Practical 5: Nerve conduction velocity (NCV)

Aim:
To determine the conduction velocity in the motor and sensory fibres of the Ulnar and or Median nerve.

Introduction:
This procedure is a standard procedure for neurological testing, to estimate damage or ongoing deterioration of the nervous system. The speed of the propagation of the neural impulses is usually a constant velocity; changes to this velocity indicate damage.

Background of diseases of the peripheral nerves

- Motor and sensory axons run together in the same nerves, consequently diseases of the nervous system affect both motor and sensory function.
- People with nerve diseases may feel numbness, pins and needles, or tingling even though there is no external stimulus, these symptoms are called paresthesias.
- People with nerve diseases can have impaired pain and temperature detection. Additionally, their proprioceptive sense of position and vibration may be lost.
- Motor changes first appear as weakness, in chronic cases it usually begins distally, in acute cases it begins proximally. Tendon reflexes can be lost.
- Diseases of the nervous system can be acute or chronic, they can also be classified as de-myelinating or axonal. Demyelination is the breakdown of the myelin sheaths; this slows down nerve conduction velocity and is the type of disease that could be found using the techniques in this prac. Axonal diseases are where the actual axon is affected but there is no attenuation of conduction velocity.
- Two factors affect how demyelination produces nerve block and slowing of conduction velocity. Firstly, there is a direct relationship between conduction velocity and axon diameter and larger axons are usually myelinated. Secondly, and more important is that the action potential attenuates when traveling along demyelinated axons.
- When disease deteriorates the myelin sheath of some axons in a nerve, the action potentials travel at different velocities. This means that the nerve loses its normal synchrony of conductance in response to a stimulus.
- The first functions that are affected depend on action potentials that have the same velocity. These functions are tendon reflexes and vibratory sensations. This slowing can could be detected by the techniques in the practical you are doing today.
Conduction velocity can be determined for both motor and sensory nerve fibres, and some typical or ‘normal’ values are given in Table 1.

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Distal Latency*</th>
<th>Nerve Conduction Velocity</th>
<th>Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor nerve conduction studies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>≤3.8 ms at 7 cm</td>
<td>≥50 m/sec</td>
<td>≥5 mV</td>
</tr>
<tr>
<td>Ulnar, below elbow</td>
<td>≤3.1 ms at 7 cm</td>
<td>≥50 m/sec</td>
<td>≥5 mV</td>
</tr>
<tr>
<td>Sensory nerve conduction studies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>≤3.5 ms at 13 cm</td>
<td>≥55 m/sec</td>
<td>≥10 µV</td>
</tr>
<tr>
<td>Ulnar</td>
<td>≤3.2 ms at 11 cm</td>
<td>≥54 m/sec</td>
<td>≥10 µV</td>
</tr>
</tbody>
</table>

Table 1.1  Normal nerve conduction values. *Note that distal latency is distance between the stimulating cathode (positive electrode), and the active recording electrode.

Nerve conduction figures are given in table 1.2, and from these, a velocity may be calculated. E.g. motor nerve conduction velocity (MNCV) in the Ulnar nerve.

<table>
<thead>
<tr>
<th>Recording electrode position</th>
<th>Distance (cm)</th>
<th>Latency (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>wrist</td>
<td>11.5 = d1</td>
<td>3.5 = t1</td>
</tr>
<tr>
<td>elbow</td>
<td>43.0 = d2</td>
<td>9.0 = t1</td>
</tr>
</tbody>
</table>

Table 1.2  Distance/latency relationship

Note that;  
Velocity = Distance/Latency

MNCV = (d2-d1)/(t2 - t1)
 = (43.0 - 11.5)/(9.0 - 3.5) cm/ms
 = 5.73 cm/ms
 = 57.3 m/sec.

The motor nerve conduction velocity and sensory nerve conduction velocity (SNCV) can be measured in both Median, and Ulnar nerves. Figures 1a, and 1b identify the location of both the Median, and the Ulnar nerves.
Sensory NCV studies usually require computer averaging, due to the signal being of the same order of magnitude as the system noise, thus making it difficult to identify the signal. Averaging has the effect of 'cleaning up' the signal, or removing noise, so that the signal may be isolated. Averaging involves taking a number of sweeps, or measurements, adding these sweeps together, then dividing by the number of sweeps to get the average response (or common signal).

Essentially, average = $\frac{1}{N} \sum_{i=0}^{N} \text{sweeps}$
Procedure:

Using the PowerLab System and LabChart software (See Fig 1.6).

Sensory Nerve Conduction

1. Locate the Ulnar, or the Median nerve (refer to Figs. 1 and 1.3) to locate either Ulnar or Median nerve), and prepare the recording site by abrading the skin surface, and cleaning with alcohol.

2. Attach coil stimulating electrodes, recording electrodes, and the ground electrode (ground electrode attaches preferably on the back of the hand between the recording and stimulating electrodes to achieve maximum noise reduction).

Figure 1.3: Experimental set-up for a Sensory Nerve Conduction Velocity measurement on the Median nerve.

1. Test skin impedance at the recording site using the impedance meter, and if too high, further abrade the site.

2. Run NCV test on software LabChart (repeat if necessary). Ask a demonstrator for access to program. Check settings.

3. Print a hardcopy of nerve action potentials or save electronically.

4. Measure the distance between the stimulating and recording electrodes, and the latency of the action potential response. From these, determine the conduction velocity of the motor fibres.
Figure 1.4: Samples of the SNCV test result
Using the PowerLab System (See Fig 1.6).

Motor Nerve Conduction

1. Locate the Ulnar, or the Median nerve (refer to fig. 1 and 1.5) to locate either Ulnar or Median nerve), and prepare the recording, and ground (the ground site on the back of the hand) sites by abrading the skin surface, cleaning with alcohol, and applying a daub of conductive gel on the electrodes (not needed if tab electrodes are used).

