Original Article

Clinical and Audiometric Assessment of Hearing Loss in Diabetes Mellitus

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Abstract

Introduction: Diabetes is the single most important metabolic disease which can affect nearly every organ system in the body. Almost all the macro and microvascular complications of diabetes have been studied extensively. Hearing loss in diabetes has not received as much attention and more research needs to be done in this area, so as to determine the magnitude of the problem, establish a cause and effect and increase awareness among health care providers and laypersons.

Aims:

1. To assess hearing loss in subjects with diabetes mellitus by clinical and audiometric examination.
2. To study type of hearing loss in diabetes mellitus.
3. To study audiometric pattern of hearing loss in diabetes mellitus.

Materials and Methods:

Source of data

This is prospective, comparative, purposive sampling study which was conducted from October 2011 to May 2013 which included 57 cases who were diagnosed to have diabetes mellitus and 50 controls without diabetes mellitus in the department of General Medicine, Yenepoya Medical College Hospital, Deralakatte.

Method of collection of data

The diagnosis of diabetes mellitus was made based on American Diabetes Association, 2011. After consent was received from the patient's detailed history, clinical examination was done. FBS, RBS, HbA1c and pure tone audiometry was done.

Results: There is an association of SNHL with diabetes with an incidence of 78.2% as compared to 38% among non diabetics. 10 patients reported gradual hearing loss rest did not realize the gradual progression of hearing loss. As age and duration of diabetes increases the incidence of SNHL increases.

Conclusion: Sensorineural hearing loss is seen in diabetes mellitus which is gradually progressive and threshold for hearing was greater for higher frequency. Age is confounding factor but diabetes mellitus alone is responsible for hearing loss. As the duration of diabetes mellitus increases the possibility of patient SNHL affected also increases.Hba1c shows a trend toward significant difference SNHL. FBS, RBS and Serum creatinine have negligible effect on SNHL has negligible effect in hearing loss.

Keywords: Audiometry, Diabetes mellitus, Hearing

INTRODUCTION

Historical Aspects

Arateus coined the term diabetes, meaning "siphon," to explain the "liquefaction of the flesh and bones into urine." He described diabetes in the following way-

Diabetes is a wonderful affection, not very frequent among men, being a melting down of the flesh and limbs into urine. Its course is of a cold and humid nature, as in dropsy. The course is the common one, namely, the kidneys and the bladder; for the patients never stop making water, but the flow is incessant, as if from the

opening of aqueducts. The nature of the disease then, is chronic, and it takes a long period to form: but the patient is short-lived, if the constitution of the disease be completely established; for the melting is rapid, the death speedy.[1]

The best early evidence of a description of the symptoms of diabetes in the world's literature is recorded in the Ebers papyrus that appears to date from 1550 BC.

Later, the word mellitus (honey sweet) was added by Thomas Willis after realising the sweetness of urine in diabetic patients in 1675. This was actually a rediscovery of an ancient Indian document. Susruta in India in about 400 BC. had described the diabetic syndrome as characterized by a "honeyed urine." [2]

It was only in 1776 that Dobson (Britain) first confirmed the presence of excess sugar in urine and blood as a cause of their sweetness. By 1889, Minkowski and von Mering (Germany) discovered the central role of the pancreas in diabetes.

Banting, Best, Collip, and Macleod discovered the pancreatic extract that reduced blood sugar in dogs.The new extract corrected the metabolic acidosis in the first person to receive the substance in January 1922 (Leonard Thompson, age 14 years, at the Toronto General Hospital in Canada). Later in 1923 "Isoelectric point" produced larger quantities of higher-potency insulin from animal sources. Finally in 1982 recombinant human insulin became available.[3]

Magnitude of the Problem

India leads the world with largest number of diabetic subjects earning the dubious distinction ofbeing termed the "diabetes capital of the world". Unlike Europeans, Indians are more prone to macrovascular complications as compared to microvascular complications. Diabetes is the single most important metabolic disease which can affect nearly every organ system in the body. It has been projected that 300 million individuals would be affected with diabetes by the year 2025. In India it is estimated that presently 19.4 million individuals are affected, which is likely to go up to 57.2 million by the year 2025. The reasons for this escalation are due to

- Changes in lifestyle
- People living longer than before (ageing)
- Low birth weight leading to diabetes during adulthood.

Diabetes related complications are coronary artery disease, peripheral vascular disease, neuropathy, retinopathy, nephropathy, etc.

