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Study of Nerve Conduction Parameters of Common Peroneal Nerve from Tibialis Anterior Muscle in Neuropathic Patients

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Abstract: Nerve conduction study (NCS) measures how quickly electrical signals move through peripheral nerve. It is used to assess peripheral nerve dysfunction thus diagnose the types of neuropathy, and nerve damage. The purpose of this study was to observe the significance of recording nerve conduction parameters (NCP) of common peroneal nerve (CPN) from tibialis anterior (TA) muscle in neuropathic subjects. This study included 153 subjects which were grouped, on the basis of clinical and routine NCS in to normal healthy subjects and neuropathic patients; axonal and demyelinating types**.** Nerve conduction parameters were recorded and analyzed by using Digital EMG machine. After categorizing the subjects, the recordings of NCP were also obtained from TA muscle on stimulation of CPN, above and below the head of fibula. Study was performed at recommended temperature (32-34^{0}C). For statistics, the data was analyzed using MS Excel 2010 and Graph pad Prism6. A t-test was applied to see the significance of NCP recorded from TA and compared it with the NCP obtained from extensor digitorum brevis (EDB) muscle in different categories of selected subjects. P-values < 0.5 were considered significant. The comparison of most NCP between TA and EDB was highly significant in these categories of selected subjects. In neuropathic patients, more than 40% were non responsive to EDB stimulation while recording from TA was comparatively convincing. Findings of the study showed that the recording of nerve conduction parameters from TA is very useful in severe neuropathic condition, therefore, should be performed routinely in nerve conduction study.

Keywords: Tibialis anterior, Common Peroneal Nerve, Nerve conduction parameter, Neuropathy

INTRODUCTION

Nerve conduction studies (NCS) assess peripheral sensory and motor functions thus used to diagnose neuropathic ailments [1-3]. It can help to define whether the underlying pathophysiology is due to demyelination or axonal loss, although most demyelinating neuropathies have some secondary axonal loss, and wise versa. In the case of polyneuropathies, this is of considerable diagnostic and prognostic importance [1, 4-6]. Nerve conduction studies have been used clinically for many years to identify the peripheral nerve lesion and to differentiate these from muscle diseases or neuromuscular junction's disorders [1, 2, 5, 7-10].

The reliability of the study is increased when the technical procedures are standardized. Stimulation of nerves evokes both an electrical and a mechanical response in the muscle innervated by the nerve distal to the site of stimulation. The electrical response is called the compound motor action potential (CMAP); it is the summated electrical activity of the motor fibers that are in region of the recording electrode and are innervated by the nerve. The general techniques of stimulating and recording of motor and sensory responses are similar for all nerves [9-12].

The CPN divides into superficial and deep branches distal to fibular neck. The superficial peroneal nerve innervates the peroneus longus and brevis. The deep peroneal nerve is primarily motor; it innervates the tibialis anterior, the extensor hallucis, and the extensor digitorum longus and brevis [13-15].

The differentiation of severe axonal degeneration from demyelination is often difficult during routine NCS and EMG testing, especially when the EDB does not respond to stimulation, which could be due to loss of muscle mass following severe axonal degeneration to the distal portion of the nerve. In patients, when there is difficulty in obtaining response from EDB, the conduction velocity of the peroneal

nerve can still be examined by recording from proximal muscle such as the tibialis anterior, it might also be used to recognize cases of injury to CPN [16]. The normal reference value of the conduction velocity can be used as a diagnostic tool and to predict the prognosis [9, 17]. The normal values of NCP i.e., amplitude, latency and conduction velocity of common peroneal nerve from proximal muscles have already been investigated by many authors [18,19]. Several factors have also been taken into consideration such as temperature and age [20] while doing NCS. To identify the abnormality on the basis of NCS, normative data from the local population is considered essential. The reference values of NCP for CPN from TA have already been established for local community [21].

Therefore, in the present study, it was emphasized that the recording of NCP from TA muscle is valuable in severe neuropathic condition. So, the plan of this study was to assess various Nerve conduction parameters of CPN, recorded from TA and compare it with the NCP obtained from EDB muscle in healthy controls and patients of axonal and demyelinating type neuropathies.

MATERIAL AND METHODS

It was basically a cross sectional study performed during routine neurophysiological testing in electro-diagnostic Lab of Neurology Department, Civil hospital Karachi from 2015-2016. The cases were referred from different outpatient departments for the diagnosis of neuropathy. The subjects were categories into normal, axonal and demyelinating type nerve disorders on the basis of detail clinical examination and routine neurophysiological findings. All of the above subjects were between 10-65 years of age, including both the sexes. Ethical permission was obtained from the concerned unit and the informed consent was obtained from the selected subjects.

