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Evaluation of hearing threshold in type 1 diabetic children

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Abstract
Objective: To assess the auditory function in a group of children with diabetes mellitus type 1 and to study the association between hearing loss and disease related factors: duration of the disease, metabolic control and diabetic complications.
Patients and Methods: Sixty-two diabetic patients below the age of 16 attending AL- Salam Teaching Hospital, Mosul, Iraq from May 2017 to June 2018 were evaluated and compared with equal number (same gender &age) of non-diabetic controls. Pure-tone audiometric tests were performed. Both air and bone conduction were tested at frequencies between 250-8000 Hz.
Results: The hearing level was lower in diabetic children than in the control group in all tested frequencies, but the differences was statistically significant only at mid and high frequencies. The hearing loss was bilateral, symmetrical and affects both sexes. HbA1c concentration, age of diabetes and microangiopathic complications showed positive association with the elevated hearing thresholds, while, age at disease onset, dose of insulin, number of hypoglycemic and DKA episodes and presence of neuropathy were not.
Conclusions: Hearing impairment may occurs early in diabetic children and is related to the disease duration and the stage of metabolic control. Careful & accurate glycemic control help prevent or delay this complication.

Keywords: Hearing loss, diabetes mellitus, children

Introduction
Hearing loss as one of the complications has been reported more commonly in diabetic children than in non-diabetic children [1], with prevalence between 20% and 35% [2, 3]. Hearing impairment in diabetic patients is usually mild and subclinical, and can be detected early by accurate and objective audiometric methods [4] and its of the sensor neural type [5]. Diabetes also accelerates the age related hypoacusis [6] as evidenced in adults with DM. Some studies didn't reveal any significant difference in audiometry between normal and diabetic children [7, 8]. This study was undertaken to correlate hearing loss, its relationship to glycemic control and to determine the risk factors. Previous studies have reported contradicting results regarding hearing impairment in diabetic patients and its relationship to other diabetic complications and to metabolic control. Several earlier studies have documented presence of bilateral sensori-neural hearing loss affecting mainly the high and middle frequencies, with wide incidence ranging from 15 to 85 percent [8-10]. Majority of these studies have included adult patients with non-insulin dependent diabetes mellitus, and described a characteristic audiometric profile that simulates presbyacusis, which is known to occur with old age [11]. On the other hand, many studies, which involved both type 1 and type 2 diabetic patients, have failed to detect any significant difference in audiometric functions between the diabetic patients and non-diabetic controls [12-14]. Only few studies to date have documented presence of significant hearing loss in young patients with type 1 diabetes mellitus particularly in children who have relatively short duration of illness. The aim of the present study was to examine the auditory function in a group of children and adolescents with type 1 diabetes mellitus and to evaluate its relationship with the duration of the disease, the tightness of metabolic control, and the acute and chronic diabetic complications.HBa1c was used to reflect the degree of glycemic control.

Patients and methods
This case control study was conducted at the AL- Salam Teaching Hospital, Mosul, Iraq. Sixty two children with Type I DM and equal number of non-diabetic controls were evaluated. Children more than 5years of age only were included as Pure tone audiometry involves cooperation of the child to perform the test.

Exclusion criteria were: 1- children with history of hearing impairment, 2-ear discharge,3- head or ear trauma,4- family history of congenital deafness. All the enrolled children were regularly followed up at the diabetic clinic every month. Their glycemic state was assessed by measuring glycated Hemoglobin (Hb A1c) once every 3 months. Complications like hypoglycemia, diabetic ketoacidosis (DKA) nephropathy, retinopathy, and neuropathy were investigated and documented. Retinopathy was assessed by fundus examination. Nephropathy was assessed by urine albumin excretion rate and albumin/creatinine ratio. Ear examination, clinical tests of hearing, and otoscopic examination were done. All children were underwent pure tone audiometry using clinical audiometer (GSI Audio Star Pro) at frequencies between 250 - 8000 Hz. They were followed up for 1 year and all of them underwent hearing assessment at least thrice during the study period. Hearing loss was defined as present if the child had an average threshold of hearing more than 25 db, in any tested frequency. Degree of hearing impairment was classified by WHO guidelines as mild degree when the average threshold of hearing was between 26 to 40 db, moderate if 41 to 55db, moderately severe if 56 to 70db, severe if 71 to 91db and profound if more than 91db in any frequency. Results were collected and statistical analysis was done. Percentages of various proportions were calculated. Chi Square test, Mann-whitney U test were used to compare the risk factors.

