# TO STUDY THE ABNORMAL MUSCLE CONTRACTION DUE TO LOWER MOTOR NEURON LESION WITH THE HELP OF STRENGTH DURATION CURVE: A PILOT STUDY

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#### ABSTRACT

The symptoms that arise from damage to the lower motor neurons of the brainstem and spinal cordare referred to as the "lower motor neuron syndrome." Damage to lower motor neuron cell bodies or their peripheral axons results in paralysis (loss of movement) or paresis (weakness) of the affected muscles. In addition to paralysis and/or paresis, the lower motor neuron syndrome includes a loss of reflexes (areflexia) due to interruption of the efferent (motor) limb of the sensory motor reflex arcs. Aim was to study the abnormal muscle contraction due to LMN (lower motor neuron) lesion with the help of SD curve patient suffering from Neurapraxia.

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Objectives was to find Rheobase and Chronaxie values in non-effected side and compare it with effected side of the Patient and identification of kink (if present) in the graph of effected side. A longitudinal study was done on 6 subjects suffering from nerve compression. Sample was collected from bilateral limb Rheobase and Chronaxie were measured at the regions of the Quadriceps, Tibialis Anterior and Deltoid muscle. Subject gone through diagnostic Electrical Stimulation (galvanic current) which produce square wave of various pulse duration ranging from 0.01 to 300 msec. Electrical stimulation used was of constant current type. Result were obtained by applying standard deviation and T test, there is a significant change in the value of Chronaxie in the effected side. P value obtained ( $p \le 0.04$ ). Presence of kink in the SD curve shows the reaction of degeneration in the effected side of the patients. Study showed that the patients suffer from disproportionate muscle excitation and contraction ability. Damage to lower motor neurons also entails a loss of muscle tone, since tone. The muscles involved may also exhibit fibrillations and fasciculation, which are spontaneous twitches characteristic of single denervated muscle fibers or motor units, respectively.

**KEYWORDS:** Rheobase, Chronaxie, SD curve, Kink, Hemiplegia, Lower motor neuron, Strength duration curve.

## INTRODUCTION

The strength-duration time constant (chronaxie) and rheobase are parameters that describe the strengthduration curve-the curve that relates the intensity of a threshold stimulus to its duration. As the duration of a test stimulus increases, the strength of the current required to activate a single fiber action potential decreases (1). The strength-duration curve is a plot of the threshold current (I) versus pulse duration (d) required to stimulate excitable tissue. As mentioned, the two important points on the curve are rheobase (b) and chronaxie (c), which correlates to twice the rheobase (2b). Strength-duration curves are useful in studies where the current required is changed when the pulse duration is changed (2).

#### Rheobase

It is a measure of membrane potential. In neuroscience, rheobase is the minimal current amplitude of infinite duration (in a practical sense, about 300 milliseconds) that

results in the depolarization threshold of the cell membranes being reached, such as an action potential or the contraction of a muscle.[1] In Greek, the root rhe translates to "current or flow", and basi means "bottom or foundation": thus the rheobase is the minimum current that will produce an action potential or muscle contraction (3).

### Chronaxie

It is the minimum time required for an electric current double the strength of the rheobase to stimulate a muscle or a neuron. Rheobase is the lowest intensity with indefinite pulse duration which just stimulated muscles or nerves (4).

Subsequent testing usually shows the curve "shifting" to the left or right, depending on whether improvement or deterioration is occurring. A shift to the left indicates improvement, since shorter durations with more currents is noted, while a shift to the right indicates deterioration as there is an increase in duration with less current.