For recording of NCP for CPN from TA, the active surface electrode (1) was placed over the Tibialis anterior muscle, Reference surface electrode (2) placed over the tibia and Ground surface electrode (G) placed between stimulating and recording surface electrode (Figure 1A). Before applying surface electrode, the skin was cleaned with alcohol swab. The stimulus was given to the nerve at two points. First distally (S1) approximately 2 cm distal to the fibular neck. Second, proximally (S2) in the lateral part of popliteal space. Using supramaximal stimulus, the recording of the nerve was taken. The distance between two stimulating point were measured to calculate nerve conduction velocity (NCV) of concern segment. Latency and Amplitude were also studied and data was expressed as Mean and standard deviation S.D. A sample of motor response recorded from TA is shown in the Figure 1B.

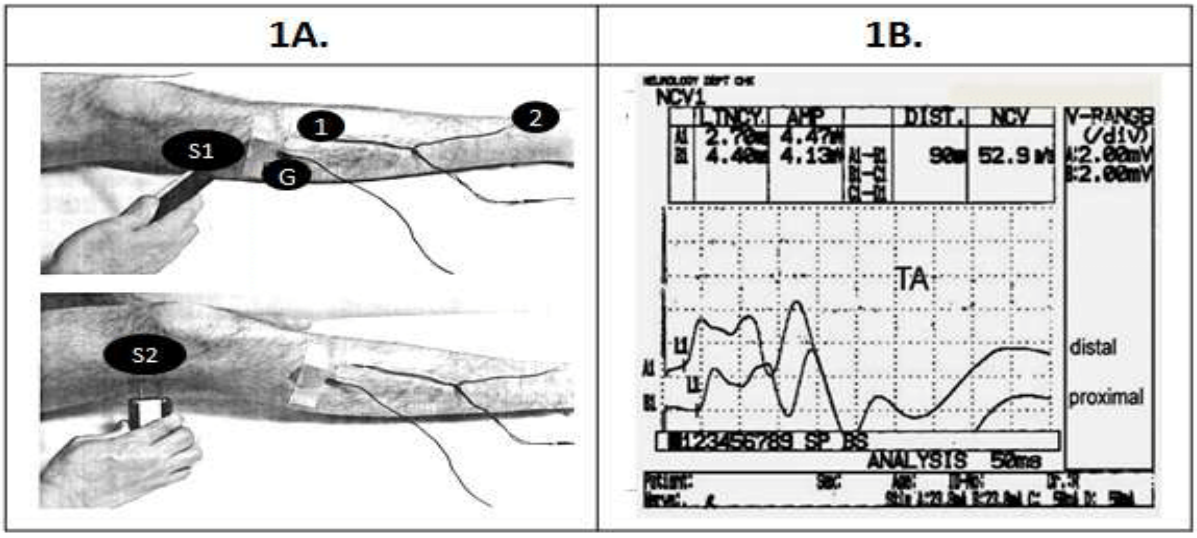

Fig-1: A) Electrode placements [recording (1, 2) , stimulating (S1, S2) and ground (G) electrodes] and B) Motor response of common peroneal nerve from tibialis anterior muscle.

The NCP were recorded from TA of the same subjects in which the NCP had already been obtained from EDB. These parameters were recorded from both the limbs in most cases. No significant difference was found in NCP between right and left limb, also insignificance was observed among different ages, therefore, these were considered individual observations. The total number of observations of neuropathic and normal (control) subjects are summarized in Table 1.

Table 1: Summary of the total number of subjects and observations of Normal, Axonal Degeneration and Demyelination Cases recorded from TA and EDB

Categories	Total No. of Subjects	Recording muscle	Total No. of observations
Normal	57	TA	101
		EDB	101
Axonal Degeneration	62	TA	124
		EDB	124
Demyelination	34	TA	68
		EDB	68
Note: No significant difference was found in nerve conduction parameters between right & left limbs.			

The NCP were recorded using EMG/NCS machine (MEB-7102, Nihon Kohiden, Japan). This machine is used to assess neuromuscular activities electro-physiologically. The standard equipment setting for NCS was used as per instructional manual.

The collected data was analyzed using statistical software (MS Excel 2010 and Graph pad Prism6). Both descriptive and inferential statistics were applied. A t-test was used to determine significant differences in NCP between TA and EDB in different subject's categories. P-values <0.5 were considered statistically significant.

RESULTS AND DISCUSSION

Table 2 shows descriptive statistics and comparison of average values of NCV, Motor Latency (DL), and amplitude of CMAP between TA and EDB of normal and neuropathic subjects (axonal and demyelinating categories).

There was a highly significant ($P < 0.05$) difference seen in comparison of most NCP between TA & EDB in normal, axonal degeneration and demyelination cases.