People with diabetes are

- 25 times more likely to develop blindness,
- 17 times more likely to develop kidney disease,
- 30-40 times more likely to undergo amputation,
- 2-4 times more likely to develop myocardial infarction and
- Twice as likely to suffer a stroke than non-diabetics.[4]

Statement of the Problem

Given the fact that both diabetes and its attendant complications are common (in epidemic proportions) and increasing year after year, it is not surprising that the associated morbidity and mortality of this disease make it a public health disease that has a negative impact on the work output of the nation. Almost all the macro and microvascular complications of diabetes have been studied extensively. Hearing loss in diabetes has not received as much attention and more research needs to be done in this area, so as to determine the magnitude of the problem, establish a cause and effect and increase awareness among health care providers and laypersons. This study aims to address all of the above issues.

AIMS AND OBJECTIVES

1. To assess hearing loss in subjects with diabetes mellitus by clinical and audiometric examination
2. To study type of hearing loss in diabetes mellitus.
3. To study audiometric pattern of hearing loss in diabetes mellitus.

MATERIALS AND METHODS

- Study Design: Prospective, comparative, purposive sampling.
- Sample size 57 case and 50 (age and sex matched) control was selected.

Inclusion Criteria for Cases

- Patients diagnosed with diabetes as per The National Diabetes Data Group and World Health Organization issued diagnostic criteria.
- Random blood glucose concentration >200 mg/dL.
- Fasting plasma glucose >126 mg/dL.
- Two-hour plasma glucose >200 mg/dL during an oral glucose tolerance test.
- Age greater than 18.

Inclusion Criteria for Controls

- Age and sex matched non diabetic subjects.
- Age greater than 18.

Exclusion Criteria for Cases and Control

- Subjects with history of chronic exposure to noise.
- Subjects with history of ear discharge, perforated tympanic membrane or any other chronic ear disease.
- Subjects with the history of intake ototoxic drugs in the past 2 months.
- Subjects with family history of hearing loss.
- Subjects on cranial nervous system sedatives.
- Subjects with trauma to the ear.

Method

- Detailed history of subjects was taken.
- Detailed examination of ear, pinna, periauricle area, external auditory canal and tympanic membrane was done.
- Cranial nerves system of the subjects will be examined.
- Eight cranial nerve will be tested in detail.
- Acuity of hearing will be tested in the bedside (cochlear test-Rinne's test, Weber's test, modified Schwabach's test, fistula test).

INVESTIGATIONS

1. Fasting blood sugar (Vibose 250 biochemistry analyzer).
2. Random blood sugar (Vibose 250 biochemistry analyzer).
3. Serum creatine (Vibose 250 biochemistry analyzer).
4. HbA1C (Biorad 10 D).
5. Pure Tone Audiometry was done in a sound proof room, using a calibrated Interacoustics Clinical audiometer-AC-40 (Denmark). The transducers used for the testing are TDH 39 Supra Aural Head phones and Radio Ear B 71 bone vibrator.
    - Modified Hughson-Westlake procedure (ASHA 1978) was used for the threshold estimation. The threshold was determined based on the American National Standard Institute (ANSI). According to ANSI S3.21, threshold is determined as the "lowest hearing level at which responses occur in at least one half of a series of ascending trials, with a minimum of two responses out of three required at a single level" (ANSI 1978, 1986). The threshold was obtained across all the frequency octaves from 250 Hz to 8000 Hz.
    - The thresholds obtained will be used for the quantitative assessment of degree of hearing loss based on the Clark's (1981) modification of Goodman classification of severity of hearing loss (1965).
    - Categories of Degrees of Hearing Loss, Based on Air Conduction Pure-Tone Average at 500, 1000, and 2000 Hz.

Degree of Hearing Loss Category		Pure tone average range
1.	Normal hearing sensitivity	–10 dB HL to 15 dB HL
2.	Slight hearing loss	16 dB HL to 25 dB HL
3.	Mild hearing loss	26 dB HL to 40 dB HL
4.	Moderate hearing loss	41 dB HL to 55 dB HL
5.	Moderately severe hearing loss	56 dB HL to 70 dB HL
6.	Severe hearing loss	71 dB HL to 90 dB HL
7.	Profound hearing loss	91 dB HL to equipment

The present study was conducted Yenepoya Medical College.

RESULTS

The occurrence of sensorineural hearing loss in diabetic patients was compared with those of non-diabetics. It was matched under the following parameters.

1. Prevalence of SNHL is diabetic patients and controls
2. Age of the diabetic patients
3. Sex of the diabetic patients
4. Duration of diabetes
5. BMI
6. FBS
7. RBS
8. HbA1C
9. Serum Creatinine
10. Hypertension.