Picture 1: Diagrammatic Representation Of Strength-duration Curve With Rheobase And Chronaxie Value Indication



### Picture 2: Showing Comparison Between Normal And Abnormal Sd Curve

Strength - duration curve and chronaxie measurement have been used for evaluation of variety of lower motor - neuron pathologies. Their greatest value is for assessment of peripheral nerve injuries (5). Strength duration curves measure the excitability of a certain target element in a given electrode-tissue system. The target element may be a single cell (such as a nerve or skeletal muscle fibre) or even a whole network of electrically coupled cells (such as the myocardium or visceral smooth muscle). The response of the target element is the all or none emergence of a propagated action potential (6). Nerve excitability is dependent on many factors, perhaps the most important are voltagedependent Na1 channels. The strength-duration time constant of a nerve is a nodal property that is longer for cutaneous afferents than for motor axons (7). Lower motor neuron lesions affect the function of the neuromuscular junction and of skeletal muscle not only by absence of impulse transmission, but also by alteration in their excitability. The strength duration curve is a graph of the excitability of nerve, muscle, or both. It can be used to demonstrate or confirm

(i) Normal innervation of muscle, and

(ii) The presence or progress of lower motor neuron disorders.

For clinical purposes, chronaxie values of greater than 1.0 millisecond are considered adequate evidence of partial denervation. The most significant signs of progressive denervation are:

(i) Progression of the curve upwards and to the right;

(ii) No response at progressively longer durations;

(iii) Emergence of a discontinuity (as early as four to five days following complete denervation which becomes progressively more obvious (8).

Reaction of Degeneration Test The reaction of degeneration (RD) test is a useful screening procedure for assessment of problems that may involve lower motor neurons. Normally innervated muscle will respond with a brisk twitch when stimulated with a short - duration pulse lasting less than 1 ms and also when stimulated with longer pulse durations, for example 100 ms (9).

The chronaxie plays a similar role in a hyperbola as the "time constant" in an exponential function; it determines how fast the strength-duration-curve approaches it final value. This temporal value is, therefore, truly characteristic for the excitability of the tissue, but can be modified by physical and physiological parameters (10)

The Neurapraxia (conduction block) is a temporary blockage of the nerve conduction due to compression or damage of the myelin sheath of the nerve fiber. Above and below the block, the conduction is unimpeded; however stimulating the motor fiber with a proper electric impulse above the block will not cause the muscle contraction. The more nerves are affected by Neurapraxia, the less a ctivethe nerves will be during stimulation. The greater damage to the nerve the more intense current is needed to activated it (11).

### **AIM OBJECTIVE**

• To study the physiological changes in muscle contraction after a nerve injury and compare it with the normal one

• To determine the sensitivity of the combined measurement of chronaxie

• To study the interdependence between stimulus strength and stimulus duration in activating the nerve, and to construct a Strength-Duration Curve.

#### MATERIAL

The examination was done by taking permission and approval by the ethical committee, on the patients who were admitted to Era's Medical College and Hospital for the treatment of neuro-muscular disorder in Department of Medicine, Neurology, Physiotherapy and in contribution with the Department of Physiology. Brief information was give to the subject and concert was taken by the patient and the guardian. Total 6 subjects were selected which including both male and female. The study was carried out to find out the excitability of the muscle tissue with the application of electrical stimulation.

#### **INCLUSION CRITERIA**

• Nerve compression and Nerve injury

#### **EXCLUSION CRITERIA**

• Skin disease, Age below 9 years and open wound in examination area.

#### METHOD

The device with constant current type was used with a pair of silica rubber electrode of size 5x7cm each with two different color coding Red as a positive electrode and Black as a negative electrode. For proper isolation of single muscle fiber metal electrode was also used with proper wet cotton covering to prevent any risk of electrical shock, while using silica rubber electrode it was properly covered with jelly for proper conduction and tightly wrapped in place with the help of Velcro. The apparatus used for plotting S-D Curve supplies rectangular impulses of different duration. Impulse with duration of 0.01, 0.03, 0.1, 0.3, 1, 3, 10, 30, 100, 300 ms.



