Biomedical and Signal Processing Lab

Experiment 7

Simulation of Motor Nerve Conduction Velocity

Aim: To Simulate Motor Nerve Conduction Velocity.

Objective:

1. To simulate the process of measurement of motor conduction velocity (MCV).
2. To understand the relationship between MCV and various abnormalities associated with muscles.
3. To understand the application of MCV.

Theory:

A nerve conduction study (NCS) is a test commonly used to evaluate the function, especially the ability of electrical conduction, of the motor and sensory nerves of the human body. Nerve conduction velocity (NCV) is a common measurement made during this test. A nerve conduction velocity test measures how quickly electrical impulses move along a nerve. It is often done at the same time as an EMG, in order to exclude or detect muscle disorders**.**

A healthy nerve conducts signals with greater speed and strength than a damaged nerve. The speed of nerve conduction is influenced by the myelin sheath - the insulating coating that surrounds the nerve. Most neuropathies are caused by damage to the nerve's axon rather than damage to the myelin sheath surrounding the nerve. The nerve conduction velocity test is used to distinguish between true nerve disorders (such as Charcot-Marie-Tooth disease - also known as hereditary motor and sensory neuropathy (HMSN)) and conditions where muscles are affected by nerve injury (such as carpal tunnel syndrome). This test is used to diagnose nerve damage or dysfunction and confirm a particular diagnosis. It can usually differentiate injury to the nerve fibre (axon) from injury to the myelin sheath surrounding the nerve, which is useful in diagnostic and therapeutic strategies. During the test, flat electrodes are placed on the skin at intervals over the nerve that is being examined. A low intensity electric current is introduced to stimulate the nerves thus generating nerve impulses.

The Nerve Impulse

The nerve impulse is a wave of cell depolarisation immediately followed by a wave of repolarisation, collectively called an action potential, occurring on the plasma membrane of a nerve fibre. Changes in ion conductances across the nerve fibre membrane are responsible for the initiation and propagation of the action potential. Experimentally, these changes can be the result of electrical current applied through electrodes. Once initiated, an action potential is usually propagated without decrement in amplitude or velocity along the plasma membrane of a nerve fibre.

The velocity or speed of the propagated (conducted) nerve impulse is directly related to the diameter of the nerve fibre and the presence of a myelin sheath. The fastest nerve fibres have large diameters and are myelinated; for example, the motor nerve fibres that supply skeletal muscles. The slowest nerve fibres have small diameters and are unmyelinated; for example, sensory nerve fibre from the stomach.

In the peripheral nervous system, nerve fibres of various diameters and functions (motor and sensory) are bundled together by connective tissue to form nerves. A compound action potential is the sum of all the action potentials occurring in the individual neurons of the whole nerve. The velocity of the compound action potential signal can be a measure and can indicate the state of health of the nerve. Diseases that damage the myelin, destroy neurons, or constrict the whole nerve will decrease the nerve's conduction velocity. However, the nerve conduction velocity may remain normal until late in a disease process as long as a few normal neurons survive. In addition, the nerve conduction velocity reflects conduction of the fastest nerve fibres, usually motor neurons.

The nerve conduction velocity is determined by recording the motor response of a muscle to the stimulation of its motor nerve at two or more points along the nerve course. If a response is much slower than normal, damage to the myelin sheath is implied. If the nerve's response to stimulation by the current is decreased but with a relatively normal speed of conduction, damage to the nerve axon is implied. The nerve is stimulated, usually with surface electrodes, which are patch-like electrodes (similar to those used for ECG) placed on the skin over the nerve at various locations. One electrode stimulates the nerve with a very mild electrical impulse. The resulting electrical activity is recorded by the other electrodes. The distance between electrodes and the time it takes for electrical impulses to travel between electrodes are used to calculate the nerve conduction velocity. Normal body temperature must be maintained (low body temperature slows nerve conduction). There is generally minimal discomfort with the test because the electrical stimulus is small and usually is minimally felt by the patient. Often the nerve conduction test is followed by electromyography (EMG) which involves needles being placed into the muscle and you contracting that muscle. This can be uncomfortable during the test, and you may feel muscle soreness at the site of the needles afterwards as well.

NCV is related to the diameter of the nerve and the normal degree of myelination (the presence of a myelin sheath on the axon) of the nerve. Newborn infants have values that are approximately half that of adults, and adult values are normally reached by age 3 - 4.

