Original Article

Comparison of Cross Sectional Areas of Median Nerve in Type 2 Diabetic Patients with Peripheral Neuropathy with Healthy Adult Subjects Measured by 2 D-B Mode High Resolution Ultrasonography

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Abstract

Background: *Patients with diabetic peripheral neuropathy (DPN) have distal, symmetrical form of the disorder characterized by numbness, burning feet, pins-and-needles sensations and lightning pain. This study was designed to find out the difference between 2 Dimentional (D)-Brightness (B) mode high resolution ultrasonographically measured cross sectional areas of median nerve in type 2 diabetic patients with peripheral neuropathy and those of non-diabetic healthy adult subjects.*

Methods: *This case-control study was done on 180 subjects aged 27-67 years in the department of Radiology and Imaging, BIRDEM from January 2012 to December 2013. Out of them 90 diabetic patients with peripheral neuropathy diagnosed electrophysiologically by nerve conduction study (NCS) were considered study group and age, sex and weight compatible 90 healthy subjects were considered as control group.*

Measurement of cross sectional areas of median nerve was performed first by the investigator himself purposefully, consecutively and subsequently confirmed by a radiologist in the department of Radiology and Imaging, BIRDEM, who did not know the subjects' condition to eliminate bias. The major axis, minor axis and the cross sectional areas (CSA) of the median nerve were measured at the carpal tunnel.

Results*: In this study, the mean cross sectional areas (mm^2) of median nerve healthy subjects was 7.78±1.00 mm^2 and in diabetic patients with peripheral neuropathy was 13.67±2.97 mm^2. The difference mean CSA of median nerve of diabetic subjects with peripheral neuropathy and control subjects were statistically significant ($p<0.05$) in unpaired 't' test.*

Conclusion: *This study showed that there is a significant difference between the cross sectional areas of median nerve in diabetic subjects with peripheral neuropathy and healthy adult subjects. The mean cross sectional areas of median nerve were increased in diabetic patients with peripheral neuropathy compared to control group.*

Key words: *Diabetic peripheral neuropathy, median nerve, ultrasonography.*

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Introduction

Diabetes mellitus is one of the most common non-communicable diseases globally. Bangladesh is a developing country that has been facing a high prevalence of diabetes mellitus. In 2011, 8.4 millions of people with diabetes have been estimated in our country with prevalence of 8.1% in urban and 2.3% in rural areas and this number will reach 11 million by the year 2030.[1]

About 35% to 45% of diabetic patients have symmetrical diabetic peripheral neuropathy (DPN). More than 80% of patients with diabetic neuropathy have a distal, symmetrical form of the disorder characterized by

numbness, burning feet, pins-and-needles sensations and lightning pain. Advanced DPN causes serious complications, such as diabetic foot ulcers, gangrene and charcot joint and all of which worsen the quality of life of diabetic patients. Therefore, early detection of nerve dysfunction is important to provide appropriate care for patients with DPN.[2]

The pathophysiology of DPN is multifactorial and involves genetic, metabolic and vascular factors. Diabetes induced endothelial dysfunction with a resultant decrease in nerve blood flow (vasa nervorum) plays a key role in axonal degeneration, demyelination of nerve fibre. Hyperglycemia includes increased metabolic flux through the polyol pathway with consequent sorbitol and fructose accumulation in DPN.[3]

Sorbitol itself causes secondary sodium accumulation resulting increased water content of peripheral nerve. Resulting to enlarged cross sectional area of peripheral nerve. Due to demyelination, there is decreased nerve conduction velocity in nerve conduction study (NCS)[2].

Median nerve originates from brachial plexus (lateral cord C5-C8 and medial cord C8-T1) runs along with brachial artery in arm and enter into forearm with two heads of pronator teres. Approximately 5 cm proximal to the flexor retinaculum it becomes more superficial. Just proximal to the carpus, the nerve lies between the tendons of the flexor digitorum superficialis and the flexor carpi radialis, partially deep to the tendon of palmaris longus. The nerve then passes deep to the flexor retinaculum into the carpal tunnel of the wrist.[4]

In healthy adult subjects, peripheral nerves are seen as hypoechoic neuronal fascicles. Because the endoneurium is too thin to reflect the sound beam, it is hypoechoeic on the ultrasonography (USG). The neural fascicle consists of several neural fibers and is embedded in a capsule called the perineurium. This capsule consists of connective tissue, vessels and lymphatic ducts and is thick enough to reflect the sound beam, resulting in hyperechoeic on USG. Therefore, a peripheral nerve is seen as several parallel hyperechoic lines and bold hypoechoic lines on longitudinal images and as a faveolate pattern on transverse images. When imaged transversely a peripheral nerve has speckled appearance.[5]

Although imaging analyses for neuropathy have not been used for diagnosis, high resolution diagnostic ultrasound equipment has improved greatly, making revelation of minute peripheral nerves by measuring cross sectional areas of peripheral nerves.

