Small Grains we may miss when busy with Routine EDX

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Special phenomena in /EMG SFEMG

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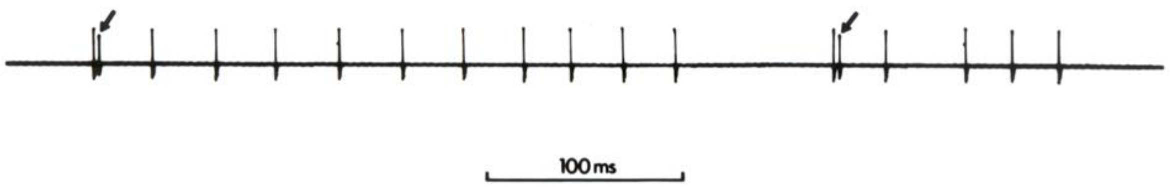
1. Firing rate

1.1. Renshaw

Firing rate in individual motor neurons is determined by central and peripheral factors. One of the regulatory mechanisms is by so called Renshaw inhibition by which a branch from the motoraxon is recurrently connected back to the motor neuron and produces inhibition.
The time to effective inhibition includes the conduction time along the motor axon via the Reshow loop and the production of an IPSP.
At the initiation of voluntary activity, one may see the effect of this delay until full Renshaw inhibition is reached. Directly after a pause in voluntary activity, say for 10 seconds the first activity that is seen is often a double pulse, with an interval between pulses of about 10 msec corresponding to a firing rate of 100 Hz. These doublets aid in the rapid production of force, increasing the "efficiency" of force production [2]. One may assume that this is the initial firing rate of that motor neuron. During continuous activity Renshaw inhibition is produced, but the first discharge is not yet inhibited by previous activity. The pulse may pass before the window is closed.



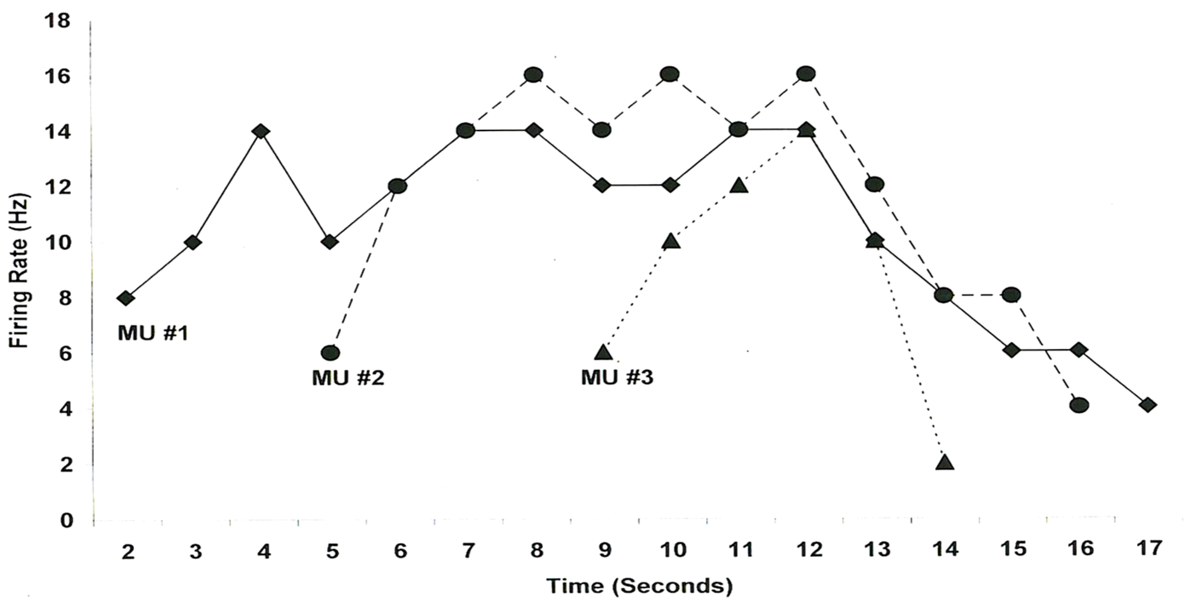
This may have few implications in EMG and relation to pathology is not known.
This phenomenon is of theoretical interest but may have physiological implications.

