EARLY DETECTION OF CONDUCTION FAILURE OF MEDIAN NERVE IN PATIENTS WITH DIABETIC TYPE I & TYPE II

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ABSTRACT
An intelligent biopotential amplifier [Electroneurograph] for measurement of conduction velocity has been fabricated and tested in diabetic type I & II patients with moderate to acute diabetic neuropathic conditions. The electrodes were placed in appropriate positions and resultant responses were measured. Latency of waveform was measured from which the conduction velocity was arrived at. Significant variations in conduction velocity in median nerve of specimen were observed in moderate to acute diabetic type I & II. Diagnosis of diabetic neuropathy at various stages is the primary significance of this technique which helps the doctor to take immediate steps for advanced treatment in patients to minimize conduction failure.

KEY WORDS
Biopotential Amplifier, Electroneurograph, Evoked Potential, Conduction Velocity, Diabetic Neuropathy.

1. INTRODUCTION
Diabetic neuropathy is one of the wide spread and awesome fall out of diabetes mellitus. It leads to great morbidity resulting in a fiscal burden for diabetes management. Diabetic neuropathy puts patients to more than ten times higher risk of amputations when compared to non-diabetic patients. Other vascular complications such as peripheral vascular disease in diabetes enhance the risk of foot complications. However, the advancement of neuropathy can be minimized by early diagnosis and management [1]. As neuropathy occurs in conjunction with low blood circulation, the condition often leads to chronic ulcers or tissue loss in untreated wounds [2].

Nerve conduction study has been a significant stage of electro diagnosis and has been widely applied as a clinical diagnostic tool in diabetic neuropathy. Neurological examination is based on evoked potential. Evoked potentials result from electric pulses that passed through the excitable tissues such as nerves and muscles. Research explorations are pursued for observing the regeneration of damaged cells on analyzing the electric signals for measuring the compound neural action potential [3]. This measurement technique enables easy study of conduction velocity of nerves and muscles [4]. Electrophysiological examination revealed conduction blocks, severely decreased conduction velocities, absent F-waves relatively preserved sensory nerve conduction velocities [5]. An intelligent biopotential amplifier has been fabricated and tested for measuring the latency to calculate the conduction velocity of median and median nerves of patients with diabetic neuropathic conditions. The specific application is developed according to the requirements of the experimental research practice on the study of compound action potentials of nerves in the field of neurophysiology [6]. This paper establishes the variations in conduction velocity of median nerve in patients with moderate to acute diabetic conditions in type I & II.

2. MATERIALS AND METHODS
An Electroneurograph has been fabricated and tested for measuring the latency. The important components of the instrument are variable cutoff for the low pass filter, variable gain, attenuation and optical isolation for the output. A fourth order low pass filter with Bessel characteristic was designed using active filters. The position of attenuator is in between the gain stage and optical isolator that attenuates the signals during supra maximal stimulations. In this intelligent bio-potential recorder, one of the outputs of the amplifier is optically separated using IC MOC 3020 so that safety of patient is totally ensured [7].

The input portion of the instrumentation amplifier which is named head stage is designed separately and the inputs from the electrodes are given to the head stage by means of shielded coaxial cable. Also the intelligent biopotential recorder is shielded properly and grounded to reduce the noise effect. Base line shift is controlled by using the Offset switch provided in the front panel. The stimulating and recording electrodes were placed in appropriate positions and evoked responses were recorded [3]. The schematic diagram of the recording setup for neurological examination is shown in figure 1.
Diabetic neuropathy is a disease associated with diabetic patients in which single nerve or multiple nerves get inflamed. Motor fibers are less affected than sensory fibers and the upper limbs appear to become less involved than the lower. In diabetic, small vascular lesions in a multifocal distribution result in a variety of patterns of abnormality on nerve conduction studies. The measurement of conduction velocity has been done by stimulating at two different points along the nerve and measuring the latency for each electrical response recorded from the muscle. Conduction velocity was calculated by dividing the nerve length between the stimulation points by difference in latency expressed in meters per second [8]. Studies on nerve conduction have been undertaken on patients who suffer from diabetic neuropathic conditions. A total of 110 subjects were identified among the age group of 30 to 70 in the range of normal – moderate – acute stages of diabetic neuropathic conditions of type I and II, such that 40 subjects (13 female and 27 male) in each stage is considered. The normal subjects are without indications of diabetic conditions and with a normal fasting glucose level of 80-120 mg/dl. The subject having duration of diabetics between 10-20 years of diabetic type I and II is considered as moderate subject with fasting glucose level in the range of 170-250 mg/dl. The subject having duration between 20-30 years of diabetic type I and II is considered as chronic subject with fasting blood sugar in the range of 300-500 mg/dl.

