ORIGINAL RESEARCH ARTICLE

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Effect of Diabetes Mellitus on the Hearing Ability of Diabetic Patients

Abbas Safavi Naini[1], Mohammad Reza Fathololoomi[1], Ali Safavi Naini[2]

[1] Department of ENT, Boo-Ali Hospital, [2] Department of ENT, NRITLD, Shaheed Beheshti University of Medical Sciences and Health Services, TEHRAN- IRAN

ABSTRACT

Background: *Diabetes mellitus is the most common endocrine disease. Most of the patients suffering from diabetes mellitus complain of hearing loss. Since the previous studies made in this regard were not complete, this study was further conducted in order to evaluate the adverse effects of diabetes mellitus on the hearing ability of the diabetic individuals referring to the clinics of the Medical Universities of Tehran, during 1994-2001 (1373-1380).*

Materials and Methods: *This investigation was a prospective analytical study carried out on two groups of population in Tehran. The first group consisted of 1500 diabetic patients (case group), and the second group consisting of 1400 normal individuals (control group). The age of the studied population was between 15-55 years. The "case group" consisted of "Diabetic Mellitus Confirmed" patients who were randomly chosen and were willing to cooperate with this study. Initially all of the patients were interviewed and later underwent complete physical examination, audiometry (pure tone, speech, impedance), and "Auditory Brainstem Evoked Response" (ABR) evaluations. The "control group" consisted of individuals that had visited the clinics due to different reasons and according to the standards of the "International Diabetes Federation" they were considered as "Not having Diabetes". They were also willing to participate in this study. Similar audiometric examinations were performed on this group. Finally the examination results of the two groups were compared.*

Results: *The following results were obtained in this study:*

1- The existence of a specific and distinct hearing loss in high frequencies (4-8KHz) between the case and control groups ($p<0.05$).

2- Presence of a significant difference in the hearing level of the NIDDM patients in the high frequencies as compared to the control group ($p<0.01$).

3- There was a distinct hearing loss in the "Complicated Diabetic Patients" in the high frequencies as compared to the normal control group ($p=0.01$).

4- Patients with short term diabetes mellitus had normal level of hearing, but in patients suffering from long term diabetes mellitus, there was a significant hearing impairment in the high frequencies (4-8 KHz) as compared to the control group ($p<0.005$).

Conclusion: *Due to the prevalence of diabetes mellitus in the community and the presence of sensorineural hearing loss (especially bilateral) in the high frequencies in a significant number of studied patients, it's recommended to carry out a complete diagnostic audiometric evaluation in all the diabetic patients and to repeat the auditory tests regularly every year. With this method, we can not only be informed of the "Hearing status" of the patient but also use the results as a guideline and outlook for a better control of diabetes and its related complications.* ***(Tanaffos 2003; 2(6): 51-58)***

Key Words*: Diabetes mellitus, Hearing ability, Hearing loss*

Correspondence to: Safavi Naini Abbas

Tel: +98-21-2401066

Fax: +98-21-2413131

INTRODUCTION

Diabetes mellitus is the most common endocrine disease. The "International Diabetes Federation" estimates the total number of diabetic patients in 139 member states being as 177 million people. This figure is just a rough estimate since there are still many individuals worldwide that are unaware of their existing diabetes mellitus and countries which are not still members of this federation (1).

Diabetes mellitus is responsible not only for early onset metabolic disorders but also for different late onset complications e.g. ocular, renal vascular hematological, and neural lesions (2). The incidence of diabetes mellitus is between 1-2 percent. This figure rises to 6.6% in some countries, and if the diagnosis of diabetes mellitus is based upon the "Glucose Tolerance Test", this figure will be as high as 11.2% (2). In long term studies, it was found that the percentage of diabetes mellitus in those individuals who had one abnormal glucose tolerance test was 1-2% (2,3). Different views exist in regard to the adverse effects of diabetes mellitus on the hearing ability (4,5,6,7,8,9). Studies performed earlier showed that there was no difference in the pure tone and speech audiometry of the normal individuals and that of the diabetic patients (4,5,6). In diabetic patients suffering from diabetic retinopathy with a normal audiometry, investigations show that by performing the specific test of "Filtered Speech Task" a clear and distinct hearing loss was detected (4,7,10). In diabetes mellitus, there is involvement of the smaller vessels of internal ear resulting in hypoxia and; thus, leading to hearing loss (11,12,13,14,15). Still some reports show the lack of relation between diabetes mellitus and hearing impairment (16).

