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NERVE CONDUCTION STUDY IN DIFFERENT CLINICAL GRADES OF DIABETIC FOOT

General Surgery

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ABSTRACT

Background: Diabetic neuropathy is one of the commonest late complications of diabetes. Diabetic neuropathy can be either peripheral or autonomic. Nerve conduction study (NCS) is the recording and measurement of the compound nerve and muscle action potentials elicited in response to an electrical stimulus. Currently, the principal uses of NCV (Nerve Conduction velocity) study are to evaluate paresthesias (numbness, tingling, burning) and /or weakness of arms or legs.

Methods: All patients diagnosed as diabetic foot were sent for Nerve Conduction Study after obtaining their written informed consent. Three nerves were studied; two motor nerves, Common peroneal and Tibial nerves, and one purely sensory nerve, Sural nerve.

Results: Mixed type neuropathy with bilateral lower limb involvement was the most common type encountered.

Interpretation and Conclusion: Mixed type of neuropathy was the most common in my study with respect to sensory and motor types of neuropathy; and also axonal and demyelinating types of neuropathy.

Number of patients with bilateral neuropathy detected by NCV study in my study is more than that detected clinically and the difference is significant by applying the test of significance. Hence, NCV is a better study to detect nerve conduction abnormalities than clinical examination in diabetic foot.

KEYWORDS

Diabetic foot, peripheral neuropathy, Nerve Conduction Study(NCV).

INTRODUCTION

Diabetic neuropathy is one of the commonest late complications of diabetes. All neuropathies are characterised by a progressive loss of nerve fibres that can be assessed non-invasively by clinical neurological examination or electrophysiology[1]. Diabetic neuropathy can be either peripheral or autonomic. Peripheral diabetic neuropathy is commonly seen as distal symmetrical sensorimotor polyneuropathy (DPN). DPN leads to sensory loss in the toes and feet which reflects dysfunction in both large and small myelinated as well as unmyelinated fibres[2]. In DPN, all sensory modalities are usually affected and patients have reduced vibratory and joint position sense, light touch, pin prick and temperature discrimination in the toes with depressed or absent ankle reflexes. DPN is a length dependent process and loss of sensation ascends from the toes up the legs. This slowly progressive fibre dysfunction produces the classical 'glove and stocking' sensory loss of DPN. There can be also mild pain with paraesthesiae and/or dysaesthesiae. Motor manifestations include small muscle wasting and absent ankle reflexes[3]. Weakness of the intrinsic muscles of the foot commonly results in a disparity between the toe extensors and flexors producing chronic metatarsophalangeal flexion (claw toe) deformity. Chronic ulceration of the foot may result and is mostly multifactorial due to both DPN and vascular insufficiency. Other diabetic neuropathies found are mononeur opathies, cranial mononeuropathies, isolated and multiple mononeuropathies, truncal mononeuropathy, proximal motor neuropathy (diabetic amyotrophy), autonomic neuropathy .

Nerve conduction study (NCS) is the recording and measurement of the compound nerve and muscle action potentials elicited in response to an electrical stimulus. It is helpful in detecting neuropathy, quantifying its severity and noting its distribution, providing information on the modality involved and can suggest whether the lesion is axonal or demyelinating.

Currently, the principal uses of NCV (Nerve Conduction velocity) study are to evaluate paresthesias (numbness, tingling, burning) and /or weakness of arms or legs. The type of study required is dependent partly on the symptoms presented. A physical examination and thorough history also helps to direct the investigation. Some of the common disorders which can be diagnosed by nerve conduction studies are peripheral neuropathy as seen in diabetes mellitus, carpal tunnel syndrome, ulnar neuropathy, Guillain-Barre syndrome, fascioscapulohumeral muscular dystrophy, spinal disc herniation.

Patches called surface electrodes, similar to those used for ECG, are placed on the skin over the nerve at various locations[3]. Each patch gives off a very mild electrical impulse, which stimulates the nerve. The nerve's 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 determine the speed of the nerve signals.