Table 2: Descriptive statistics and comparison of NCP between TA and EDB obtained from Normal, Axonal degeneration and Demyelination subjects

Parameters	Normal		
	TA	EDB	P value
NCV (m/sec.)	56.562 ± 0.788	47.881 ± 0.460	0.00001 (*)
Motor Latency (ms)	2.989 ± 0.077	3.946 ± 0.079	0.00001 (*)
Amplitude (mV)	3.935 ± 0.100	4.738 ± 0.169	0.00031 (*)
	Axonal Degeneration		
	TA	**EDB**	**P value**
NCV (m/sec.)	45.815 ± 0.826	34.456 ± 0.803	0.00001 (*)
Motor Latency (ms)	4.142 ± 0.112	5.285 ± 0.177	0.00001 (*)
Amplitude (mV)	1.962 ± 0.112	0.917 ± 0.132	0.00001 (*)
	Demyelination		
	TA	**EDB**	**P value**
NCV (m/sec.)	22.988 ± 1.217	24.91 ± 1.927	0.2006
Motor Latency (ms)	7.266 ± 0.703	11.0 ± 0.907	0.0007 (*)
Amplitude (mV)	1.203 ± 0.123	0.55 ± 0.117	0.0001 (*)
All values are given as mean ± Std. Error. A value $P < 0.05$ is considered statistically significant and represented as (*).			

Further, in neuropathic patients (either axonal type or demyelinating type) more than 40% of total number of observations from the selected subjects showed no response on stimulation to EDB while responses were obtained from TA in majority of these cases shown in Figure 2.

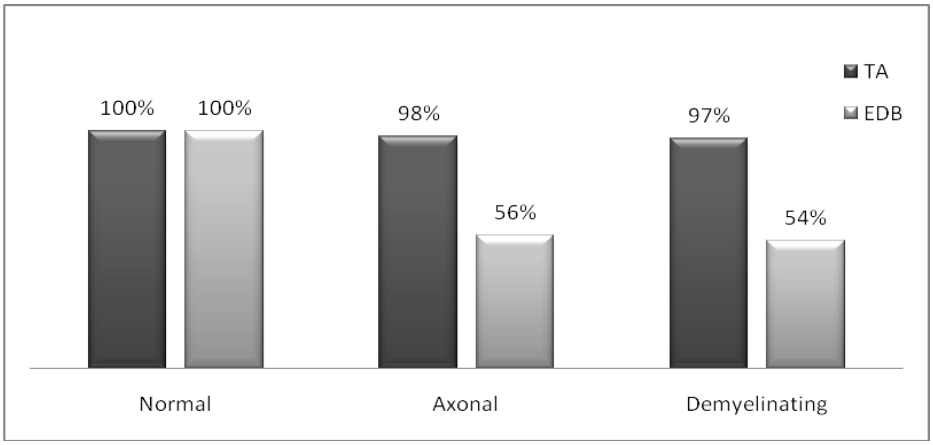

Fig-2: Percentage of Obtainable CMAP responses from total number of observations. (comparison between TA and EDB of Normal, Axonal Degeneration and Demyelinating cases)

The selected graphs shows importance of recording from TA which identify the type of neuropathy ie., demyelinating where the EDB showed no response on stimulation (Figure 3).