In diabetes mellitus, the auditory system shows the following histopathological changes (13):

a) Microangiopathic changes with PAS deposition in stria vascularis, internal auditory artery, modiolus, nutrient vessels of 8th cranial nerve and spiral ligament.
b) Hemorrhages in endolymph and perilymph
c) Decrease in the number of cilliated cells, atrophy of spiral ganglion, demyelination of 8th cranial nerve, degenerative changes in brain stem, and cerebellum.

Due to the high prevalence of diabetes mellitus in the community and, also, due to probable adverse effects that it has on the auditory system, this study was carried out to complete the earlier controversial investigations, and researches made in this regard. This study was conducted on diabetic patients referring to different medical centers affiliated to the universities throughout Tehran between 1994 and 2001 (1373-1380).

MATERIALS AND METHODS

The study was a case-control, prospective-analytical research. The numbers of the individuals in the case and control groups were 1500 and 1400 respectively. Their ages were between 15-55 years. The individuals in the "case group" were "Diabetic Confirmed" patients who had referred to the clinics affiliated to medical universities throughout Tehran. They were randomly selected and were also ready to cooperate with this research.

Initially, they were interviewed and later on questionnaire forms were given to them. Then they had complete physical examination of their ear as well as a full audiometric evaluation. The presence of the following factors were reasons for excluding the patients from this study: age>55 years, occupational history of working in noisy environments, use of ototoxic drugs, past history of ear diseases, alcohol usage, head trauma, meningitis, allergy, family history of hearing impairment, and systemic disease. The "control group" consisted of those individuals that attended the above clinics at the same time and according to standards of "International Diabetes Federation" did not have diabetes mellitus or any of the exclusion factors mentioned above. They were also willing to cooperate with this study similarly. These individuals underwent the above-mentioned examinations. These groups were referred to a specific audiometry center. The examination was planned according to single blind method in which the audiologist was unaware of the diabetic status of the individual (i.e. whether diabetic or not). The following examinations were performed:

1- Pure tone audiometry in the following frequencies:
i) 250-500-1000-2000-4000 and 8000 Hertz.(Hz) for air conduction
ii) 250-500-1000-2000 and 4000 Hertz for bone conduction.
2- Speech audiometry including (SRT, MCL and SDS)
3- Impedance audiometry (acoustic compliance, acoustic reflex, tympanometry)
4- Auditory Brainstem Evoked Response (ABR) including duration of absolute latency of waves III and V, interwave latency between the waves III and V, interaural latency between the two ears and distance between waves I to V.

RESULTS

This investigation was carried out on 1500 diabetic patients and 1400 normal individuals whose average age was 40 years. 450 diabetic patients (30%) were male and the remaining 1050 (70%) were female. Around 1100 (73%) of the diabetic patients were NIDDM and the rest of 400 patients (27%) had IDDM. The average fasting blood sugar (FBS) was 199 mg/dl with a standard deviation of 72. About 1350 of the patients (90%) had an FBS which was higher than normal level, and only 150 patients (10%) had normal FBS levels. The average postprandial blood sugar (BS) in the diabetic patients was 258 mg/dl with a standard deviation of 68. In this group, 350 of the patients (23%) had normal blood sugar level and 1150 patients (77%) had a blood sugar that was more than the normal level. The average FBS of NIDDM patients was 217 mg/dl with a standard deviation of 69. This figure for IDDM patients was 152 mg/dl with a standard deviation of 61. The mean blood sugar of NIDDM and IDDM patients were 269 mg/dl and 227 mg/dl with standard deviations of 64 and 73, respectively. From the total 1500 diabetic patients present in this study, 650 patients (43%) suffered from complications of diabetes including: retinopathy in 450 individuals (69.2%), hypertension and coronary vascular disease in 150 patients (23.1%) and diabetic coma in 50 patients (7.7%). The duration of diabetes varied between less than one to 25 years with an average diabetes duration of 8 years and a standard deviation of 6.5. The middle ear function was normal in all of the patients. The curve of the tympanogram was of type A. The acoustic reflexes in four patients were in the form of contralateral and ipsilateral on both sides. Also, there was the "absence of acoustic reflexes" in the following forms:
1- In 4 patients in the form of ipsilateral on one or both sides.
2- In 2 patients in the form of contralateral on both sides.
3- In 2 patients in the form of ipsilateral and contralateral on one side.