Table 1: Non age matched correlation of the hearing loss
Conditional logistic regression

Model summary

Step	–2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	128.764[a]	0.167	0.223

[a]Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001

Classification Table[a]

Observed		Predicted		
		Hearing loss mild to profound		Percentage correct
		Wnl/ minimal	Mild to profound	
Step 1	Hearing loss mild to profound			
	Wnl/minimal	36	17	67.9
	Mild to profound	14	40	74.1
	Overall percentage			71.0

[a]The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1[a]							
	Group (1)	1.800	0.428	17.705	1	<0.001	6.050
	Constant	−0.944	0.315	8.991	1	0.003	0.389

[a]Variable (s) entered on step 1: Group

Result: There is a significantly higher chance of developing hearing loss in diabetes with R value of 0.167.

Table 2: Correlation of hearling loss with age included (age matched analysis)

Model summary

Step	−2 Log likelihood	Cox & Snell R square	Nagelkerke R square
1	120.827[a]	0.227	0.302

[a]Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001

Classification Table[a]

	Observed	Predicted		
		Hearing loss mild to profound		Percentage correct
		Wnl/ minimal	Mild to profound	
Step 1	Hearing loss mild to profound			
	Wnl/minimal	35	18	66.0
	Mild to profound	15	39	72.2
	Overall percentage			69.2

[a]The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1[a]	Age	0.050	0.019	7.126	1	0.008	1.051
	Group (1)	1.697	0.446	14.507	1	<0.001	5.459
	Constant	−3.417	1.018	11.260	1	0.001	0.033

[a]Variable(s) entered on step 1: Age, group

Result: There is a significant association of age and diabetetes with SNHL.

The diabetes group beta value reduced (highlighted in red) compared to the one without age included R value is increased 0.227.

This shows that age is a confounding factor but diabetes alone is associated with hearing loss.

Total 57 diabetic patients were included in the study. 10 patients reported hearing loss. Total 45 patients had SNHL. All the patients had gradual onset of hearing loss. Of the 50 controls 31 had normal hearing 5 had minimal and 5 had mild and 9 controls had moderate SNHL. None of the controls had reported hearing loss on direct questioning.

Table 3: Prevelance of hearing loss in diabetic patients and control

Hearing loss

Group		Frequency	Percent	Valid percent	Cumulative percent
Diabetics	Valid				
	Wnl	12	21.1	21.1	21.1
	Minimal	5	8.8	8.8	29.8
	Mild	8	14.0	14.0	43.9
	Moderate	19	33.3	33.3	77.2
	Severe	8	14.0	14.0	91.2
	Profound	5	8.8	8.8	100.0
	Total	57	100.0	100.0	
Control	Valid				
	Wnl	31	62.0	62.0	62.0
	Minimal	5	10.0	10.0	72.0
	Mild	5	10.0	10.0	82.0
	Moderate	9	18.0	18.0	100.0
	Total	50	100.0	100.0	