2. Soak the stimulating electrodes in saline solution.

3. Attach the ground electrode.

4. Test skin impedance at the recording and ground sites using the impedance meter, and if too high, further abrade the site.

5. Have the subject seated comfortably, with the arm outstretched and relaxed to minimise muscle artifact.

Figure 1.5: Experimental setup for a Motor Nerve Conduction Velocity measurement on the Ulnar Nerve.
Figure 1.6  Powerlab Systems. Note that all the features of the previous stimulator; pulse duration, frequency etc, is all set with the Powerlabs software.
Figure 1.7 Example Motor Potential
The suggested settings for the AMPLIFIER are:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Frequency Filter</td>
<td>0.1 Hz</td>
</tr>
<tr>
<td>High Frequency Filter</td>
<td>10 kHz</td>
</tr>
<tr>
<td>Gain (approximate)</td>
<td>2 K</td>
</tr>
<tr>
<td>Coupling</td>
<td>A.C.</td>
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</tbody>
</table>

Table 1.3: amp settings.

9. Open Chart and connect the "OUTPUT" of the AMP to CH1 of the PowerLab, and the "SYNCH. OUT" (at the back of the stimulator unit) to Output 1 of the PowerLab.

Suggested Settings for Chart;

- Set-up ⇒ sampling ⇒ mode = average
  - source = external average = 25
  - sweeps trigger = at event
- Set-up ⇒ stimulator ⇒ mode = off.
- Input Amplifier ⇒ AC coupling, filter off

10. Set the isolated stimulator to the following settings:

   a) "STIMULUS CURRENT" at 2x threshold;

   b) Switch stimulator to “REPETITIVE”;

   c) Turn stimulus frequency to minimum;

   d) Press "GATE/TRIGGER" to stimulate the nerve.

11. Record an averaged action potential at both the wrist, and the elbow (it may be necessary to increase stimulus strength when recording at the elbow, but not above the subject’s comfort level).

12. Print a hardcopy of the averaged nerve action potentials.

13. Measure the distance between the stimulating and recording electrodes, and the latency of the averaged action potential response. From these, determine the conduction velocity of the sensory fibres.
Results and Discussion:

1. Draw a sketch of the experimental set-ups.

2. For each experiment, fill in the following table, and calculate nerve conduction velocities.

<table>
<thead>
<tr>
<th>Nerve. Eg. Median.</th>
<th>Nerve fibre type. Eg. motor.</th>
<th>Position</th>
<th>Latency (ms)</th>
<th>Distance (cm)</th>
<th>Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>2.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Are the values of latency and conduction velocity consistent with normal or pathological function? Explain why.

2. Discuss at least two clinical conditions that nerve conduction velocity test are used for diagnosis and the physiological basis of these clinical conditions.
Appendix

Step by step Instructions

Motor

- Abrade a spot on the back of the participants hand for the ground electrode
- Use wipe to clean, allow to dry then attached ground electrode (usually green)
- Attach the two recording electrodes on the fleshy mount of the palm following the same procedure (usually red positive, black negative)
- Take note of the order of the electrodes, Positive closer to the fingers then when applying the stimulating electrode you need to place the positive on closer to the fingers
- The order of stimulating electrodes and recording electrodes must be the same (the stimulating electrodes are together in a plastic cover, keep the stimulating pads wet by dipping them in solution)
- Place the stimulating electrode on the nerve sight just behind the elbow and begin with the amplitude (stimulus intensity) on about 5μA
- Slowly increase Amps while moving the electrode around to find the best stimulation site

- The bottom is time and the vertical is amplitude, In the figure above the arrow indicates where to take the reading for milliseconds from
- The students need to know the latency, stimulation intensity and distance to work out the velocity.
- Do this test again using a place on the wrist
Sensory

• First it is necessary to find the ulnar nerve by using only the simulating electrodes
• The stimulating electrode is plugged directly into the bioamp with black cable to black input and red cable to red input
• Make sure the computer is set to produce one stimulation not “averaging” which is many stimulations
• Now is a good time to create a text document with the groups lab time, demonstrator and type of stimulation to paste your recording on when you have found one with a clear wave
• Press the wet stimulating electrodes in different places behind the elbow slowly increasing the amplitude while moving it around
• It is important that the participant has it high enough to get a result but not so high that they experience pain
• When the nerve is found put on an elastic band to keep it in place
• Attach the loop electrodes to the little and ring fingers with conductive patse making sure the conductive paste oes not make a bridge between the electrodes
• Change the stimulation from a single stimulus to averaging by clicking “Set up” “Sampling”, “mode” then choose “average” set it to 32 times, this can be changed if too much noise is in the recording and the participant can not cope with an increase of amplitude

The diagram above shows where to take the latency reading from, time is on the bottom axis amplitude on the vertical
• When a result has been found measure the distance between the electrodes, either positive to positive or negative to negative
• Paste the screen capture into a word document
• Repeat but move the stimulating electrode to the wrist
• To find the nerve again to record the stimulation from the wrist you need to change the computer back to single stimulus. Go to, “My document” and choose “Motor nerve conduction”

To make a screen capture

• Because the keyboards are mac they don’t have a print screen button so you need to go to the keyboard of the computer, go to “Programs” “accessories” “…….” then “On screen keyboard”. It will appear on the screen, move it down to the bottom so you can see the graphed waves.
• When ready to copy your graph click “PSC” go to the word document then press “Option and V” to paste • At the bottom of the graph get a group member to type in the details:
  o Latency  o Distance  o Intensity  o Sweeps
  o To work out the velocity use distance over time