The measurements were taken on fasting conditions of the subject. Each subject was measured consecutively over a period of 6 days and the mean reading is reported. The nerve conduction velocity was determined by stimulating the nerve at two points one at the elbow and the other at the wrist as shown in [Fig 1]. The latencies for the above two responses were calculated. The length of the nerve segment was obtained by measuring the distance between the cathodes when placed for each stimulation [9].

For accuracy of measurements, the two stimulation points [cathode to cathode] was separated by a minimum distance of 10cm [10]. Sample waveforms recorded from normal subject, moderate diabetic patients and from chronic diabetic patients are shown in figure 2(a), 2(b) and 2(c) respectively. It can be seen that the amplitude of the waveforms recorded decreases from normal to chronic conditions.

![Fig 1: Recording Setup](image1)

![Fig 2: Nerve action potential of subjects with (a) normal (b) moderate and (c) chronic conditions](image2)
Fig 2: Continued

Fig 3: Conduction velocity for Median nerve of normal subjects

Fig 4: Conduction velocity of Median nerve of moderate subjects of diabetic type I

Fig 5: Conduction velocity of Median nerve of moderate subjects of diabetic type II

Fig 6: Conduction velocity of Median nerve of chronic subjects of type I

Fig 7: Conduction velocity of Median nerve of chronic subjects of type II
3. RESULTS AND DISCUSSIONS

Conduction velocities and related parameters of median nerves of specimen with diabetic type I and type II in the range from normal–moderate to acute stages are given in the Figures 3 to 7. In the normal conditions, the conduction velocity of median nerve was found at a mean value of 54.38 m/s. It has a standard deviation of ±2.077 m/s.

Fig 8: Conduction velocity of median nerve versus fasting blood sugar for normal, moderate to acute diabetic type I and type II.

In the moderate conditions, the conduction velocity of median nerve of diabetic type I was found at a mean value of 37.34 m/s. It has a standard deviation of ±2.85. The value for conduction velocity of median nerve of diabetic type II was found at a mean of 36.21 m/s with a standard deviation of ±2.98. In the chronic conditions, the conduction velocity of median nerve of diabetic type I was found at a mean value of 9.49 m/s. It has a standard deviation of ±2.93. The value for conduction velocity of median nerve for diabetic type II was found at a mean of 8.98 m/s with a standard deviation of ±2.35. It is found that the conduction failure is more predominant in diabetic type II than in diabetic type I.

The plot in figure 8 shows a steady drop in the conduction velocity of subject from normal to moderate where as a rapid drop in the conduction velocity in subject from moderate to acute. It is observed that the amplitude of waveform figure 9 has been significantly reduced with the progress of diabetic neuropathic conditions. A reduction in amplitude of the evoked response and slowing in conduction velocity could be due to axonal destruction or due to multiple small additive lesions [11].

By doing the conduction velocity measurement in diabetic type I and type II patients the slowdown in conduction velocity can be detected in early stages so that the doctor can start treatment. This helps not only to prevent nerve damages but also to prevent damages to various organs due to the increase in the blood glucose level. This technique can be applied to perform conduction studies on normal subjects and also subjects with clinical conditions with optimum patient safety. This intelligent biopotential amplifier helps the doctors to diagnose conduction failure of median nerves at an early stage so that peripheral neuropathy is managed timely and effectively.

4. CONCLUSION

The results of conduction velocity studies from presently available literature [Webster’s Handbook] are comparable with those of our studies indicates not only the proper functioning of the Electroneurograph but also the appropriateness of methodology of our study. The developed instrument is very cheap compared to the existing machines and shows very good performance in recordings. Diagnosis of diabetic neuropathy at various stages is the primary significance of this technique. The early detection of conduction failure helps the doctor to take immediate remedial steps to prevent further conduction loss.

In future, this work can be extended to measure the conduction velocity of leprosy, myasthenia gravis patients and to record different types of neurogram signals having different types of muscular diseases and also to monitor the auto toxic effects.

ACKNOWLEDGEMENTS

I acknowledge the generous support extended by the Principal, Dean PG and UG, College of Engineering Trivandrum, my colleagues and Professionals of Medical College Trivandrum.
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