

## **Functional analysis of auditory pathway in type 2 diabetes by brainstem auditory evoked response-a pilot study.**

**Rajesh Paluru<sup>1\*</sup>, Yogananda Reddy Indla<sup>2</sup>, Ramaswamy C<sup>3</sup>, Rajani Santhakumari<sup>1</sup>**

<sup>1</sup>Department of Physiology, MediCiti Institute of Medical Sciences, Telangana, India

<sup>2</sup>Department of Physiology, SVS Medical College, Telangana, India

<sup>3</sup>Department of Physiology, Saveetha Medical College, Tamilnadu, India

### **Abstract**

**Background:** Diabetic neuropathy is one of the major complications reported widely in type 2 diabetes. It affects all the sensory, autonomic and motor systems including auditory pathway.

**Objectives:** Present study is focused on functional analysis of auditory pathway by Brainstem Auditory Evoked Response (BAER) and with Pure Tone Audiometry (PTA) in type 2 diabetes. To compare the same in healthy individuals with euglycaemia.

**Materials and methods:** This is a cross sectional study, ten type 2 diabetic subjects were recruited as test group, age and sex matched ten healthy subjects were selected as control group. Inter wave peak latencies with BAER and pure tone averages with PTA for both the ears were recorded in test and control groups. Unpaired “t” test was carried out to compare the data, p value <0.05 is considered as significant.

**Results:** Right ear stimulus threshold in controls and test groups are  $14.9 \pm 2.04$  &  $30.9 \pm 11.43$  ( $p=0.01$ ) respectively and for left ear,  $18.9 \pm 7.48$  &  $30.6 \pm 4.0$  ( $p=0.01$ ) respectively. Wave I-III inter peak latencies of BAER for right ear in control and test groups are  $1.79 \pm 0.15$  &  $2.20 \pm 0.30$  ( $p=0.02$ ) respectively and for left ear,  $1.79 \pm 0.12$  &  $2.25 \pm 0.40$  ( $p=0.04$ ) respectively.

**Conclusion:** The present study concludes that in type 2 diabetes inter wave peak latencies and pure tone averages were higher when compared with controls.

**Keywords:** Type 2 diabetes, Glycosylated haemoglobin, Pure tone audiometry, Brainstem auditory evoked response.

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### **Introduction**

Diabetes affects the sensory, motor and autonomic nervous systems, including the auditory pathway. Uncontrolled diabetes causes difficulty in hearing [1] and Jardao first ever reported hearing loss in a diabetic patient [2]. Sensory neuronal deafness is observed in diabetes, particularly for high frequency sounds [3]. Globally 382 million people have diabetes and the number is set to rise beyond 592 million in less than 25 years. Currently 175 million undiagnosed diabetic cases are present across the globe and the number is increasing at a robust rate, a vast amount of people with diabetes are progressing towards complications unawares [4]. It is an established fact that diabetes effects the functional status of the endothelium and studies shows that there is sudden sensory neuronal hearing loss with endothelial dysfunctioning [5,6]. Type 2 diabetics with a familial history of diabetes are having low levels of nitric oxide, and this can damage the endothelium [7]. The glycosilated haemoglobin (HbA1c) and Pure Tone Audiometry (PTA) tests are gold standard [8,9] in monitoring the diabetic control and assessing the hearing threshold

respectively. In the present study HbA1c concentration is measured to assess the glycaemic status. PTA and Brainstem Auditory Evoked Response (BAER) are used for the functional analysis of auditory pathway.

### **Hypothesis**

Functional status of auditory pathway is affected in type 2 diabetes.

### **Objectives of the study**

1. To observe the effect of type 2 diabetes on inter wave peak latencies in BAER.
2. To illustrate the auditory threshold in type 2 diabetics with PTA.
3. To observe the glycaemic status by measuring the HbA1c levels.

**Material and Methods**

**Study design**

It is a cross sectional study. Study was approved by the institutional ethical committee (FWA00002084 dated 16/03/2015).

**Inclusion criteria**

Ten type 2 diabetic subjects of both the sex, aged between 30-55 years were included in the study as cases. Age and sex matched 10 healthy individuals were also included in the study as controls. Written informed consent was obtained from both the groups after making them to understand the objectives of the study.

**Exclusion criteria**

Subjects were excluded from the study if they have present or past history of using ototoxic drugs, noise exposure, ear surgeries, chronic middle ear diseases, cranial trauma, metabolic disorders except for diabetes mellitus, underwent recent surgeries, any type of chronic infections, congenital hearing problems, type 1 diabetes, smokers and alcoholics.

