Received: 13.11.2009 **Accepted: 2.8.2010**

Original Article

Evaluation of hearing loss in juvenile insulin dependent patients with diabetes mellitus

Sayyed Ahmadreza Okhovat[a], Mohammad Hassan Moaddab[b], Sayyed Hanif Okhovat[c], Anwar Abdullah Ali Al-Azab[d], Fadhl Ali Ahmad Saleh[d], Samira Oshaghi[d], Zahra Abdeyazdan[e]*

Abstract

BACKGROUND: Diabetes mellitus is one of the most important epidemics of our era. Complications of this disease are diverse and include retinopathy, nephropathy and neuropathy. This study has been designed to evaluate hearing loss patterns in young children suffering from IDDM and define risk factors for this complication.

METHODS: This descriptive analytic study includes 200 youngsters divided into two groups: 100 patients in diabetic group and 100 healthy individual in control group. Hearing thresholds are determined in 250, 500, 1000, 2000, 4000 and 8000 Hz and metabolic controls are evaluated as average of one year HbA1C, dividing diabetic group into well control and poor control subgroups.

RESULTS: Twenty one out of 100 patients in diabetic group showed significant hearing loss. Hearing loss is correlated with metabolic control, showing less loss in patients with HbA1C less than 7.5%. Results showed that hearing loss is not related to sex of patients but duration of disease (more or less than 5 years) affects degree of hearing loss in some frequencies.

CONCLUSIONS: Hearing loss in children suffering from IDDM is sensorineural, bilateral and symmetrical and is related to the duration of disease and state of metabolic control (HbA1C).

KEYWORDS: Diabetes Mellitus, Type 1, Hearing Loss, Hemoglobin A, Glycosylated.

JRMS 2011; 16(2): 179-183

Diabetes mellitus is believed to be a chronic metabolic disorder. Its characteristics are hyperglycemia and numerous abnormalities in metabolism of fat and protein. Its association with a number of microvascular complications has been known for long, most commonly affecting eyes and kidneys. Neuropathy, involving somatic and autonomic nerve fibers is one of the many microvascular complications of diabetes mellitus.

An association between maternally inherited type of diabetes mellitus in Wolfram syndrome and congenital severe hearing impairment has been established.[1] Apart from this association, the relationship of hearing loss and type 1 diabetes mellitus has been debated following a case report of hearing loss and incipient diabetic coma by Jordao, dating back to almost 150 years ago.[2] Previous studies have been inconclusive regarding presence, patterns and severity of hearing loss in diabetic patients and its relationship to metabolic control. Some of the earlier studies have documented bilateral sensorineural hearing loss in high and mid

[a] Associate Professor, Department of Otorhinolaryngology, Head and Neck Surgery, Isfahan University of Medical Sciences, Isfahan, Iran.
[b] Associate Professor, Department of Pediatric Endocrinology, Isfahan University of Medical Sciences, Isfahan, Iran.
[c] Resident, Department of Otorhinolaryngology, Head and Neck Surgery, Isfahan University of Medical Sciences, Isfahan, Iran.
[d] Generl Practitionere, Isfahan University of Medical Sciences, Isfahan, Iran.
[e] Associate Professor, Department of Nursing and Midwifery, Isfahan University of Medical Sciences, Isfahan, Iran.
***** Corresponding Author
E-mail: Okhovat@Hotmail.com

frequencies in this patient group.[3-6]

It has been postulated that diabetes mellitus is associated with progressive bilateral high tone sensorineural hearing loss starting at an earlier age than the normal population, but eventually the general population catches up; meaning that by the age of 60, they cannot be easily differentiated.[7] Good control of diabetes mellitus should supposedly be associated with slower progression of hearing impairment.

Majority of studies regarding effects of diabetes mellitus on sensorineural hearing loss have included adult patients suffering from type 2 diabetes mellitus. Up to now, few studies have documented significant hearing loss in juvenile patients suffering from type 1 diabetes mellitus, especially in children with relatively short duration of the disorder.

Because the hearing impairment has adverse consequences on educational attainments, a protocol for screening of auditory thresholds in children suffering from type 1 diabetes mellitus should be sculptured. This study tries to take the first few steps on the path towards reaching this goal.