What abnormal results mean - Most often, abnormal results are caused by some sort of neuropathy (nerve damage or destruction) including:

- Demyelination (destruction of the myelin sheath)
- Conduction block (the impulse is blocked somewhere along the nerve pathway)
- Axonopathy (damage to the nerve axon)

Some of the associated diseases or conditions include:

- Alcoholic neuropathy
- Diabetic neuropathy
- Nerve effects of uremia (from kidney failure)
- Traumatic injury to a nerve
- Guillain-Barre syndrome
- Diphtheria
- Carpal tunnel syndrome
- Brachial plexopathy
- Charcot-Marie-Tooth disease (hereditary)
- Chronic inflammatory polyneuropathy
- Common peroneal nerve dysfunction
- Distal median nerve dysfunction
- Femoral nerve dysfunction
- Friedreich's ataxia
- General paresis
- Lambert-Eaton Syndrome
- Mononeuritis multiplex
- Primary amyloid
- Radial nerve dysfunction
- Sciatic nerve dysfunction
- Secondary systemic amyloid
- Sensorimotor polyneuropathy
- Tibial nerve dysfunction
- Ulnar nerve dysfunction

Patient risk

Nerve conduction studies are very helpful to diagnose certain diseases of the nerves of the body. The test is not invasive, but can be a little painful due to the electrical shocks. However, the shocks are associated with such a low amount of electrical current that they are not dangerous to anyone. Patients with a permanent pacemaker or other such implanted stimulators such as deep brain stimulators or Spinal Cord Stimulators must tell the examiner prior to the study. This does not prevent the study, but special precautions are taken.

Screen Shot:

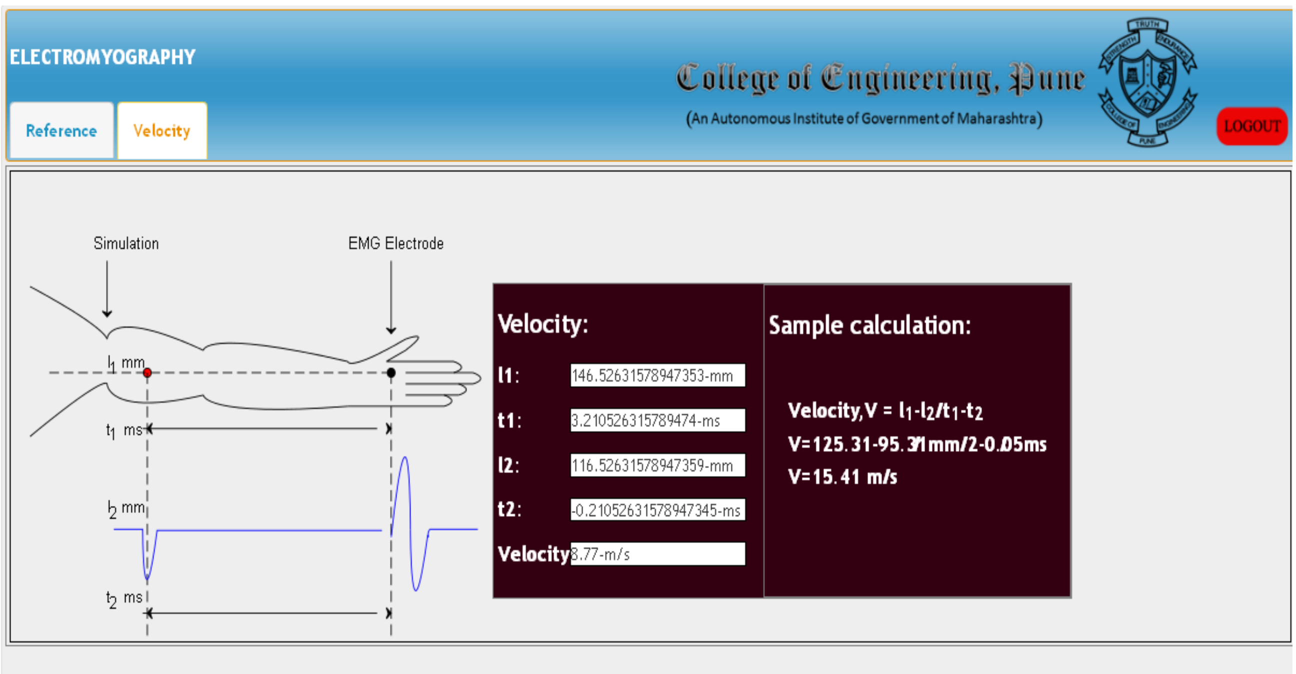

Fig. 1 Screen shot of MCV simulation

Conclusion:

Results:

1. Tabulate the result of distance between two electrodes and MCV.

Assignment:

1. What are the different stimulators used for testing the functionalities of nerves available in the body? Explain.
2. Comment on the abnormalities associated with nerve in the body.

Further Reading:

1. Khandpur R. S., "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, Second Edition.
2. Webster J. G., "Medical Instrumentation Application & Design", John Wiley & Sons, Inc., Fourth Edition.
3. Carr, J. J., Brown, J. M., 'Introduction to Biomedical Equipment Technology', Pearson Education, Fourth Edition.
4. Joseph D. Bronzino," The biomedical engineering handbook", Volume 1 & 2, CRC Press, USA, 2000.
5. John G. Webster, "Encyclopedia of Medical Devices and Instrumentation Vol. I , II, III, IV", Wiley Publication.