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 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.

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. 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 asymptomatic 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 conduction 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 currently, the principal uses of NCV (Nerve Conduction velocity) study are to evaluate paresthesias (numbness, tingling, burning) and/or weakness of arms or legs.

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).
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. 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 (ms). 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.

**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. 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 classification**

<table>
<thead>
<tr>
<th>Depth Classification</th>
<th>Definition</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>At-risk foot, no ulceration</td>
<td>Patient education, accommodative footwear, regular clinical examination</td>
</tr>
<tr>
<td>1</td>
<td>Superficial ulceration, not infected</td>
<td>Offloading with total contact cast (TCC), walking brace, or special foot wear</td>
</tr>
<tr>
<td>2</td>
<td>Deep ulceration exposing tendons or joints</td>
<td>Surgical debridement, wound care, offloading, culture-specific antibiotics</td>
</tr>
<tr>
<td>3</td>
<td>Extensive ulceration or abscess</td>
<td>Debridement or partial amputation, offloading, culture-specific antibiotics</td>
</tr>
</tbody>
</table>

**Table 2: F response**

<table>
<thead>
<tr>
<th>Nature</th>
<th>From any distal muscle by stimulating the appropriate nerve.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best elicited in</td>
<td>Any distal muscles</td>
</tr>
<tr>
<td>Method</td>
<td>From any distal muscle by stimulating the appropriate nerve.</td>
</tr>
</tbody>
</table>

**Table 3: Wagner and Brodsky depth-ischemia classification**

<table>
<thead>
<tr>
<th>Ischemia Classification</th>
<th>Definition</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Not ischemic</td>
<td>Observation</td>
</tr>
<tr>
<td>B</td>
<td>Ischemic without gangrene</td>
<td>Noninvasive vascular testing, vascular consultation if symptomatic</td>
</tr>
<tr>
<td>C</td>
<td>Partial (forefoot) gangrene</td>
<td>Vascular consultation</td>
</tr>
<tr>
<td>D</td>
<td>Complete foot gangrene</td>
<td>Major extremity amputation, vascular consultation</td>
</tr>
</tbody>
</table>
RESULTS

Table 3: Comparative table of three nerves

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Stimulation site</th>
<th>Amplitude (mV)</th>
<th>Velocity (m/s)</th>
<th>Distal Latency (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibial Nerve (motor)</td>
<td>Ankle</td>
<td>5.1 ± 2.3</td>
<td>48.3 ± 3.9</td>
<td>3.77 ± 0.86</td>
</tr>
<tr>
<td>Sural Nerve (purely sensory)</td>
<td>Behind and proximal to the medial malleolus</td>
<td>5.1 ± 2.3</td>
<td>48.3 ± 4.5</td>
<td>3.77 ± 0.86</td>
</tr>
<tr>
<td>Peroneal Nerve (motor)</td>
<td>At the neck of fibula</td>
<td>3.77 ± 3.5</td>
<td>50.9 ± 5.4</td>
<td>3.77 ± 0.86</td>
</tr>
</tbody>
</table>

Table 4: Number of patients in different types of neuropathy

<table>
<thead>
<tr>
<th>Type of neuropathy</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axonal</td>
<td>8</td>
</tr>
<tr>
<td>Demyelinating</td>
<td>2</td>
</tr>
<tr>
<td>Mixed</td>
<td>38</td>
</tr>
<tr>
<td>Normal</td>
<td>4</td>
</tr>
</tbody>
</table>

DISSCUSSION

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.

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. 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 polymicrobial 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. The inability of diabetic 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. Other correlates and associations include age, duration of diabetes, quality of metabolic control, height, the presence of background or proliferative 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. Propriopception and deep tendon reflexes are relatively preserved. Nerve conduction studies may be normal or minimally abnormal when small-fiber features dominate; hence 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.

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. 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.

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REFERENCES