- These initial double pulses should not be mistaken for extra discharge in the nerve.
- In jitter analysis, this will cause an abnormal inter discharge interval with a shortening of the latency and decrease in amplitude due to the VRF and AMF effects[4]
- The motor effect of the double discharge is temporal summation of two close pulses, which gives rise to the acute increase in initial force. This has been described and is a way to reach attempted force output faster than if thee force one builds up via regularly firing of the motor unit action potentials.

1.2. Recruitment of new MUs

One of the important regulator a firing rate is also the music spindle drive. With unloading, as seen when testing silent period, ongoing voluntary activity may be completely stopped. This can also be seen om single neuron level by the similes interval histogram where a "disturbing" stimulus is given

during voluntary activity (see below) . The disturbance in the firing pattern can be quantitated and the excitability of the anterior horn cell and the pyramidal cell and be studied.. This unloading phenomenon can also be seen in a different way.
Doing slow increase in force, the firing rate of individual MUs increases and the firing increases regularly. When new MU starts is activity as a normal phenomenon in the increase of force, the firing rate shows a transient decrease in firing rate of already MUs FIG. (see separate Stålberg lecture on this)



Thr firing rate of already activity MU(s) is decrease with a new MU starts to fire (MU#2, MU#3. Casa engineering, with permission

1.3. Abnormal extradischarge

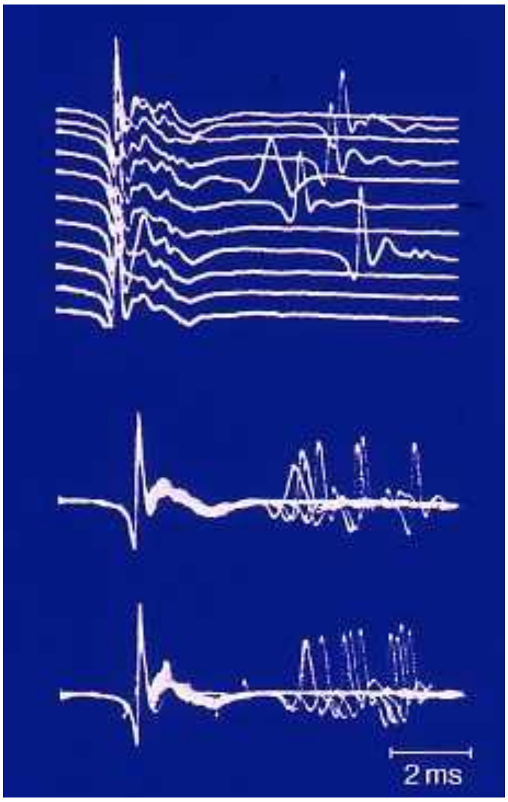
During voluntary activation with low force, we sometimes see double discharges, usually generated in the nerve and not the muscle since the entire MUPs shape is repeated. Here a few characteristics of extradischarges (EDs):

- The interval is more than 3 ms between the two discharges
- The ED has a lower amplitude, related to the interval to the first discharge
- Next regular discharge is often missing and the interval to next discharge is doubled.

