatures from proximal to distal and deep to superficial within the respective limb.

The main effects of cooling on electrophysiological measurements are as follows:

1. Prolongation in distal latency
   a. approx 0.2 msec/deg C (motor)
2. Slowing of conduction velocity
   a. approx 2.4 M/s/deg C in the arms (motor)
   b. approx 2.0 M/s/deg C (medians sensory)
   c. approx 1.7 M/s/deg C in the legs (motor)
3. Increase in CMAP and SNAP amplitude
4. Increase in CMAP and SNAP duration
5. Decrease in decrement during rep stimulation
6. Decrease in post-exercise increment
7. Increase in motor unit duration and polyphasia
8. Decrease in fibrillation potentials
9. Increase in myotonic discharges





Effect of cooler temperature on latency, duration and amplitude of the recorded sensory nerve action potential.

Artifacts in nerve conduction studies

Physiological Issues

B. Failure to correct or control for decrease in temperature can result in:

1. Overdiagnosis of polyneuropathy
2. Overdiagnosis of distal entrapment neuropathy (eg. CTS)
3. Underdiagnosis of neuromuscular junction disorders (eg. myasthenia gravis, Lambert Eaton)
4. Underappreciation of active denervation (eg. ALS)

Artifacts in nerve conduction studies

Physiological Issues

C. Methods to deal with low temperature

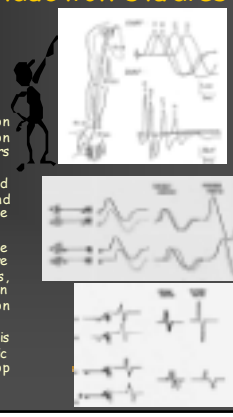
1. In general, it is preferable to raise limb temperature to approx 34 deg C than to use corrective formulas
2. Thermistor-controlled infrahead heating lamps are better at maintaining than raising temperature, so for significantly cool limbs, it is preferable to immerse the limb in warm water initially and then apply the lamp.

Artifacts in nerve conduction studies

Physiological Issues

D. Temporal dispersion

1. Compound sensory and motor action potentials are spatially-summed population responses which reflect a range of fibers with different conduction velocities.
2. As distance between the stimulus and recording electrodes increases, CMAP and SNAP duration increases and amplitude declines.
3. SNAP declines more than CMAP amplitude because individual nerve fiber potentials are briefer than motor unit potentials, dispersion producing more phase cancellation (and amplitude reduction). No magnification in SNAP.
4. In acquired demyelinative neuropathy, it is often impossible to distinguish pathologic dispersion with phase cancellation and drop in CMAP amplitude from conduction block.

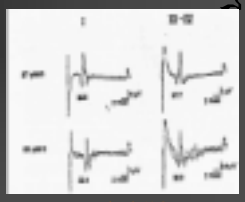


Artifacts in nerve conduction studies

Physiological Issues

E. Age

1. Electrophysiologic measurements must be interpreted in light of the patient's age.
2. Nerve conduction velocity rapidly increases from birth to 3-5 yrs of age, at which point they begin to plateau.
3. Beginning at about age 40, there is a slow decline in velocity, CMAP and SNAP amplitude, and an increase in motor unit duration and phases.



Interdigital CNAPs

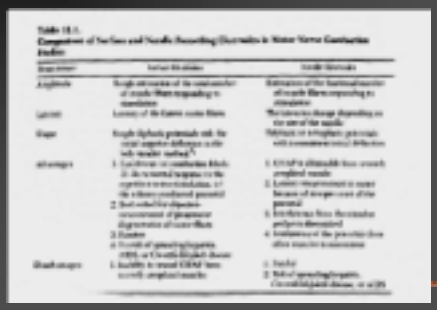
Artifacts in nerve conduction studies

Physiological Issues

F. Nerve Length and Height

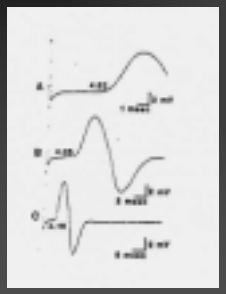
1. Shorter nerves conduct faster than longer nerves.
2. This is true to some extent at the individual level in that median and ulnar nerves conduct faster than peroneal and tibial.
3. Some argue that this is also true between individuals, such that nerve conduction in very tall subjects is slower than in shorter subjects. (Others suggest that this is only an artifact of height-dependent cooling.)
4. Whether due to nerve length itself or to associated cooling, failure to recognize this finding may result in overdiagnosis of neuropathy in the very tall.

Artifacts in nerve conduction studies



Artifacts in nerve conduction studies

Sweep

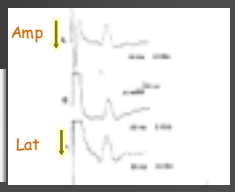


Artifacts in nerve conduction studies

Filtri

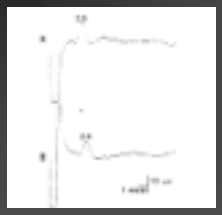
Change of the amplitude on the CMAP with a filter change

Change of the CNAP with a filter change



Artifacts in nerve conduction studies

Polarity



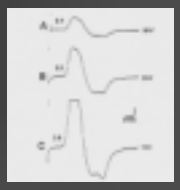
Proximal cathodic stim

Distal cathodic stim

Artifacts in nerve conduction studies

Sensitivity

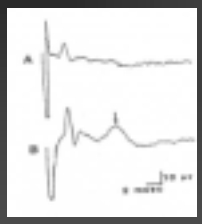
Small CNAP preceding CMAP



Change of latency with different sensitivity

Artifacts in nerve conduction studies

Contamination of CNAP by a musde artifact

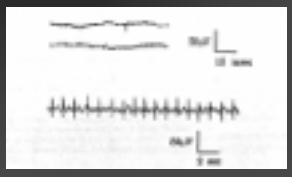


Ortodromic

Antidromic

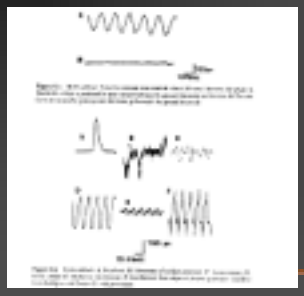
Artifacts in nerve conduction studies

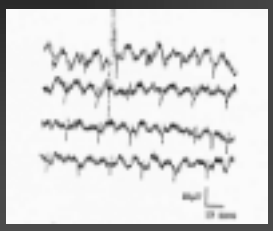
Pace-Maker



Artifacts in nerve conduction studies

Rete



Artifacts in nerve conduction studies

Radiofrequency artifacts mimicking fibrillations