Results

Of the 62 diabetic children, 13(20.9%) had hearing loss of sensorineural type compared to none in the control group (p<0.001), figure (1). An assessment of the hearing loss in different range of frequencies via low frequency (250 to 1000 Hz), mid frequency (1000 to 4000 Hz) and high frequency (4000 to 8000 Hz) revealed all the 13 diabetic children to have developed mild degree hearing loss. Of these 4 children (30.7%) developed hearing loss at all frequencies, 9 (69.2%) children developed hearing loss at mid and high frequencies. Hearing loss was statistically significant in all the three different ranges of frequencies (p<0.05) but hearing loss at mid and high frequency was higher than at low frequency (p<0.001, p<0.05). The hearing threshold was compared between the diabetic children without hearing loss and non-diabetic children. It was found that in the former it was significantly higher than in the later with p<0.001.During the follow up with strict glycemic control over 1 year of study period, none of them progressed from mild to higher degrees of hearing loss. They also did not show recovery to normal threshold of hearing (<=25 db). Among the risk factors analyzed for hearing loss, diabetic age (fig 2) and glycemic control, had a positive correlation and other risk factors did not show any correlation (Table 1). Acute and chronic complications of DM like hypoglycemia, DKA, nephropathy, retinopathy did not show any correlation to hearing loss. The relationship between hearing loss at different frequencies and metabolic control revealed that poor glycemic control lead to hearing impairment at all frequencies but much higher in mid and high frequencies. This was found to be statistically significant (p<0.001). Of the 49 diabetic children without hearing loss, 35 children had Glycated Hb value less than 8% and remaining had values more than 8%. All the 13 diabetic children with hearing loss had Glycated Hb value, more than 10%.

Table 1: Risk factors and hearing loss in diabetic children (n =62)

Risk Factors	Hearing Loss Present	Hearing Loss Absent	p value*
+Gender: Male	6(46.1%)	22 (44.8%)	0.94
Female	7(53.8%)	27 (55.1%)	
Age 5-10 yrs	4(30.7%)	10 (20.4%)	0.43
11-15 yrs	9(69.2%)	39 (79.5%)	
Age at onset of DM < 5 yrs	7(53.8%)	34(69.38%)	0.3
5-10 yrs	6(46.1%)	15 (30.6%)	
Diabetic age< 5yrs	9(69.2%)	45 (91.8%)	0.03
5-10 yrs	4 (30.7%)	4 (8.1%)	
HBA1c Level > 8%	13 (100%)	35	0.03
< 8%	0	14	