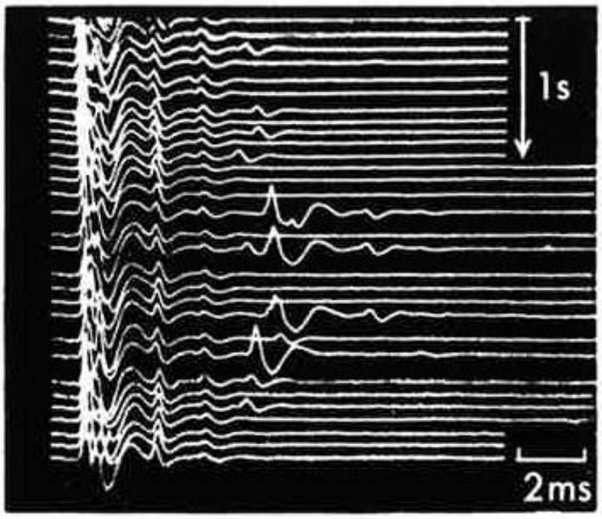
This ED may sometimes lead to complex MUPs mistaken for being complex with some jitter.
In SFEMG the disturbed rhythm during voluntary contraction will cause a temporary effect on the jitter.

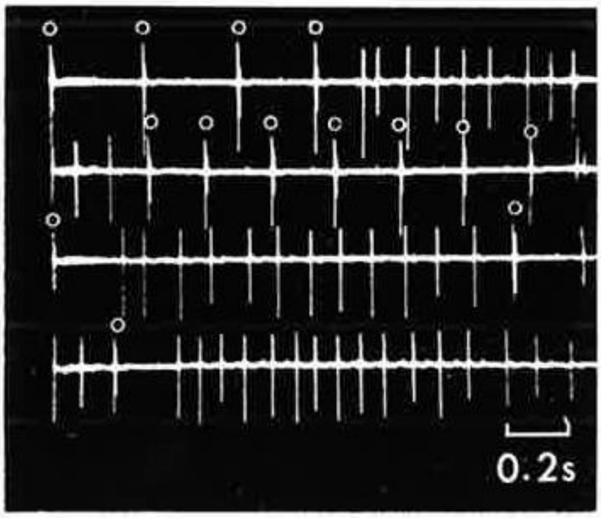
This phenomenon may be due to various reasons, not studied in detail

- collision of the abnormal ED nerve impulse when this is travelling in proximal direction
- Renshaw activation of antidromic travelling impulse (not likely that this should cause a complete drop out of one normal dischagrge, rather a disturbed rhythm)
- unloading caused by the extradischarge e.g. if the spindle is the vicinity of the active MU, not far away in the muscle. This has been called the muscle unit. (read Hagbarth). Unlikely, as above.

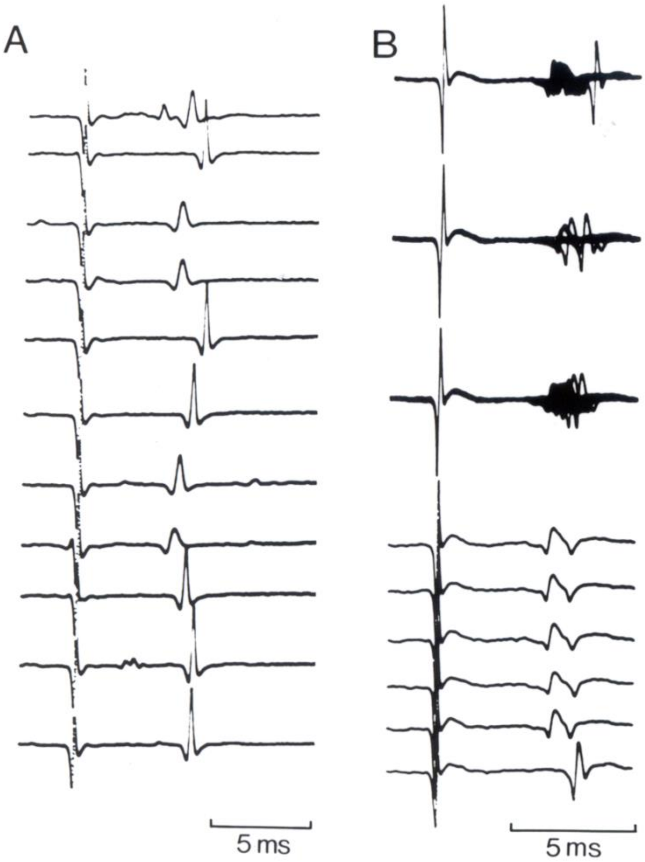


Extradischarges (ALS) in some MUPs. Note the change in shape if the ED is close to the original discharge.