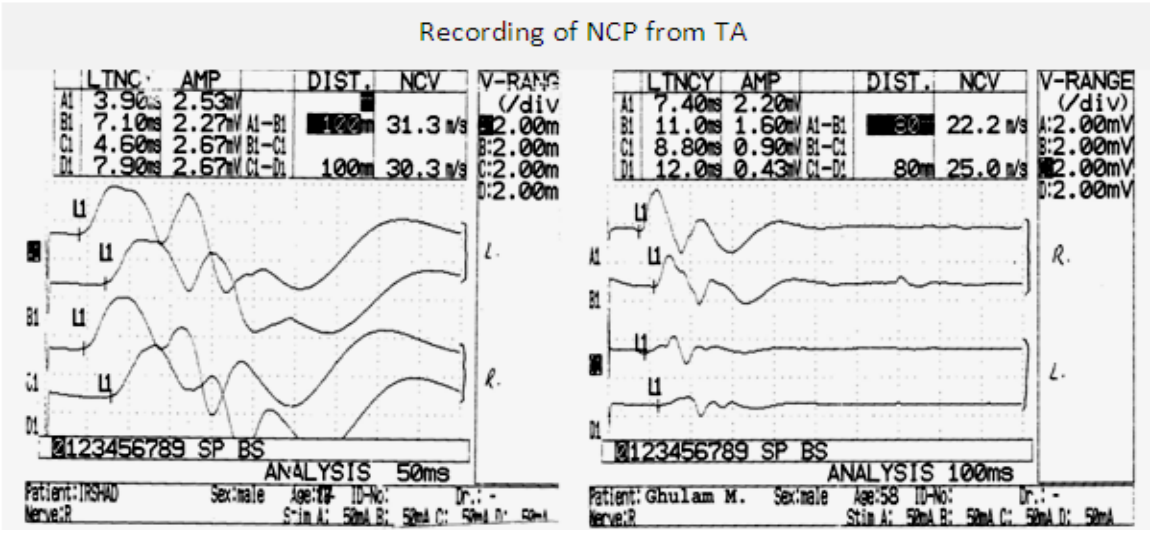

Fig-3: Recording of NCV from TA in subjects of demyelinating neuropathy

In the evaluation of patients having generalized polyneuropathy, one of the immediate goals is to identify the primary pathophysiology (underlying the neuropathy) as either axonal or demyelinating [8]. While many neuropathies are characterized by a combination of these pathologic changes, it is important to identify one of the two as the primary or predominant abnormality whenever possible. Kaeser and Lambert [22] were the first to compare electrophysiological and histological changes in experimental demyelinating and axonal neuropathies, and to establish the correlation between slowing of conduction velocity and segmental demyelination. Since then, a number of criteria have been established for the electrodiagnosis of primary demyelinating neuropathies [23, 24]. While they differ somewhat in their precise values, but included in slowing of motor conduction velocity, as their diagnostic criteria.

The reference values of NCS are very useful and important to describe the limits of normal function [7, 11, 18, 19, 25], the test values outside the reference range suggesting the presence of the type of neuropathy. Lee *et al.* [26] described the procedure and established reference values of peroneal motor nerve conduction of the proximal muscles. Buschbacher [27] also published the reference values of different nerve conduction parameters using standard recording technique for peroneal nerve through recording from EDB, he also presented [19] reference data for peroneal nerve motor conduction to the TA. For NCS of any nerve, reference values should be established from the local population because previous studies have shown differences in NCS function related to ethnicity and demographic factors[28,29]. Mustufa MA *et al.* [21] estimated the NCS parameters of CPN from TA in healthy subjects and established the reference value for local population.

In most of the literature the commonly used NCP have been mentioned, i.e., motor latency (DL), amplitude and NCV. The recording techniques was explained using surface disc electrodes and normative mean data of NCP for common peroneal nerve was proposed to the EDB as well as TA [30] and other nerves of lower limb [10, 28, 31, 32] along with their importance in the diagnosis of nerve disorders [33]. Since, these parameters are clinically important in confirming the nerve pathology; therefore, these have also been measured in the present study.

In routine neurophysiological testing, the EDB is commonly used to record action potential of peroneal nerve [27, 34, 35]. While, peroneal motor studies to the tibialis anterior muscle are not performed routinely in neurophysiological testing.

The conduction velocity has been assumed to remain relatively static throughout the adult years but has some tendency to decrease slightly as an individual age. The relationship of conduction velocity to age is most dramatically seen in individuals younger than age 4 and older than 60 [36].

Some of the previous studies showed relationship between NCS parameters and age [36, 37]. Whereas in some other studies, no significance difference has been reported statistically between NCP and age (10-65 years), and also no significance difference was noticed between right and left limb [25, 38].

In this study, we also found no significant correlation among the age and NCP and also no significance was observed between the right and left side in relation to the NCP. NCV is fastest at proximal portion of nerve than the distal site [39]. It was also stated that NCV is related to the diameter of the nerve and the normal degree of myelination of the nerve, which is usually more at proximal site of the nerve, so the proximal NCV recorded from TA was significantly higher than NCV obtained from EDB [9, 34, 39, 40].

Often the electrophysiological testing fails to recognize the nerve pathology clearly, particularly where the EDB does not provide the clear image of disease. So, in the present study, the recordings of Nerve Conduction parameter of peroneal nerve from TA have been undertaken, using standard protocol, along with routine electro-diagnostic study. It was revealed that the recording from TA is more beneficial and helpful in clarification of the nerve disorders where the recording from EDB is not comprehensible. As shown in Figure 2, the nerve disorders, either axonal degeneration or demyelination type, the recording of NCP from EDB in selected patients were indecisive in more than 40% cases of the total observations, while recordings from TA were comprehensible with few exceptions. This comparison highlights the importance of recording NCP from TA in nerve pathology.

CONCLUSION

On the basis of results obtained in the present study, it was concluded that recordings of NCP from TA is very helpful, especially when recording from EDB is not clear, We suggest that the NCP of common peroneal nerve to the TA should be studied during routine electrophysiological testing, it may help in making a decision regarding diagnosis and progress of the nerve injury.

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