**Glycosylated haemoglobin (HbA1c)**

Glycosylated haemoglobin was estimated on the basis of latex agglutination inhibition assay by using Rx imola automated analyser. Here the haemoglobin is hydrolysed by the enzyme protease in the haemoglobin denaturant reagent. The reported HbA1c result is calculated as a percentage of the total haemoglobin concentration (Randox, UK).

**Pure Tone Audiometry (PTA)**

Hearing threshold was measured with PTA and is performed in a sound attenuated chamber. Pure tone audiometry was recorded with Elkon3N3 Multi Diagnostic Audiometer, Bombay, India.

**Brainstem Auditory Evoked Response (BAER)**

Inter wave peak latencies in auditory pathway were recorded with Biologic Navigator Pro system, AEP Software version 6.3

**Table 1.** PTA thresholds in dB in control(C) and test (T) groups with mean and SD.

| Parameter         | C Right Ear | T Right Ear  | p value | C Left Ear  | T Left Ear  | p value |
|-------------------|-------------|--------------|---------|-------------|-------------|---------|
| Pure tone average | 14.9 ± 2.04 | 30.9 ± 11.43 | 0.01    | 18.9 ± 7.48 | 30.6 ± 4.00 | 0.01    |

**Table 2.** BAER results in milliseconds in control(C) and test (T) groups with mean and SD.

| IPL   | C Right Ear | T Right Ear | p value | C Left Ear  | T Left Ear  | p value |
|-------|-------------|-------------|---------|-------------|-------------|---------|
| I-III | 1.79 ± 0.15 | 2.20 ± 0.30 | 0.02    | 1.79 ± 0.12 | 2.25 ± 0.40 | 0.04    |
| III-V | 1.53 ± 0.26 | 1.60 ± 0.41 | 0.74    | 1.64 ± 0.13 | 1.92 ± 0.17 | 0.02    |

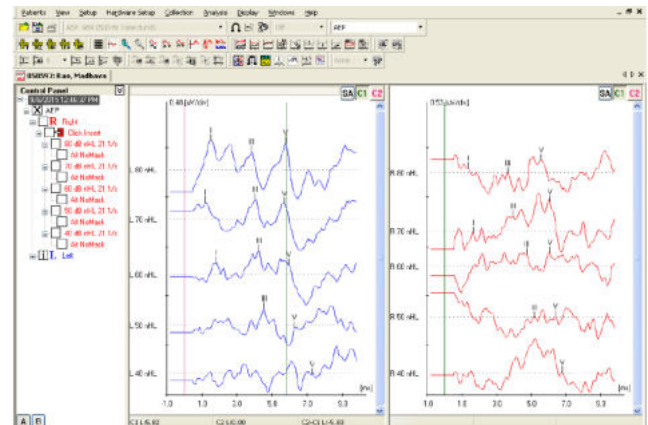
(Natus Hearing, USA). Considering the test particulars, click stimulus with an alternating polarity was used at intensity levels of 80, 70, 60, 50, 40, 30 dB nHL. The filter setting ranges from 150Hz-1500Hz, with an epoch time of 10.26 ms and stimulus rate of 11.1/sec and 1024 sweeps of stimulus.

**Statistical analysis**

Statistical analysis of the data was conducted by using Med Calc Statistical Software version 12.7.8 (Med Calc Software bvba, Ostend, Belgium; <http://www.medcalc.org>; 2014). Unpaired t-test was performed to compare the mean differences between test and control groups, male and female subjects. P value<0.05 is considered as statistically significant.

**Results**

HbA1c percentage among test group subjects ( $7.82 \pm 1.57$ ) and controls ( $5.18 \pm 0.27$ ), is significant (0.006). HbA1c percentage among diabetic males ( $7.30 \pm 1.52$ ) and diabetic females ( $7.96 \pm 1.45$ ) is not significant (0.53). Pure tone averages and inter wave peak latencies were compared between the test group subjects and controls, mentioned in the Tables 1 and 2 respectively. Tables 3 and 4 shows the PTA and BAER values for diabetic male and diabetic female subjects. Figure 1 reflects the recording of BAER in test group subject.