Note the "pause" after each double discharge, As raster mode, free run and in the histogram of IDI.



Note that the amplitude of the ED has a lower amplitude than the first discharge with strong dependency on inter-discharge interval. This reflects the so call amplitude recovery function.

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1.4. Silent period

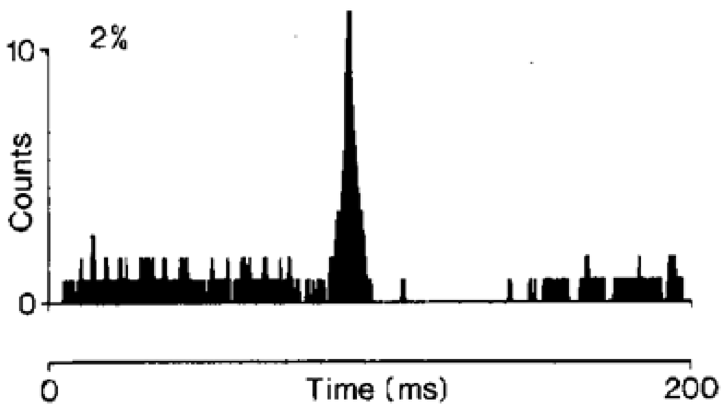
An overall picture of this unloading effect, demonstrated in detail above, is the so called silent period. This is a standard method to test excitability. During voluntary activity, the peripheral nerve is supramaximally stimulated, or a cortical magnetic stimulation is given, still recording from a muscle. In the first case, spinal neurons are tested, in the second the cortical neurons. These techniques are well described in standard EMG textbooks.

1.5. Post stimulus histogram

Post-stimulus time histogram, (PSTH) is a histogram of the times at which neurons fire. These histograms are used to visualize the rate and timing of neuronal spike discharges in relation to an external stimulus or event..

The PSTH is obtained by continuous recording of action potentials of a motor unit with random delivery of external stimulation (nerve or skin depending on the aim of the study). The afferent input from such stimulation will influence the active neuron. Depending on timing of the external signal the firing pattern will change. If an excitatory stimulus occurring just before the triggering of a neuronal discharge i.e. during the initial, preparatory phase spike generation, the external depolarization will add to the ongoing depolarization of the neuron, that now may fire somewhat earlier than if no extra depolarization had been superimposed. Depending on the strength of the external depolarization and its timing in relation to the normal firing cycle of the neuron, a concentration of spikes will occur, time locked to the stimulus.

In practice the subject/patient is asked to keep a steady firing of a motor unit, guided by it sound or b a ratemeter. The sweep of the display oscilloscope is triggered by the randomly delivered stimulus. Each MUP is converted into standard pulses. The sweep. long enough to catch the response from the stimulation. Its firings (standard pulses) are averaged. With no external stimulation, these firings occur randomly along the sweep, but after a stimulation, a local concentration (or the reverse depending on stimulation site) of firings is seen as a sign of the external influence. This time histogram of firings can be analyzed with special algorithms. From this the neuronal depolarization event before it firing, can be extracted. Different curves are obtained if the stimulation is excitatory, e.g. after stimulation the nerve from an agonist muscle, or if a nerve to the antagonist muscle is stimulation[1]. These curves can also be obtained with cortical stimulation.