The acoustic reflexes had increased in 6 patients (by more than 100 dB), but in the remaining individuals, it was in the normal range i.e. 85-100 dB. The hearing impairment in the diabetic patients was in the form of sensorineural hearing loss.

The most important findings in this research were as follows:
1- There was a hearing loss of about 10-decibel in 31% of diabetic patient in the frequency of 4KHz and in 34% of them in the frequency of 8KHz as compared to the control group. The t-test showed that this difference had a statistical significance. In the 4KHz and 8KHz frequencies the p value was $p<0.05$ (Diagram 1) and $p<0.25$ (Diagram 2) respectively.

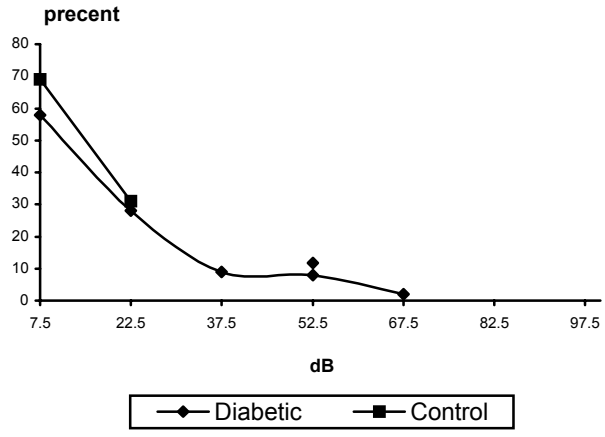

Diagram 1: The relation between diabetes mellitus and hearing level in the 4 KHz frequency in 2900 individuals (both case and control groups) in different clinics affiliated to various medical universities throughout Tehran during 1994-2001.

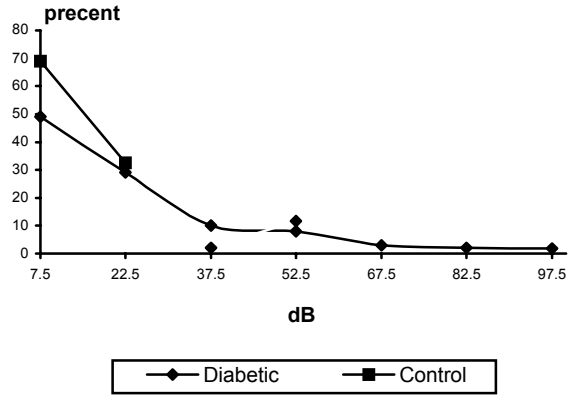

Diagram 2. The relation between diabetes mellitus and hearing level in the 8 KHz frequency in 2900 individuals (case and control groups) in different clinics affiliated to various medical universities throughout Tehran during 1994-2000.