* (chi square test) p<0.05 significant

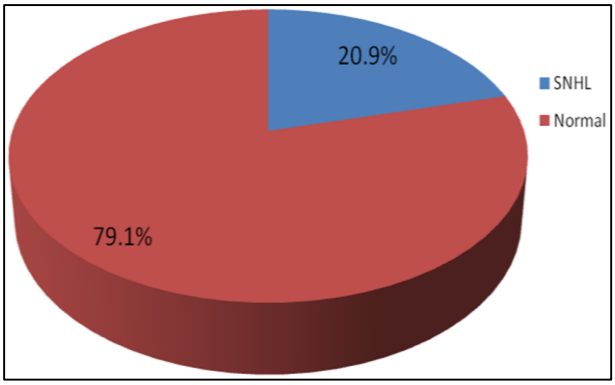

Fig 1: Rate of SNHL of diabetic children

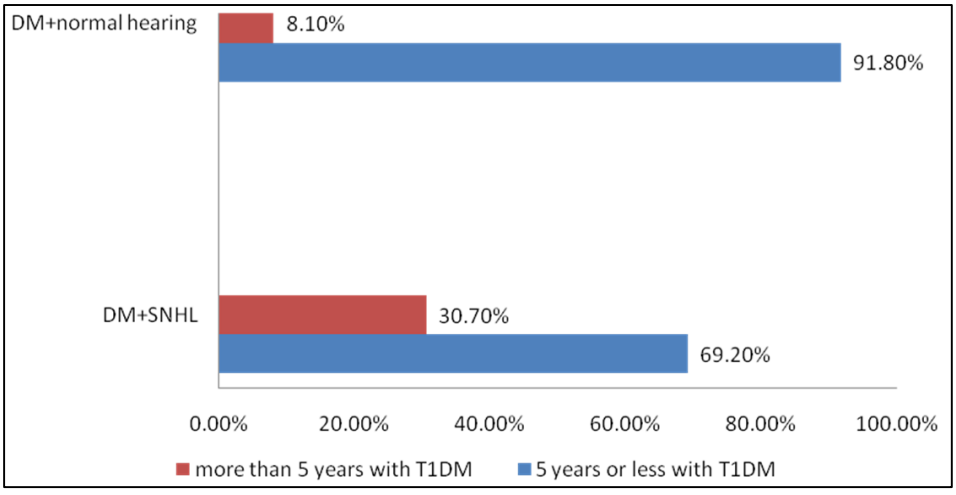

Fig 2: Comparison of Both Groups Related To DM Age

Discussion

Hearing loss is one of the complications of DM and is secondary to diabetic microangiopathy of cochlea or diabetic auditory neuropathy [16, 17]. Three main theories have been postulated by Hisaki Fuskushima *et al.* [18] to explain the pathogenesis of hearing impairment in diabetes mellitus: microangiopathy of cochlea, auditory neuropathy and combination of both. Elamin *et al.* (2003) favors microangiopathic theory which was supported by the histopathological findings on the temporal bones and the inner ear by Hisake Fuskushima *et al.* [18].

Auditory neuropathy have been demonstrated to cause hearing loss in diabetic patients and animal by Durmus *et al.*, In 1980 [19]. The type of hearing loss identified was sensorineural. Hearing threshold was higher in children with diabetes than the normal children indicating that diabetes does affect hearing and should be considered a complication of the disease. Hearing loss was shown to be significant in mid and high frequencies in this study and can be explained by the fact that diabetic microangiopathy initially affects mainly the basal turn of cochlea. As the diabetic age increases, it is expected to proceed further affecting the apical turn concerning with low frequencies. The same has been brought out by De Espana *et al.* [20]. All the 13 children with hearing loss were followed up with hearing evaluation. They had poor glycemic control (HbA1c) initially and subsequently with improved glycemic profile, the hearing loss did not deteriorate, indicating the need to maintain the optimum glycemic control. It is also relevant to point out that good glycemic control did not reverse the hearing loss pointing to the permanent changes in the cochlea. This study validates the study done by Doyle K. J. *et al.* [21] that Micro-angiopathy of cochlea is irreversible. Typical HbA1c level is considered a tool for good diabetic control. HBA1c level of 8% was taken as the cut off in these diabetic children more than 5 years of age [22]. The longer the duration of diabetes the more the chances of having hearing loss across all ranges of frequencies. Brown *et al.* [16] raised this point and also calculated the mean diabetic age at which hearing loss was demonstrated to be 7 years. This study showed the mean diabetic age for hearing loss to occur to be 5 years. Odds ratio calculation has shown the risk to increase 5 folds if diabetic age is more than 5 years. Celik *et al.* [17] demonstrated a positive correlation of hearing loss with retinopathy and nephropathy in 205 diabetic adults while no such correlation found in our study. In our study two of the children with nephropathy did not develop hearing loss while retinopathy was not demonstrated.

Conclusion: Hearing loss is common in diabetic children mainly in the mid and high frequency. Hearing threshold is much higher in diabetic children in comparison to non-diabetic children and its related to the duration of diabetes and degree of glycemic control. Screening program of diabetic children for hearing assessment after 5 years from the onset of diabetes and maintaining them on strict glycemic control is of paramount importance to avoid this complication.

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