Normal body temperature must be maintained. Temperature significantly influences the conduction velocity and the amplitude of compound muscle action potential. Low temperature results in slowing of nerve conduction velocity and increases the amplitude. For each degree Celsius fall in temperature, the latency increases by 0.3ms. On increasing the temperature, the velocity increases by 5 % per degree from 29-38°C. The laboratory temperature, therefore, should be maintained between 21- 23°C. If skin temperature is below 34°C, the limb should be warmed by warm water immersion.

Precautions may need to be taken for a cardiac defibrillator or pacemaker. The impulse may feel like an electric shock. 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. The shocks are associated with a low amount of electrical current so 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.

NCV is related to the diameter of the nerve and the normal degree of myelination of the nerve[4]. Newborn infants have values that are approximately half that of adults and adult values are normally reached by age of 3 - 4 years. Most often, abnormal results are due to some sort of nerve damage or destruction, including axonopathy or conduction block or demyelination. There are no risks.

In symptomatic diabetic neuropathy, there is slowing of nerve conduction velocity owing to demyelination and loss of large myelinated fibers; and a decrease in nerve action potentials owing to loss of axons. Interpretation is complex; but in general, different pathological processes result in changes in latencies, motor and/or sensory amplitudes, or slowing of the conduction velocities to differing degrees. Slowing of all nerve conductions in more than one limb indicates generalized peripheral neuropathy as in diabetes mellitus.

In 1998, a small-pain-fibers nerve conduction study (spf-NCS) method

came into practice. This method uses an electrical stimulus with a neuroselective frequency to determine the minimum voltage causing conduction. Rather than comparing the data with population averages on a bell-shaped curve, which at best has about 65% sensitivity, the patient was used as his own control. In a three year, LSU (.Louisiana State University) Pain Center study, it was found that the nerve requiring the greatest voltage to cause conduction of the A-delta (fast pain) fibers identified nerve root pathology with 95% sensitivity. Besides being painless, the test is fast. A new version, uses a potentiometer to objectively measure the amplitude of the action potential at a distant site along the nerve being tested. The previous version relied on the patient reporting a sensation when the nerve fired. The spf-NCS does not require myelin loss to detect function change, so velocity is not measured.

The nerve conduction study is sometimes combined with electromyography. Other special nerve conduction studies that are occasionally performed include double stimuli and repetitive stimulation.

NCV study has certain pre-requisites. Patients with any electrical device in situ such as cardiac pacemakers cannot be included in the NCV study[3]. There are also certain drawbacks like pain while doing EMG (Electromyography) in NCV study and electrical stimulation and the site of stimulating electrode that may not be tolerable for the patient.

DESCRIPTION:

The nerve conduction study consists of the following components-

1. Motor NCS: It is performed by electrical stimulation of a peripheral nerve and recording from a muscle supplied by that nerve and the resultant CMAP (compound muscle action potential) is measured. The time it takes for the electrical impulse to travel from the stimulation to the recording site is measured. This value is called the latency and is measured in milliseconds (rns). The size of the response called the amplitude is also measured. Motor amplitudes are measured in millivolts (mV). By stimulating.in two or more different locations along the same nerve, the NCV across different segments can be determined. Calculations are performed using the distance between the different stimulating electrodes and the difference in latencies.
2. Sensory NCS: It is performed by electrical stimulation of a peripheral nerve and recording from a purely-sensory portion of the nerve, such as on a finger and the resultant potential is SNAP (sensory nerve action potential). Sensory amplitudes are measured in microvolts (μV). It is calculated based upon the latency and the distance between the stimulating and the recording electrode. This cannot be changed.
3. F-wave study: It uses supramaximal stimulation of a motor nerve and recording of action potentials from a muscle supplied by the nerve. It is not a reflex, per se, in that the action potential travels from the site of the stimulating electrode in the limb to the spinal cord's anterior horn cell and back to the limb in the same nerve that was stimulated. The F-wave latency can be used to derive the conduction velocity of nerve between the limb and spine, whereas the motor and sensory nerve conduction studies evaluate conduction in the segment of the limb. F waves vary in latency.
4. H-reflex study: It uses stimulation of a nerve and records the reflex electrical discharge from a muscle in the limb. It also evaluates conduction between the limb and the spinal cord, but in this case, the afferent impulses are in sensory nerves while the efferent impulses are in motor nerves. This process cannot be changed. NCV study remains the only investigation that can confirm and locate the different nerves affected in diabetic neuropathy. Nerve conduction velocity studies are of use in firming up the diagnosis of diabetic neuropathy.