Methods

This article is a descriptive analytic research carried out as a case-control study during years 2007 and 2008 in Isfahan University of Medical Sciences, School of Medicine.

The study included 100 children and adolescents from 5 to 18 years old with type 1 diabetes mellitus referred to the Isfahan Diabetes Research Center. Diabetes mellitus was diagnosed according to definition of ADA 2003.[8]

Sampling was carried out using consecutive method. One hundred patients were selected as diabetic group. Another 100 healthy school children, matching the diabetic group regarding their sex and age served as control group. Fully informed written consents were filled out by participants' guardians.

Patients with positive family history of deafness, past history of head trauma associated with loss of consciousness, complicated otitis media, ear surgery or prior administration of ototoxic medications were excluded from the study.

Patients in diabetic group were on a mixture of short acting and intermediate acting insulin given twice a day. Recorded data included sex, age, insulin dosage and duration of diabetes. Their hemoglobin A1C (HbA1C) concentration was recorded too.

In diabetic group, HbA1c concentration was measured four times a year and the average of the readings was used to evaluate the glycemic control. Patients were categorized as well controlled (HbA1C $< 7.5\%$) and poor controlled (HbA1C $\geq 7.5\%$).[9]

Hearing thresholds were assessed by pure tone audiometric test. Bone and air conductions thresholds were both tested at frequencies between 250-4000 Hz and 250-8000 Hz, respectively. The mean of air conduction thresholds of both ears at each frequency was recorded as hearing threshold of the subject. Hearing loss was defined as a hearing threshold higher than 25 dB.

Mann-Whitney U test was used to compare hearing threshold between diabetic and control groups and between well controlled and poor controlled subgroups within diabetic group. P values < 0.05 were considered as statistically significant.

Results

A total of 200 subjects were studied (case = 100; male/female: 48/52; control = 100; male/female: 48/52). Age range was 5-18 years (12.19 ± 3.1).

No patients in diabetic group showed evidence of retinopathy or nephropathy.

None of the children in case or control group demonstrated conductive hearing loss therefore mean air conduction threshold of both ears at each frequency was used in the analysis.

Means of auditory thresholds of diabetic patients were higher than that of control group, and the differences were assumed clinically significant in all frequencies (from 250 to 8000 Hz) ($p < 0.05$) (Table 1).

Table 1. Comparison of hearing thresholds in dB between case and control groups. Data is presented as mean ± SD

	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Diabetic Group*	18.75 ± 7.23	16.3 ± 7.51	16.53 ± 8.10	15.95 ± 7.57	19.55 ± 7.96	22.25 ± 8.26
Control Group	10.6 ± 4.59	8.15 ± 4.27	8.75 ± 3.13	9.01 ± 3.26	9.05 ± 4.35	9.45 ± 4.78

* P = 0.000 for all frequencies

Twenty one patients (21%) showed significant hearing loss with auditory threshold over 25 dB in at least one frequency. Hearing impairment in these patients was symmetrical, sensorineural in nature and affected all frequencies. Quantifying the degree of hearing impairment, 8 out of 21 patients (38.1%) had mild hearing loss (ranging from 25 to 40 dB), 11 patients (52.38%) had moderate hearing loss (range: 41-65 dB), 2 patients (9.52%) suffered from severe hearing loss (66-90 dB), and no patient showed profound hearing loss above 90 dB.

Auditory thresholds were comparable between male and female patients and there were no statistical significance difference between them ($p > 0.05$).

Hearing thresholds over different frequencies were significantly higher in diabetic patients with history of diabetes more than five years compared to those with shorter durations (Table 2).

Furthermore, auditory threshold was in positive correlation with the average yearly HbA1C concentration at 250, 500, 1000 and 4000 Hz frequencies ($p < 0.05$). Detailed data regarding this correlation are depicted in table 3.