Post-stimulus histogram

Ashby,Hilton-Brown,Stålberg

2. Conduction block explain “pings” in neurotonia

In a study of a patient with hereditary neurotonia [5] a spectrum of findings were seen. In the description they are placed along a severity scale according to the following.
The slightest degree of abnormality was a motor nerve hyperexcitability, only seen after the passage of a voluntary impulse, detected as a extradischarges.
Next step is when this site generates grouped spontaneous activity, without voluntary activity for triggering. This is described in these patients as myokymic discharge. When the triggering site is in one of the terminal nerve branches, the entire motor unit will be activated via the so called axon reflex, i.e. antidromic activation
The next step is when this spontaneous activity cannot be influence be a proximal stimulation, ie.the extradischarges are not influence by stimulation of that axon (alternative explanation is that the spontaneous activity travels antidromic and causes collision, a double stim should be done). Thus, here we have most likely a conduction block. If the spontaneous activity starts very distally in the terminal nerve tree, these signals cannot invade the motor unit, but only fibers distal to the generation site, sometime only one fiber and may produce so call “pings”, i.e. short high frequency spontaneous activity.

3. Amplitude drop at proximal nerve stimulation compared to distal

In neurography, special attention is paid to the difference in shape of the CMAP obtained with proximal and distal stimulation. The CMAP may be different due to many factors such as;

3.1. Erroneous stimulator petition at one of the sites

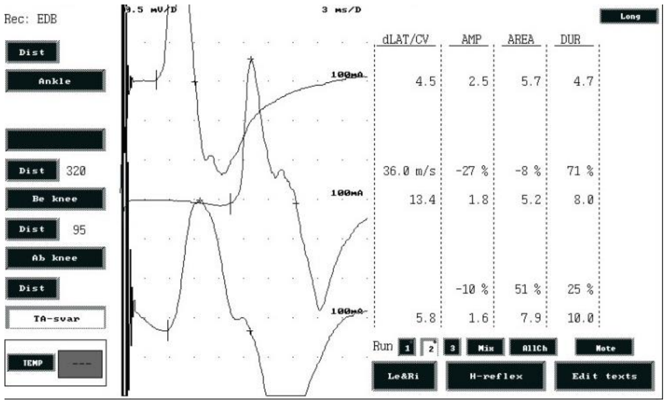
This is usually an obvious technical artifact that should be corrected

3.2. Subliminal stimulation at one of the stimulation sties

This is usually a technical artifact that should be checked and corrected

3.3. Volume conduction from muscles stimulated by proximal but not distal stimulation

When stimulating a motor nerve, all distal muscles innervated by that nerve will be activated. The volume conducted activity from those muscles will recorded with same latency and amplitude by the 2 poles of the recording electrode and therefore the activity should usually be cancelled. Nevertheless, small differences e.g. in electrode impedance my lead to small difference in the recorded signal which may result in an incomplete cancellation of remote activity. This may be seen for studies of median, fibular or tibial nerves.
In practical work this may lead to erroneous latency setting, and a comparison between take off for distal stimulation (without this artifact) and proximal should always be made.