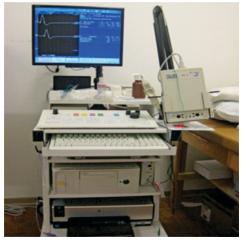

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Fig.1 Nerve conduction study machine.

AIM :

To study the nerve conduction in various clinical grades of diabetic foot.

OBJECTIVES :

1) To grade diabetic foot clinically.
2) To study nerve conduction in different grades.
3) To find the correlation between the clinical grading of diabetic foot and nerve conduction study.

MATERIAL AND METHODS:

This proposed study was carried out as a prospective ,randomized clinical trial in 50 patients diagnosed diabetic foot in department of surgery, Krishna Hospital karad from June 2018 to May 2019.

Inclusion criteria: Patients diagnosed as diabetic foot admitted in Krishna Hospital .

Exclusion criteria:

a) Patients with cardiac defibrillator or pacemaker
b) Any electrical machine in situ
c) Traumatic neuropathy
d) Hansens neuropathy

All patients diagnosed as diabetic foot were sent for Nerve Conduction Study after obtaining their written informed consent. Three nerves were studied; two motor nerves, Common peroneal and Tibial nerves, and one purely sensory nerve, Sural nerve[2]. After obtaining their nerve conduction study values, their results of nerve conduction study were tabulated according to clinical grades of diabetic foot I have used classification system developed by Wagner and Brodsky.

Table 1: Wagner and Brodsky depth-ischemia clasification

Depth Classification	Definition	Treatment
0	At-risk foot, no ulceration	Patient education, accommodative footwear, regular clinical examination
1	Superficial ulceration, not infected	Offloading with total contact cast (TCC), walking brace, or special foot wear
2	Deep ulceration exposing tendons or joints	Surgical debridement, wound care, offloading, culture-specific antibiotics
3	Extensive ulceration or abscess	Debridement or partial amputation, offloading, culture-specific antibiotics
Ischemia Classification	**Definition**	**Treatment**
A	Not ischemic	Observation
B	Ischemic without gangrene	Noninvasive vascular testing, vascular consultation if symptomatic
C	Partial (forefoot) gangrene	Vascular consultation
D	Complete foot gangrene	Major extremity amputation, vascular consultation

M wave: It is the travel of impulse from nerve to muscle without going to spinal cord after stimulation of nerve.

FACILITIES AND EQUIPMENTS:

All facilities and equipments were available in the institute. The Nerve Conduction Study was assessed objectively by using nerve conduction study machine, which gives exact velocity of conduction of impulse along the nerve and other parameters like amplitude, latency and F wave

Table 2: F response

	F response (the name F wave described by Magladery and Mcdougal in 1950)
Nature	Not a reflex but due to antidromic activation of alpha motor neurons
Best elicited in	Any distal muscles
Method	From any distal muscle by stimulating the appropriate nerve.

Position of patient	Placed in a belly tendon mortage done for a relaxed muscle
Stimulation	Supramaximal
Persistence	Variable
Amplitude	5% of M wave
Amplitude (mV)	The upper limit of normal adult, minimal F latency in 31 ms for hand and61 ms for foot muscles respectively. Right to left asymmetry of minimal F latency exceeding 2 ms in hand and 4 ms in foot is considered abnormal.