Discussion

Although hearing loss has been observed in patients with diabetes mellitus for a long time, no cause and effect relationship has ever been proved. Most of the studies which have addressed the association have been conducted in adults, screening both type 1 and 2 diabetics. These reports have established significant hearing impairment in patients with either type of diabetes, demonstrating it to be more prevalent in type 2 diabetic patients, and related to microvascular complications and age.[6,10,11]

Although there is no consensus among researchers regarding the exact etiology of hearing loss in diabetic patients, a large body of evidence is accumulating in favor of a strong relationship between poor glycemic control and hearing loss.[1]

Histologically, demyelination of eighth cranial nerve, loss of ganglion cells and hair cells of organ of corti, central auditory pathway degeneration, thickening of endothelial vessel walls of vasa nervorum and stria vascularis have all been documented in diabetic cochleae.[12-16]

Among the reviewed articles, only Ferrer et al [17] reported higher auditory thresholds in over all frequencies from 250 to 8000 in juvenile patients suffering from type 1 diabetes mellitus when compared to healthy youngsters. Another study on children with IDDM in Sudan showed that 33% of children with IDDM had significant hearing impairment demonstrated by thresholds over 25 dB in at least one frequency.[4] In a recent study, 40

Table 2. Means of auditory thresholds compared between two subgroups of diabetic patients based on duration of diabetes (< 5 years versus ≥ 5 year) over different frequencies. Data is presented as mean ± SD

	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
< 5 years	17.53 ± 8.32	15.41 ± 8.12	15.41 ± 7.81	14.93 ± 8.15	18.22 ± 8.64	20.82 ± 9.28
≥ 5 years	22.04 ± 8.84	18.7 ± 8.62	18.89 ± 8.37	18.7 ± 8.10	23.15 ± 9.16	26.11 ± 10.34
P value	0.018	0.105	0.018	0.033	0.061	0.090

Table 3. Means of hearing thresholds compared according to metabolic control

	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Well control*	13.86 ± 6.68	11.59 ± 6.20	12.27 ± 5.91	12.27 ± 6.33	13.18 ± 6.53	15.9 ± 6.85
Poor control**	15.7 ± 7.43	13.75 ± 6.88	13.75 ± 7.16	13.39 ± 6.95	15.45 ± 7.32	18.9 ± 7.71
P value	0.006	0.010	0.000	0.058	0.013	0.096

* Well Control: average annual HbA1C less than 7.5%
** Poor Control: average annual HbA1C ≥ 7.5%

IDDM patients (children and adults) were compared to 20 individuals in diabetic group. Tinnitus and hearing loss were the most prevalent symptoms. Mild high tone sensorineural hearing loss was observed in 4 of 40 diabetic patients. Hearing loss was shown to be bilateral and symmetric and no speech discrimination abnormality was evident. Hearing loss was more frequent with increased age, increased duration of disease beyond 11 years and high HbA1C concentration.[5]

On contrast, studies by Parving et al,[18] Sieger et al[19] and Osterhammel et al[20] could not demonstrate any negative effect of diabetes mellitus on hearing thresholds. However, many recent clinical trials have been able to show absence of otoacoustic emissions and abnormal ABR in diabetics with no overt hypoacusia and normal pure tone audiometric results.[21,22]

The significant correlation between HbA1C concentration and auditory thresholds in the presented cohort and some other studies,[4,5] demonstrates that inadequate control of glycemic state can be a crucial factor for development of hearing impairment in patients with type 1 diabetes.

Possibly due to short duration of disease and the young age of patients, no complications of diabetes such as nephropathy or retinopathy were observed in the current study; so it was impossible to evaluate the correlation between diabetic endorgan complications and hearing loss.

Conclusions

Asymptomatic hearing loss is a relatively common finding in children with IDDM. Hearing loss pattern in this disease is bilateral, sensorineural in nature and symmetrical, affecting all frequencies. Severity of hearing loss is not related with sex of children but shows a positive correlation with duration of disease and glycemic control reflected by HbA1C concentrations.

Conflict of Interests

Authors have no conflict of interests.

Authors' Contributions

SAO designed the study, supervised the conduct, and interpreted the audiologic results wherever needed. He is also the corresponding author. MHM helped in designation of the project, introduced most of pediatric patients for further follow up, and supervised data analysis. SHO modified the project into this manuscript, and helped in reanalysis of the data. AAAA, FAAS and SO helped in the conduct of the study by searching the files and filling out the forms, and also helped in informing families about the study. ZA helped in referring to some of the patients for further evaluation. All authors have read and approved the content of the manuscript.