Nerve conduction study is time consuming. In contrast, sonographic examination can be performed to assess peripheral nerves with less discomfort, more over it is painless, noninvasive, less expensive and to screen extensive length of nerves quickly with good resolution and has already been used for the evaluation of disorders of the peripheral nerves. Thus, this would be a beneficial tool for the doctor to assess and make quick decision about patient with diabetic peripheral neuropathy and to follow up the patients[13-107].

Methods

This case-control study was carried out in the department of Radiology and Imaging, BIRDEM in Collaboration with the department of Neuromedicine, BIRDEM.

This study was done on 180 subjects aged 27-67 years in the department of Radiology and Imaging, BIRDEM from January 2012 to December 2013. Out of them 90 diabetic patients with neuropathy were considered study group and 90 healthy subjects were considered as control group.

The patients referred to the Department of Radiology and Imaging of BIRDEM from Department. of Neuromedicine, BIRDEM after confirmed peripheral neuropathy by nerve conduction study.

Measurement of cross sectional areas of median nerves was performed first by the investigator himself blindly and subsequently confirmed by a radiologist in the department of Radiology and Imaging, BIRDEM, who did not know the subjects' condition to eliminate bias.

Before measurement of cross sectional areas of median nerves by 2D-B mode high resolution ultrasonography examination proper counseling and reassurance to the patient regarding the examination procedure was done to reduce their apprehension and to get full cooperation. No other specific preparation was required.

The equipment used for this study are Simens Sonoline Anteres and Medison Sonoace 800 live machines with multifrequency linear transducer of 6-10 mHz. All participants were examined in supine position on a firm bed with fingers semiextended during examination of the median nerve. The volar wrist crease and pisiform bone were used as initial external reference points and

landmarks during scanning. Transverse and longitudinal sonograms of the nerve at each position were recorded.

The major axis, minor axis and the cross sectional areas (CSA) of the median nerve were measured at the carpal tunnel.

The CSA was calculated by the indirect method using the formula –

Major axis × minor axis × π ×1/4 (mm^2)

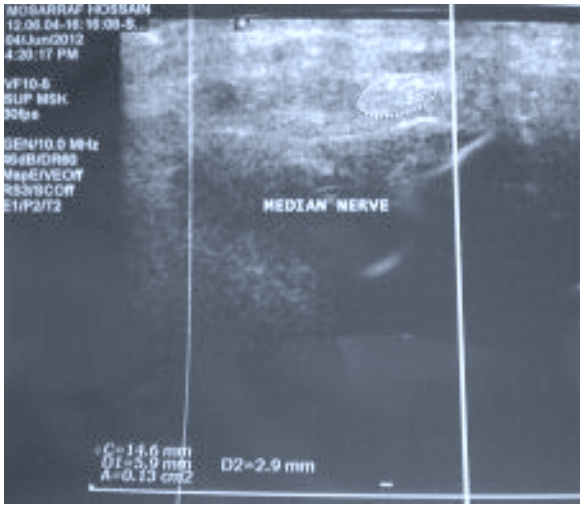

Figure 1. Measurement of cross sectional area of median nerve

Each measurement was taken 3 times and the mean value was used in the analysis. Statistical analyses of the results were done by computer software device as statistical packages for social science (SPSS). A value of $p < 0.05$ was considered statistically significant. Difference between the cross sectional areas of median nerves in type 2 diabetic patients with peripheral neuropathy and nondiabetic healthy adult control subjects were analyzed by the unpaired student "t" test.

Results

Total 90 type 2 diabetic patients with peripheral neuropathy and 90 healthy adult control subjects were included in this study according to the criteria mentioned in material and methods. Mean age of diabetic patients was 49.28 ± 7.42 years with range from 27 to 67 years and most of the patients (47.7%) were found in 4th decade. In this present study it was found that 51.1% and 48.9% were males and females respectively. Mean age of healthy control subjects was 47.36 ± 7.68 years with range from 30 to 59 years and majority (52.2%) were found in 4th decade, out of which 57.8% were males and 42.2% were females. Cross sectional area of median nerve was significantly more in diabetic group (13.67± 2.97 mm^2 vs 7.78± 1.00 mm2, $p<0.05$).