**Figure 1.** BAER recording of the subject.

|     |             |             |      |             |             |      |
|-----|-------------|-------------|------|-------------|-------------|------|
| I-V | 3.46 ± 0.32 | 3.98 ± 0.33 | 0.03 | 3.71 ± 0.15 | 4.14 ± 0.33 | 0.03 |
|-----|-------------|-------------|------|-------------|-------------|------|

**Table 3.** PTA Thresholds in dB in diabetic males (M) and females (FM) with mean and SD.

| Parameter         | M Right Ear  | FM Right Ear | p value | M Left Ear   | FM Left Ear  | p value |
|-------------------|--------------|--------------|---------|--------------|--------------|---------|
| Pure tone average | 27.00 ± 12.8 | 17.00 ± 2.6  | 0.23    | 25.43 ± 8.22 | 20.67 ± 5.13 | 0.38    |

**Table 4.** BAER Results in milliseconds in diabetic males and females with mean and SD.

| IPL     | M Right Ear | FM Right Ear | p value | M Left Ear  | FM Left Ear | p value |
|---------|-------------|--------------|---------|-------------|-------------|---------|
| I - III | 1.79 ± 0.32 | 1.82 ± 0.35  | 0.92    | 2.39 ± 0.44 | 2.18 ± 0.23 | 0.45    |
| III - V | 1.82 ± 0.47 | 2.05 ± 0.61  | 0.53    | 1.56 ± 0.33 | 1.65 ± 0.42 | 0.71    |
| I - V   | 3.57 ± 0.54 | 3.87 ± 0.36  | 0.42    | 3.95 ± 0.53 | 3.83 ± 0.46 | 0.75    |

## Discussion

In the present study it was observed that the stimulus threshold was increased in both the ears for diabetic patients when compared with control group. Test group subjects are having mild hearing loss for both the ears. These findings were in line with earlier studies where the auditory thresholds were increased in type 2 diabetes [10-13]. The threshold is much higher in right ear than the left ear for diabetic males when compared with the diabetic females though both the values were not significant. Inter wave peak latencies are more dependable than the absolute latencies in assessing the functional status of various nuclei or ganglion in the auditory pathway, and that is why, in the present study inter wave peak latencies were recorded. The obtained BAER results have shown that in test group, except for right ear inter wave peak latency of wave III-V, all the other inter wave peak latencies were increased when compared with controls. Though the inter wave peak latencies were increased in test group subjects they were within the physiological limit that is the inter wave peak latencies of wave I-III and wave III-V are not more than 2.5 ms which is the upper limit and the inter wave peak latency of wave I-V is also less than 4.5ms, which is also the critical value [14]. In the present study it was observed that increased inter wave peak latency of wave I-V for both the ears in test group subjects, which is also in line with the earlier research findings [13,15-20].

These increased inter wave peak latencies along with increased strength of the threshold stimulus in both the ears of the test group subjects clearly indicates the adverse effects of hyperglycaemia on auditory pathway in type 2 diabetes. Further studies are needed in exploring why the inter wave peak latency of right ear wave III-V is not increased significantly when the rest of the inter wave peak latencies were increased in test group subjects when compared with the controls. Normally in females the inter wave peak latencies are less when compared with the males and this is attributed to their higher core temperature and lesser head size [21,22]. But in the present study there was no significance of inter wave peak latencies between diabetic male and diabetic female

subjects in both the ears. This finding is in contradiction with the earlier research reported, where inter wave peak latencies were prolonged in diabetic males than in diabetic females [23].

Mild hearing loss in both ears in test group is observed and earlier studies attributed this hearing loss to the effect of hyperglycaemia on the inner row of hair cells through altering the endolymph concentration by changing the secretion of striavascularis [24]. Some other studies have explained that in type 2 diabetes, hyperglycaemia causes thickening of the basilar membrane, demyelination of the cochlear nerve, and atrophy of the spiral ganglion [25] resulting in hearing loss. Increased intra neuronal glucose levels in the auditory pathway structures results in damaging them by enhancing the enzymatic activity of poly ADP ribose and that will result in alteration in the functioning of the auditory structures [26] and disrupt cochlear functions as well [27]. Diabetes also enhances the aging of auditory system [28,29]. At this juncture the present study is unable to explain the exact pathophysiological basis for the deafness but, all above mentioned changes might have attributable to the mild hearing loss. Cohort and prospective studies with larger sample size are helpful in further analysis of the effect of diabetes on auditory pathway.

## Conclusion

Hyperglycaemia in type 2 diabetes affects the functional status of structures along the auditory pathway. Early diagnosis of increased strength of acoustic threshold stimulus and functional delay in auditory conduction that is increased inter peak latencies, definitely helps the patients in taking the prompt prophylactic and therapeutic measures. These precautionary measures will help in enhancing the quality of life and also delaying the further complications.

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### \*Correspondence to:

Rajesh P

Department of Physiology

MediCiti Institute of Medical Sciences

India