References

1. Guillausseau PJ, Massin P, Dubois-LaForgue D, Timsit J, Virally M, Gin H, et al. Maternally inherited diabetes and deafness: a multicenter study. Ann Intern Med 2001; 134(9 Pt 1): 721-8.
2. Jordao AMD. Consideration sur un cas du diabete. Union Medicale du Paris 1857; 11: 446.
3. Cullen JR, Cinnamond MJ. Hearing loss in diabetics. J Laryngol Otol 1993; 107(3): 179-82.
4. Elamin A, Fadlallah M, Tuevmo T. Hearing loss in children with type 1 diabetes. Indian Pediatr 2005; 42(1): 15-21.
5. Pessin AB, Martins RH, Pimenta Wde P, Simões AC, Marsiglia A, Amaral AV. Auditory evaluation in patients with type 1 diabetes. Ann Otolo Rhinol Laryngol 2008; 117(5): 366-70.
6. Wackym PA, Linthicum FH Jr. Diabetes mellitus and hearing loss: clinical and histopathologic relationship. Am J Otol 1986; 7(3): 176-82.
7. Vaughan N, James K, McDermott D, Griest S, Fausti S. A 5-year prospective study of diabetes and hearing loss in a veteran population. Otol Neurotol 2006; 27(1): 37-43.
8. The DECODE study group on behalf of the European Diabetes Epidemiology Group. Glucose tolerance and mortality: comparison of WHO and American Diabetes Association diagnostic criteria. Lancet 1999; 354(9179): 617-21.
9. Behrman RE, Kliegman RM. Nelson essentials of pediatrics. 4th ed. New York: W.B. Saunders Company; 2002. p. 753.
10. Kakarlapudi V, Sawyer R, Staecker H. The effect of diabetes on sensorineural hearing loss. Otol Neurotol 2003; 24(3): 382-6.
11. Friedman SA, Schulman RH, Weiss S. Hearing and diabetic neuropathy. Arch Intern Med 1975; 135(4): 573-6.
12. Jorgensen MB. The inner ear in diabetes mellitus. Histological studies. Arch Otolaryngol 1961; 74: 373-81.
13. Axelsson A, Sigroth K, Vertes D. Hearing in diabetics. Acta Otolaryngol Suppl 1978; 356: 1-23.
14. Rust KR, Prazma J, Triana RJ, Michaelis OE 4th, Pillsbury HC. Inner ear damage secondary to diabetes mellitus. II. Changes in aging SHR/N-cp rats. Arch Otolaryngol Head Neck Surg 1992; 118(4): 397-400.
15. Smith TL, Raynor E, Prazma J, Buenting JE, Pillsbury HC. Insulin-dependent diabetic microangiopathy in the inner ear. Laryngoscope 1995; 105(3 Pt 1): 236-40.
16. Makishima K, Tanaka K. Pathological changes of the inner ear and central auditory pathways in diabetics. Ann Otol Rhinol Laryngol 1971; 80(2): 218-28.
17. Ferrer JP, Biurrun O, Lorente J, Conjet JI, de España R, Esmatjes E, et al. Auditory function in young patients with type 1 diabetes mellitus. Diabetes Res Clin Pract 1991; 11(1): 17-22.
18. Parving A, Elberling C, Balle V, Parbo J, Dejgaard A, Parving HH. Hearing disorders in patients with insulin-dependent diabetes mellitus. Audiology 1990; 29(3): 113-21.
19. Sieger A, White NH, Skinner MW, Spector GJ. Auditory function in children with diabetes mellitus. Ann Otol Rhinol Laryngol 1983; 92(3 Pt 1): 237-41.
20. Osterhammel D, Christau B. High frequency audiometry and stapedius muscle reflex thresholds in juvenile diabetics. Scand Audiol 1980; 9(1): 13-8.
21. Di Leo MA, Di Nardo W, Cercone S, Ciervo A, Lo Monaco M, Greco AV, et al. Cochlear dysfunction in IDDM patients with subclinical peripheral neuropathy. Diabetes Care 1997; 20(5): 824-8.
22. Di Nardo W, Ghirlanda G, Paludetti G, Cercone S, Saponara C, Del Ninno M, et al. Distortion-product otoacoustic emissions and selective sensorineural loss in IDDM. Diabetic Care 1998; 21(8): 1317-21.