Picture 3: Dynostim , ACCO Medical Electrical Stimulator Produces Pulse Duration. Widely Used To Electo Diagnostic Purpose



Picture 4 :ELECTRODES Silicon Rubber And Metal With Connecting Cables

S.No.	Gende	er	Age in	Days	Effected	Testing Muscle	Kink
			years	after injury	side		
1	Male	e	65	453	Right	Quadriceps	Absent
2	Male	•	45	90	Right	Deltoid	Present
3	Femal	le	55	121	Left	Tibialis Anterior	Present
4	Femal	le	56	95	Left	Deltoid	Present
5	Femal	le	58	94	Left	Tibialis Anterior	Absent
6	Femal	le	39	66	Left	Deltoid	Present



 Table 1: Distribution of Rheobase and Chronaxie In

 Normal And Abnormal Muscle In Total Number Of Cases

	Ν	Normal	Abnormal	Normal	Abnormal
		muscle Rheobase	muscle Rheobase	muscle Chronaxie	muscle Chronaxie
Mean ±SD	6	30.67±12.31	26.00±8.39	61.33±24.61	52.00±16.78

 Table 2:- Mean±SD of Rheobase and Chronaxie in

 Normal and Abnormal Muscle

	Normal muscle	Abnormal muscle	
Mean ±SD	30.67 ±12.31	$26.00\pm\!\!8.39$	
t value	6.104	7.59	
p value	0.002	0.001	

 Table 3:- Pair T Test Between Rheobase and Chronaxie

Mean value of Rheobase in normal muscle was 30.67 milivolt with standard deviation of 12.31 milivolt, w/a mean value of Rheobase in abnormal muscle was 26.00 milivolt with standard deviation of 8.39 milivolt and mean value of Chronaxie in normal muscle was 61.33 milivolt with standard deviation of 24.61 milivolt w/a mean value of Chronaxie in abnormal muscle was 52.00 milivolt with standard deviation of 16.78 milivolt.

Mean value of Rheobase and Chronaxie in a normal muscle was 30.67 milivolt with standard deviation of 12.31 milivolt (p < 0.002) w/a mean value of Rheobase and Chronaxie in a abnormal muscle was 26.00 milivolt with standard deviation of 8.39 milivolt (p < 0.001).

### DISCUSSION

Together with the clinical and electrodiagnostic evaluation of a peripheral neuropathy, the systematic examination of sensory strength-duration curves provides useful help in diagnosis. The correlation of the S-D curve with pathological clinical and electrodiagnostic findings in the same patient provides further information as to the anatomical substrate tested by the psychophysical technique (the scientific study of the relation between stimulus and sensation). Discontinuities in the classical S-D curve result from the difference in excitability threshold between muscle and nerve tissue. Therefore, sensory S-Dcurves representing properties of afferent nerve fibers are expected to be smooth also in case of partial denervation. Pathological conditions are characterized by an over-all increase in threshold excitability providing both a shift of the curve and changes in temporal integration properties (12). Chronaxie and Rheobase was first defined more than one hundred years (13) ago, and since that time, various researchers have studied these parameters in cases of peripheral nerve lesion. They found that Chronaxie, which provides a measure of the neuromuscular electrical excitation threshold, was the most sensitive parameter for use in detection of nerve lesions. In this study, Chronaxie was also found to be the most sensitive parameter for use in lesion diagnosis and assessment of recovery (14-16). This study has shown clearly, how strength-duration behavior should be related to the electrotonic and voltage-dependent properties of myelinated nerve. The value of strength-duration measurements is clearly limited, since they depend on so many membrane parameters. On the other hand, strength-durationmeasurements, like those of conduction velocity, can readily be made on undissected nerves in vivo, but unlike conduction velocity measurements they relate specifically to the part of the nerve stimulated (17).

This study give a picture of abnormality comes after an injury to the nerve resulting abnormal muscle tissue excitation and contraction ability. Lower Motor Neuron lesion can leads to a low grade muscle contraction and muscle weakness. Denervation of skeletal muscles has been shown to result in many changes in structure and function. One of these changes is the decrease in the excitability of the muscles, associated with a large increase in the chronaxie. Denervated muscles do notrespond at all to short stimulating impulses; they require pulses of longer duration than those that are adequate for innervated muscles. The simplicity of the method (no complex recording and averaging equipment) represents a further advantage in comparison with electroneurographic procedures. However, the isolated constant-currentstimulator has to be capable of producing truesquare-wave stimuli over a wide range of pulse durations. Moreover, the subject tested must be attentive and cooperative during the behavioral assessment of peripheral nerve function. The examination can be reduced to a few representative pulse-durations. The amount of current of infinite duration required to produce minimal sensation (rheobase) represents a valuable measure and approximates stimulus durations of 10 to 50 milisec. The chronaxie, that is the duration of a threshold stimulus of twice the rheobase, proved to be less informative, especially because it is based on calculation.