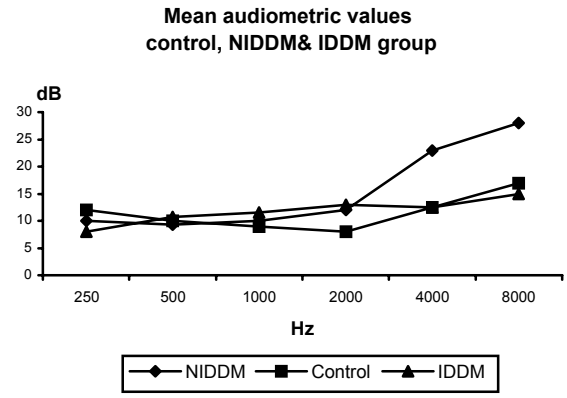

Diagram 3. The relation between the Type of diabetes mellitus and the hearing level in 2900 individuals (case and control group) in the different clinics affiliated to various medical universities throughout Tehran during 1994-2001.

There was a hearing loss of about 10 dB in 39% of NIDDM patients in the 4KHz frequency and in 42% of them in 8KHz frequency, as compared to the control group. The t-test showed the significance of this difference. The hearing level of the IDDM patients in the above-mentioned frequencies was in the normal range and did not differ from the normal control group. It was seen that about 45% of NIDDM patients in the 4KHz frequency and 50% of them in the 8KHz frequency had a hearing loss of about 10-15 decibel (dB) as compared to the IDDM patients. The t-test showed the significance of this difference ($p<0.01$) (Diagram 3).

About 42% of the "complicated diabetic patients" had a hearing loss of about 10 decibel (dB) in the frequencies of 4 and 8KHz as compared to the control group. The t-test showed the significance of this difference ($p<0.01$). Meanwhile, the hearing level of the uncomplicated diabetic individuals did not differ from that of the control group and was in the normal range (Diagram 4).

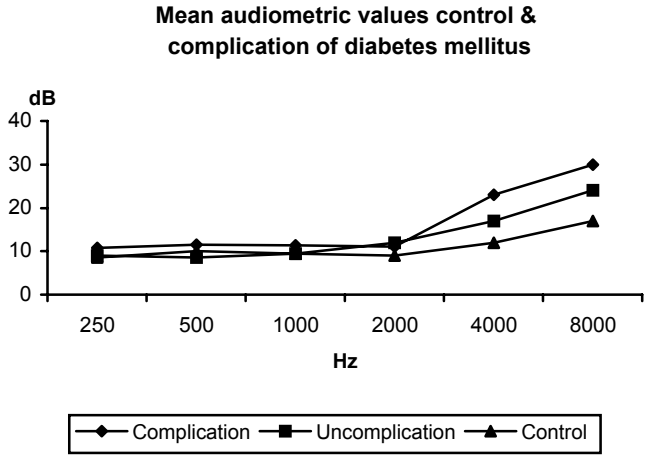

Diagram 4. The relation between the complications of diabetes mellitus and the hearing level in 2900 individuals (case and control group) in different clinics affiliated to various medical universities throughout Tehran during 1994-2001.

The hearing ability of the patients with short-term diabetes was in the normal range and the t-test showed the negligibility of this difference ($p<0.1$). It was seen that patients having diabetes mellitus duration of 10-19 years (44%) had a hearing loss of about 10dB in the frequency of 4KHz and 59% from the same group had a hearing loss of about 20dB in the frequency of 8KHz, as compared to the control

group. The t-test showed that this difference also had a statistical importance ($p<0.005$). Also, 72% of the patients having diabetes mellitus duration of 20-29 years had a hearing loss of about 35dB in the frequency of 4KHz. Meanwhile 77% of them had a hearing loss of 50dB in the frequency of 8KHz as compared to the control group. The t-test showed the significance of these differences ($p<0.005$) (Diagram 5).

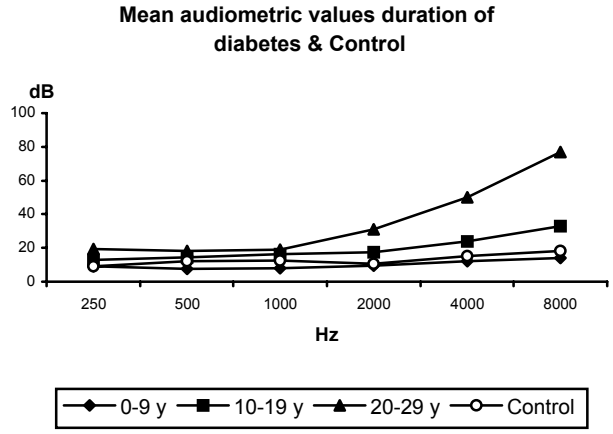

Diagram 5. The relation between the diabetes mellitus duration (10-19 years and 20-29 years) and the hearing level in 2900 individuals (case and control groups) in the different clinics affiliated to various medical universities throughout Tehran during 1994-2001.