Details of Nerve Conduction Study

Table 3: Compartive table of three nerves

	Common Peroneal Nerve (motor)	Tibial Nerve (motor)	Sural Nerve (purely sensory)
Recording from	Extensor digitorum brevis	Abductor halluces	Between lateral malleolus and tendoachilles.
Stimulation at (supramaximal stimulation used)	1.Ankle 2.At the neck of fibula	1. Behind and proximal to the medial malleolus 2. In the popliteal fossa along the flexor crease of the knee slightly lateral to midline of popletial fossa	Stimulated antidromically 10-16 cm proximal to the recording electrode, distal to lower border of gastrocnemius at the junction of middle and lower third of leg
Velocity	48.3 ± 3.9 m/s	48.3 ± 4.5 m/s	50.9 ± 5.4 m/s
Distal Latency	3.77 ± 0.86 ms	3.77 ± 0.86 ms	3.77 ± 0.86 ms
Amplitude	5.1 ± 2.3 mV	5.1 ± 2.3 mV	Amplitude of SNAP (sensory nerve action potential) 18.0 ± 10.5 µV

RESULTS

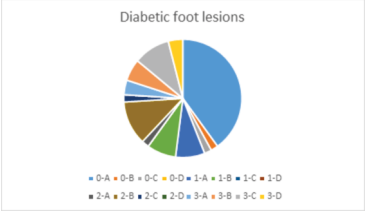

Figure 1: Pie diagramshowing number of patients in different wagner and Brodsky depth-ischemia classification of diabetic foot lesions.

Table 4: Number of patients in different types of neuropathy

Type of neuropathy	Numberof patients
Axonal	8
Demyelinating	3
Mixed	38
Normal	1

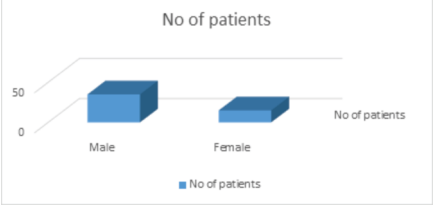

Figure 2: Bar diagram showing number of patients according to gender.

Table 5: Side affected clinically and according to NCV

Side affected	Clinically side affected	Side affected according to NCV	Test of significance
Right	21	7	X2 = chi-square = 6.979, p < 0.05
Left	17	3	
Bilateral	12	40	

DISCUSSION

The principal pathogenic mechanisms in diabetic foot disease are ischemia, neuropathy and infection; acting together they contribute to the sequence of tissue necrosis, ulceration and gangrene. Neuropathy affects around 50% to 60% of all the patients and more than 80% of diabetic patients with foot lesions[5].

Broadly the neuropathies are classified as focal and diffuse, the later more common and include the autonomic and chronic sensorimotor polyneuropathies, which both contribute to foot ulceration.

Sensorimotor neuropathy initially involves the distal lower extremities, progress centrally and is typically symmetric[4]. Sensory nerve- fiber involvement leads to loss of the protective sensation of pain, whereas motor-fiber destruction results in small-muscle atrophy in the foot.

The spectrum of infection in diabetic foot ranges from superficial ulceration to extensive gangrene with fulminant sepsis. The majority of infections are polymicrobic with the most common pathogens being staphylococci and streptococci. Potential sources of diabetic foot infection include a simple puncture wound or ulcer, the nail plate and the interdigital web space.

A proper evaluation for underlying vascular disease is essential for limb salvage in patients with diabetic foot ulceration, even when neuropathy and infection are present. There are two types of vascular disease in patients with diabetes; one, the nonocclusive microcirculatory impairment involving the capillaries and arterioles of the kidneys, retina and peripheral nerves; second, macroangiopathy characterized by atherosclerotic lesions of the coronary and peripheral arterial circulation. The single most important indicator of adequate perfusion is the presence of palpable pedal pulses .

Peripheral sensory neuropathy has been identified as the major risk for diabetic foot ulceration and also for amputation[2]. The inability ofdiabetic patients to feel pain places him or her at significant risk for future problems.

Diabetic neuropathies have many phenotypes. Distal sensory neuropathy is the most common variety of neuropathy with mild distal sensory impairment and minimal motor deficits and comprises greater than 50% of all diabetic neuropathies. Distal small fibre neuropathy is the other variety, characterized by distal positive symptoms including painfulness and impairment in both pain and temperature sensation . Hyperglycemia is now well established as a risk factor in both patients with type 1 diabetes and type 2 diabetes[1]. Other correlates and associations include age, duration of diabetes, quality of metabolic control, height, the presence of background or proliferaive diabetic retinopathy, cigarette smoking, high-density lipoprotein cholesterol and the presence of cardiovascular disease.