### STUDY LIMITATIONS AND FUTURISTIC PERSPECTIVES

Though it is a small study, but on the basis of the conclusions drawn, further research work can be undertaken with a larger sample size to findany significant relationship between normal and abnormal muscle chronaxie. The value of strength-duration measurements is clearly limited, since they depend on so many membrane parameters. On the other hand, strength-durationmeasurements, like those of conduction velocity, can readily be made on undissected nerves in vivo, but unlike conduction velocity measurements they relate specifically to the part of the nerve stimulated.

### REFRENCES

- 1. Geddes, L. A. Accuracy limitations of chronaxie values. IEEE Transactions on Biomedical Engineering. 2004:51:1:204-205.
- 2. Geddes, L.A., & Bourland, J. D. The Strength-Duration Curve. IEEE Transactions on Biomedical Engineering. 1985:32:6:458–459.
- 3. Ashley, et al. Determination of the Chronaxie and

## CONCLUSION

Rheobase of Denervated Limb Muscles in Conscious Rabbits; Artificial Organs, Volume. 2005;29(3):212.

- 4. Irnich W. The Chronaxie Time and Its Practical Importance, Pacing and Clinical Electrophysiology.1980;3(3):292–301.
- 5. Brocker D.T., Grill W.M. Handbook of Clinical Neurology, Elsevier. 2013;116:1:3-18
- 6. Antola S.R.; Thrushold Dynamics and Strength-Duration Curve. Biological complexity; 1996;10:131-136.
- Mogyoros I, Matthew C.K, Bruke D, Bostok H, Strength-duration properties of sensory and motor axons in amyotrophic lateral sclerosis; Brain; Oxford university press.1998;121:851-859.
- 8. Barry C. Stillman; Some aspects of the theory, performance, and interpretation of the strength duration test; Australian journal of physiotherapy. 1967; 8: 62-71.
- 9. Taradaj J. usefulness of electrodiagnostics and electrotherapy in medicine [Internet]. Publication [cited 16 June2017], Available from: http://www.biofizyuk.sum.edu.pl/lab2&3pnr.pdf
- 10. Werner Irnich; The term Chronaxie and Rheobase are 100 year old; Pacing and Clinical Electrophysiology. 2010; 33:491-496.
- Honorata N.B, Tuliszka M, Kubisz L.Electrodiagnostics; Chronaxymetry; [internet]. Publication 2009[cited 25may2017]. Available

from:http://www.biofizyuka.ump.edu.pl/media/ vid/9\_b066daaf0\_-2\_6c2/3426a3.pdf

- 12. WG Friedli, M Meyer, Strength-duration curve: a measure for assessing sensory defect in peripheral neuropathy, journal of neurology neurosurgery and psychiatry. 1984;47:184-189.
- 13. Irnich W. The terms "chronaxie" and "rheobase" are 100 years old. Pacing Clinical Electrophysiology.2010;33(4):491-506.
- Luciane F. R. M. Fernandes, Nuno M. L. Oliveira, Danyelle C. S. Pelet, Agnes F. S. Cunha, Marco A. S. Grecco, Luciane A. P. S. Souza; Stimulus electrodiagnosis and motor and functional evaluations during ulnar nerve recovery; Brazilian journal of physical therapy. 2015;3:138-144.
- 15. Russo TL, França C, Castro C, Salvini TF. Alterations of chronaxie, rheobase and accommodation in denervated skeletal muscle submitted to electrical stimulation. Rev Bras Fisioter. 2004;8(2):169-175.
- Russo TL, Peviani SM, Freria CM, Gigo-Benato D, Geuna S, Salvini TF. Electrical stimulation based on chronaxie reduces atrogin-1 and myoD gene expressions in denervated rat muscle. Muscle Nerve. 2007;35(1):87-97.
- 17. H. Bostock; the strength-duration relationship for excitation of myelinated nerve: computed dependence on membrane parameters; journal of physiology. 1983: 341: 59-74.