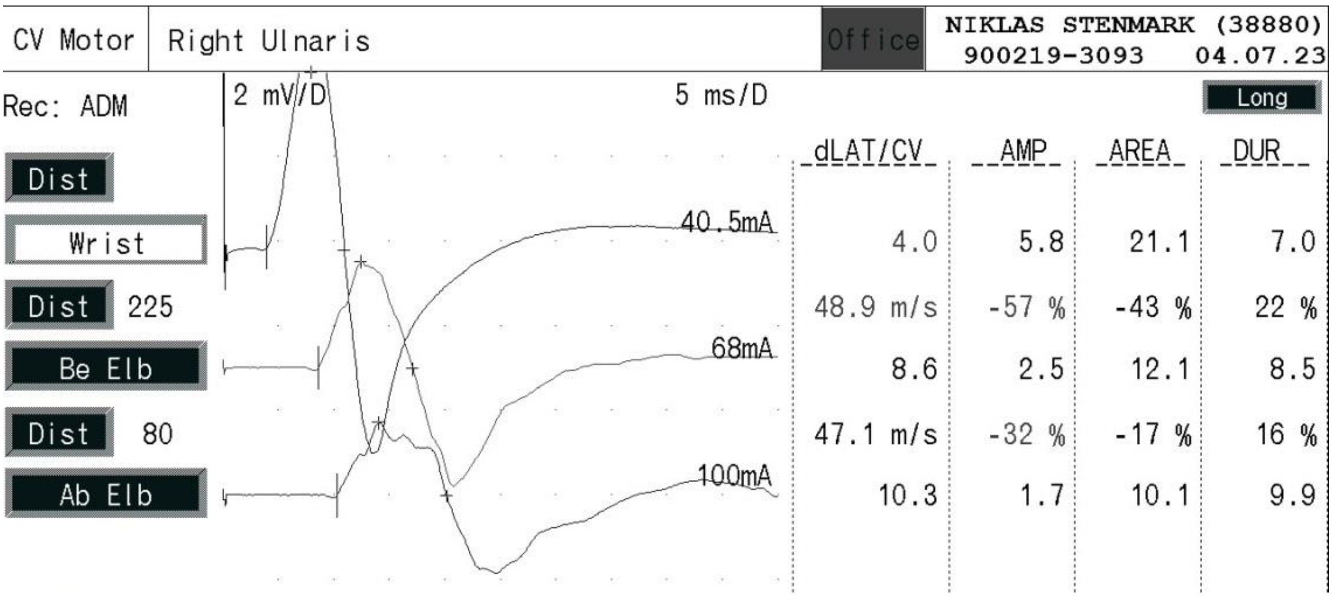


3.4. Anomalous innervation

Examples of various types of Martin Gruber anastomosis, accessory fibular nerve and Riche Cannieu[3] anastomosis may all give confusion the motor conduction studies. Careful inspection of the response at distal and proximal stimulation is suggested

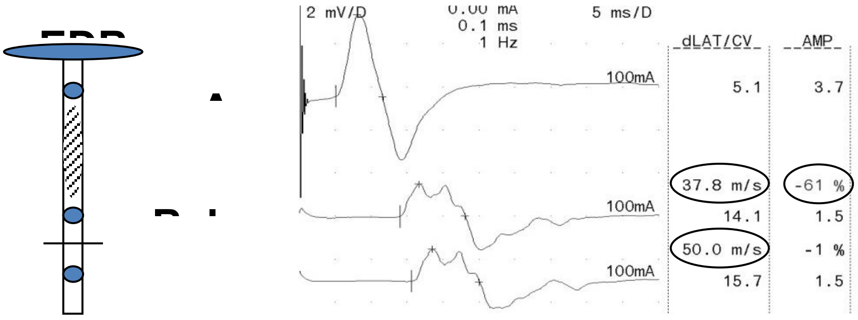
3.5. Conduction slowing

In cases of local compression or general slowing, particularly if axons of a special size are most effected than others, the shape of the CMAP will be different with stimulation distal and proximal to the affected segment. Such length dependent shape changes can be very useful to consider in attempts to localize the site of pathology

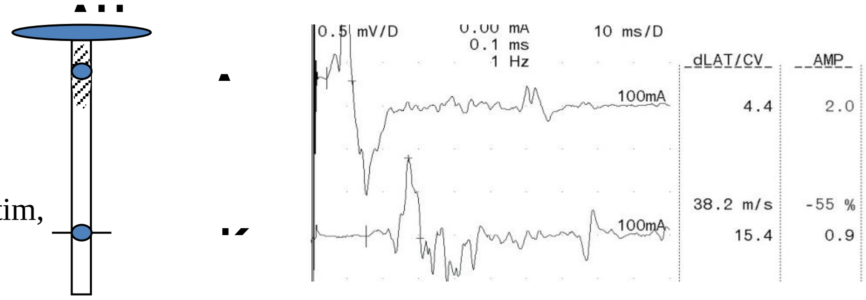


Dispersion across elbow

Dispersion below fibula head



Dispersion distally, not increasing with more prox stim, terminal slowing



3.6. Conduction block

If conduction block occurs between proximal and distal stimulation, the obtained CMAP will show difference in amplitude and to some degree in duration. There are rules for declaring a CMAP difference as a sign of conduction block

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