Table I. Cross sectional areas (mm^2) of median nerve in healthy adult control subjects

Cross sectional areas (mm^2)	Number of control subjects	Percentage
6-6.9	24	26.6
7-7.9	29	32.2
8-8.9	24	26.
9-9.9	13	14.4
Total	90	100
Mean ± SD	7.78 ± 1.00 mm^2	
Range	6.20-9.60 mm^2	

Table II. Cross sectional areas (mm^2) of median nerve in the type-2 diabetic patients with peripheral neuropathy

Cross sectional areas (mm^2)	Number of subjects	Percentage
8-10.9	22	24.4%
11-13.9	23	25.5%
14-16.9	29	32.2%
≥ 17	16	17.7%
Total	90	100%
Mean ± SD	13.67 ± 2.97 mm^2	
Range	8.3 – 18.70 mm^2	

Discussion

High resolution sonographic examination can be performed to assess the peripheral nerves with less discomfort. More over it is painless, noninvasive, less expensive and to screen extensive length of nerves quickly with good resolution and has already been used for the evaluation of disorders of the peripheral nerves. Thus, this would be a beneficial tool for the doctor to assess and make quick decision about patient with DPN and to follow up the patients[3,11,12,20].

In this study 90 patients were divided into five age groups. The ages of the patients ranged from 27 to 67 years with the maximum number of cases found in the 40-49 years age group. Similar study done by

Heinemeyer et al[10] showed no significant difference between the study and reference group with respect of age.

For control group, age, sex and weight compatible 90 healthy adult control subjects were recruited from hospital personnel, voluntary workers and also referred to the Radiology and Imaging department for other purposes.

In this study, the mean cross sectional area (mm^2) of median nerve 90 healthy subjects and was 7.78±1.00 mm^2 and 90 diabetic patients with peripheral neuropathy was 13.67±2.97 mm^2. CSA of median nerves of 90 diabetic subjects with peripheral neuropathy and 90 control subjects was statistically significant ($p<0.05$) in unpaired 't' test.

The previous investigator Watanabe et al.[2] who compared the mean cross sectional area of median in diabetic patients with peripheral neuropathy and healthy subjects and found there was significant difference ($p<0.001$)in the cross sectional area in the diabetic patients compared with that in the controls. The mean differences of cross sectional areas (mm^2) of median nerve was 8.3±1.8 mm^2 in control subjects and diabetic patients with peripheral neuropathy was 14.0±6.1mm^2. So, the result of present study coincides with those of the previous studies. The mean cross sectional area of median nerves of diabetic patients with peripheral neuropathy is significantly higher than that found in control group.

It has further been hypothesized that the peripheral nerve is swollen in individual with diabetes mellitus because of increased water content related to increased aldose reductase conversion of glucose to sorbitol.[18,19,21]

From the results of the present study, higher mean cross sectional area of median nerve favoured the diagnosis of diabetic peripheral neuropathy. High resolution sonographic measurement of cross sectional areas of median nerve is one of the important diagnostic imaging tools to assess and make quick decision about patients with DPN. The mean cross sectional areas of median nerve were increased in diabetic patients with peripheral neuropathy study group compared to control group. So, statistically significant difference of mean cross sectional areas of median nerve between the groups was observed. So, Null hypothesis is rejected at $p=0.001$. Hence hypothesis of this study is accepted.

Conclusion

From the findings of present study it can be concluded that, there was statistically significant difference between cross sectional areas (CSA) of median nerve measured by 2D-B mode high resolution ultrasonography in type 2 diabetic patients with peripheral neuropathy and those of healthy control adult subjects included in this study. Higher cross sectional areas (CSA) of median nerve in type 2 diabetic patients may predict the diabetic peripheral neuropathy.

Limitations

Although optimum care had been tried by the researcher in every steps of this study, still some limitations exist. In spite of maximum effort by the researcher, due to limited study period and resource limitation, sample size was relatively small; a larger sample size would have given a better result. Assessing single nerve may not predict diagnose neuropathy. Another nerve may be added in future study for better predictive value.

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Conflict of interest: Nothing to declare.

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