The hearing level of the diabetic patients, between the ages of 15-44 years, in all the frequencies was in the normal range. The t-test showed the insignificance of this difference ($p<0.1$). Meanwhile, in the ages between 45-55 years 48% of diabetic patients in the frequency of 4KHz and 41% of them in the frequency of 8KHz had a hearing loss of about 15dB as compared to the control group (normal). The t-test showed the importance of this difference. The value of "p" for 4KHz and 8KHz were $p<0.005$ and $p<0.025$ respectively (Diagram 6).

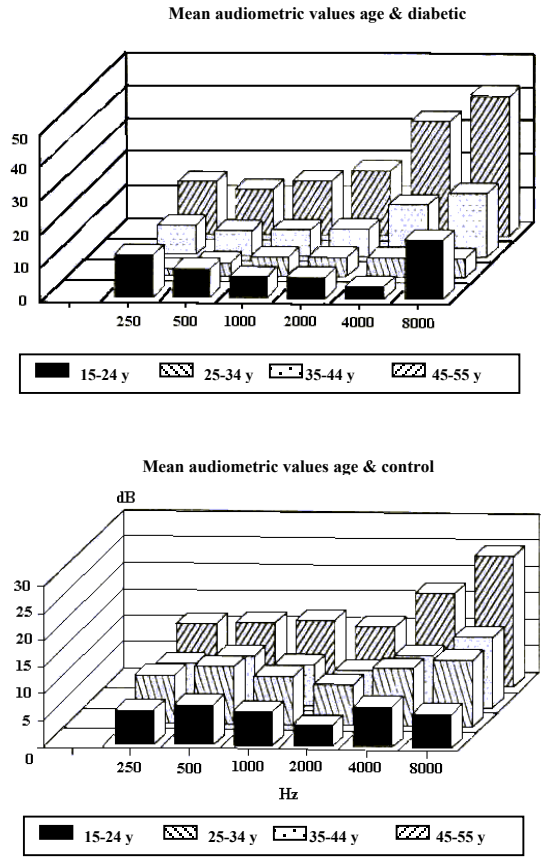

Diagram 6. The relation between the age and the hearing level in 2900 individuals (case and control group) in different clinics affiliated to various medical universities throughout Tehran during 1994-2001.

DISCUSSION

According to the studies made by "International Diabetes Federation" (IDF), the cost and expenses of treating and controlling diabetes mellitus in millions of diabetic patients all over the world is about 10% of the national health budget, which is a significant figure. The number of the present diabetic patients in Iran is about 4 million people. Unfortunately more than 50-60% of these individuals are unaware of their existing diabetes mellitus (1). Diabetes mellitus has not only early onset metabolic disorder but also late onset complications such as ocular, renal, vascular, and neural lesions (8). In regard to the adverse effect

of diabetes mellitus on the ear and in causing hearing impairment, different views exist (4,5,6,7,8,9,15,16).

The present study showed that there was hearing impairment in 31% of diabetic patients in the frequency of 4000Hz and in 34% of them in the frequency of 8000Hz as compared to the control group. The hearing loss in 90% of cases in the 4000 and 8000 Hz frequencies was symmetrical. The results obtained from the above study were similar to the conclusions reached by Kurien in 1989 (11) and Buch in 1981 (7). In a research performed by Irwin and Taylor in 1978, there was hearing impairment in the low frequency range among the diabetic patients (9). In the investigations made by Miller in 1989 and Davis in 1985, no relation was found between diabetes mellitus and the hearing level. The conclusion reached from our study as well as that of Martin in 1985 and Fedele in 1984, was the presence of cochlear and retrocochlear leisons in ABR among the diabetic patients (8). The investigations made by Khardori and Goldscher in 1986 only showed 8th cranial nerve neuropathy (11). In the present study 73% of the patients had NIDDM. In this group of patients there was a hearing loss of about 10dB in the 4 and 8KHz frequencies as compared to the normal control group ($p<0.01$). Also it was seen that the hearing level of IDDM patients was similar to that of control group.