Both lightly myelinated and unmyelinated small nerve fibers an demyelinated large nerve fibers are affected. Dysfunction of small and large fibers occurs in varying combinations ; however in most cases the earliest deficits involve the small nerve fiber. Features characteristic of a small-fiber peripheral neuropathy include deficits in pain and temperature perception, paresthesias and dysesthesias, pain, deficits in the perception of visceral pain. Dysautonomia and predisposition to foot ulceration. Proprioception and deep tendon reflexes are relatively preserved. Nerve conduction studies may be normal or minimally abnormal when small- fiber features dominate since these measurements are dependent on conduction in the surviving large, myelinated nerve fibers. Once established, sensory and sensorimotor distal neuropathy is a permanent condition; although the course of painful manifestations is highly variable.

Although selected large fiber neuropathies might be expected to cause muscle weakness, painless loss of vibration and position sense, and impaired tendon reflexes, pathologic, clinical and quantitative sensory studies have not demonstrated pure loss of large fibers in diabetic peripheral neuropathy[4].

Foot ulceration and neuropathic arthropathy are two of the more dreaded complications of diabetic neuropathy. Foot ulcers usually

occur in patients with small- or large- fiber neuropathy. Painless ulcers in weight-bearing areas occur on a background of insensitivity to pain, impaired proprioception, atrophy of intrinsic foot muscles, and the consequent maldistribution of weight-bearing, disturbed sweating, impaired capillary blood flow caused by autonomic neuropathy and noninflammatory edema.

Numbness and paresthesia begin in the toes and gradually and insidiously ascend to involve the feet and lower legs[3]. Sensory deficit usually occurs symmetrically in the distal territory of overlapping nerves, but not infrequently, asymmetric patterns of sensory loss in root or nerve distribution may be superimposed on this distal symmetric pattern of sensory loss. Because the distal portion of longer nerves are affected first, the feet and lower legs are involved before the hands, producing the typical "stocking-and-glove" pattern of sensory deficit .

Nerve conduction velocity studies are of use in firming up the diagnosis of diabetic neuropathy .

Clinically, the patients in my study "Nerve Conduction Study In Different Clinical Grades Of Diabetic Foot" were assigned into different grades according to Wagner and Brodsky Depth-Ischemia Classification of Diabetic Foot Lesions.

Maximum number of patients in my study were found to be in the 0-A grade. Mixed type of neuropathy was the most common in my study with respect to sensory and motor types of neuropathy; and also axonal and demyelinating types of neuropathy. Maximum number of patients in my study were from the age group 61 to 65 years.

Number of patients with bilateral neuropathy detected by NCV study is more than that detected clinically and the difference is significant by applying the test of significance. Hence, NCV is a better study to detect nerve conduction abnormalities than clinical examination.

CONCLUSION

Nerve conduction study in different clinical grades of diabetic foot".
Present study was earned out as a prospective, randomized clinical trial in 50 patients diagnosed diabetic foot; in department of surgery, Krishna Institute of Medical Sciences, Karad.

All 50 patients were examined clinically and were investigated with NCV (Nerve Conduction Velocity) study. Three nerves were studied; two motor nerves, common peroneal and tibial nerves; and one purely sensory nerve, sural nerve.

Clinically, the patients were assigned into different grades according to Wagner and Brodsky Depth-Ischemia Classification of Diabetic Foot Lesions.

Maximum number of patients in my study were found to be in the 0-A grade. Maximum number of patients were from the age-group 61-65 years. Mixed type of neuropathy was the most common in my study with respect to sensory and motor types of neuropathy; and also axonal and demyelinating types of neuropathy.

Number of patients with bilateral neuropathy detected by NCV study in my study is more than that detected clinically and the difference is significant by applying the test of significance. Hence, NCV is a better study to detect nerve conduction abnormalities than clinical examination in diabetic foot.

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