The studies made by Sieger in 1983 and Piras in 1985 confirm the above mentioned finding (9), while researches made by Gibbin and Davis in 1981 rule out this fact (6). It was also seen that 42% of diabetic patients with complications had hearing loss of about 10dB in the frequencies of 4000 and 8000 hertz, as compared to the control group ($p<0.01$). Meanwhile the hearing level of the diabetic patients without complications was normal in all the frequencies. This was confirmed by results of ABR (Auditory Brain Stem Evoked Response). According to the results obtained from the ABR test, it was seen that the duration of the absolute latency in wave V in 38% of diabetic patients with complications (especially the long term complications) had increased by 0.3 msec. While in 29% of the same group, there was an increase of 0.2 msec in the duration of absolute latency in wave III as compared to the control group. Investigations made by Miller in 1983 confirmed the above results (9,10). As it is evident from this study, the hearing level of patients having a diabetes-duration of less than one to 25 years was normal. Whereas in patients having diabetes of a longer duration i.e. 10-19 years, there was a hearing loss of about 10dB in 4000hz frequency and of 20dB in 8000hz frequency as compared to the control group ($p<0.005$). In patients having a "very long duration" of diabetes mellitus i.e. more than 20 years, the hearing loss would be around 30dB and 50dB in frequencies of 4000hz and 8000hz respectively, as compared to control group.

The conclusions reached in our study were contrary to the findings of the researches made by Axelsson and Faberberg in 1968, since they did not find any relation between the duration of diabetes mellitus and hearing loss (8). The conducted studies on ABR reveal that patients having a "short term diabetes mellitus" (less than 10 years) have no abnormality in their ABR, while those having a diabetes duration of 10-19 years, the duration of absolute latency in waves III to V had increased by 0.3 msec, as compared to the control group. These figures still differ in those patients suffering form diabetes of 20-29 years duration. In such a way that the duration of absolute latency in waves III and V had significantly increased i.e. by 0.5 msec., as compared to the normal control group. Another conclusion reached from this research, which was contrary to the results of the previously made investigations, was the presence of sensorineural hearing loss in high frequencies in the long term

diabetic patients. This shows that there is a relation between the hearing ability and long term diabetes mellitus. In other words, hearing loss as well as impairment is one of the late-onset complications of diabetes mellitus, which is seen in the long term diabetic patients. It was also obvious that the hearing ability of the diabetic patients between the ages of 15-44 years in all frequencies was the same as that of the normal control group. Meanwhile the ABR test did not show any significant difference in the duration of latency of waves III and V in this group, as compared to the control group. There was a hearing loss of about 10dB in the high frequency range (4-8KHz) in 41-48% of the diabetic patients between the ages of 45-55 years as compared to the control group. The values of "P" were: $p<0.005$ in 4KHz and $p<0.025$ in 8KHz. The results of ABR also showed the increase in the duration of absolute latency in the waves of III and V of diabetic patients as compared to that control group. Finally due to presence of about 4 million diabetic patients in our country; and therefore, a high occurrence rate and also due to high incidence of sensorineural hearing loss in the high frequencies in a large number of patients, it is necessary to consider the "hearing status" as a long-term complication of diabetes. It is recommended to perform an audiometry test initially on all the diabetic patients and to keep this as an "initial record of auditory examination of patient". Also, performing this test every year on a regular basis could help the physician to up-date their records of the hearing status of the patients as well as to give the necessary guidance in regard to the control of diabetes to them.

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