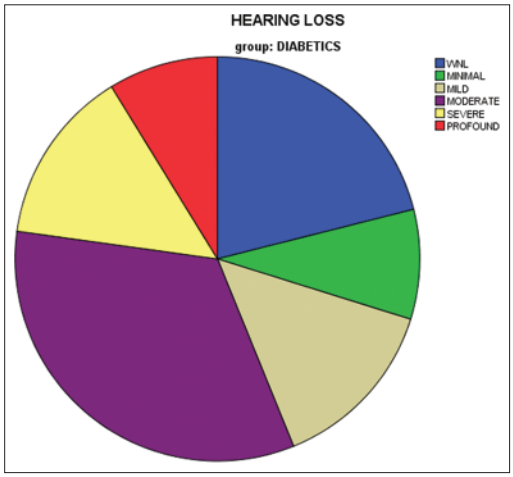


Figure 1: Hearing loss pattern in diabetics

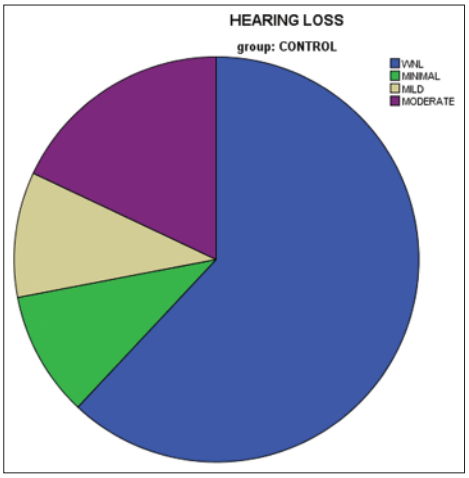


Figure 2: Hearing loss pattern in control group

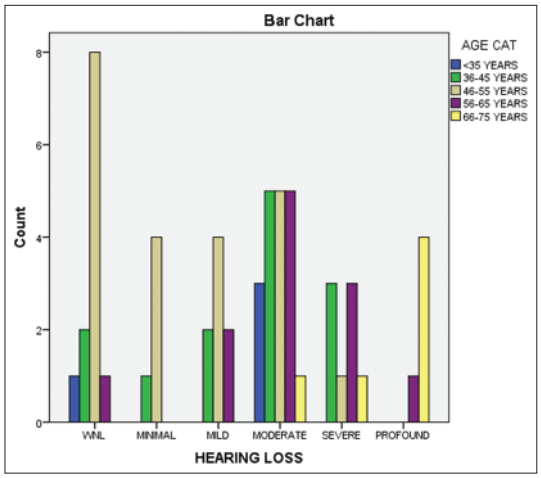
Table 4: Chi square tests in the case group alone hearing loss *age cat cases group

Crosstab			Age cat					Total
			<35 years	36-45 years	46-55 years	56-65 years	66-75 years	
Hearing loss	Wnl	Count	1	2	8	1	0	12
		% within hearing loss	8.3%	16.7%	66.7%	8.3%	0.0%	100.0%
		% within age cat	25.0%	15.4%	36.4%	8.3%	0.0%	21.1%
	Minimal	Count	0	1	4	0	0	5
		% within hearing loss	0.0%	20.0%	80.0%	0.0%	0.0%	100.0%
		% within age cat	0.0%	7.7%	18.2%	0.0%	0.0%	8.8%
	Mild	Count	0	2	4	2	0	8
		% within hearing loss	0.0%	25.0%	50.0%	25.0%	0.0%	100.0%
		% within age cat	0.0%	15.4%	18.2%	16.7%	0.0%	14.0%
	Moderate	Count	3	5	5	5	1	19
		% within hearing loss	15.8%	26.3%	26.3%	26.3%	5.3%	100.0%
		% within age cat	75.0%	38.5%	22.7%	41.7%	16.7%	33.3%
	Severe	Count	0	3	1	3	1	8
		% within hearing loss	0.0%	37.5%	12.5%	37.5%	12.5%	100.0%
		% Within age cat	0.0%	23.1%	4.5%	25.0%	16.7%	14.0%
	Profound	Count	0	0	0	1	4	5
		% within hearing loss	0.0%	0.0%	0.0%	20.0%	80.0%	100.0%
		% within age cat	0.0%	0.0%	0.0%	8.3%	66.7%	8.8%
Total		Count	4	13	22	12	6	57
		% within hearing loss	7.0%	22.8%	38.6%	21.1%	10.5%	100.0%
		% within age cat	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

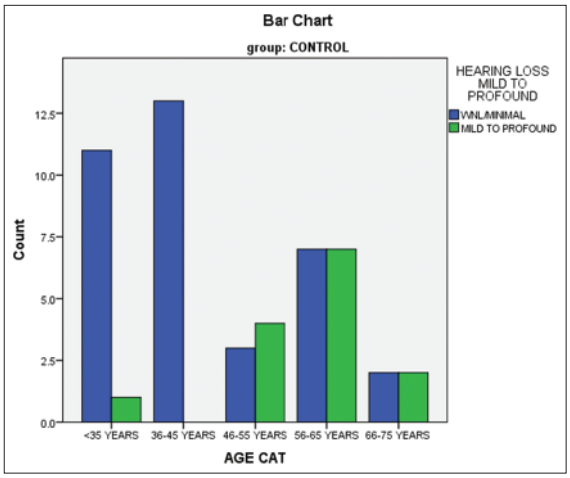
As age of the subjects increase the percentage of severe and profound hearing loss increase. No patients in the age group 66 to 75 years had normal hearing or minimal hearing loss.Patients who were less than 35 years (25%) 1 patient had normal hearing and (75%) 3 patients had moderate hearing

Chi-Square tests	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	44.596	20	0.001
N of valid cases	57		

Result: There is a significant correlation. As age of the diabetic patient increases the hearing loss also increases.



Graph 1: Age correlation to hearing loss in diabetics



Graph 2: Age correlation to hearing loss in control group

Patients who were diagnosed with diabetes less than 5 years had maximum percentage with normal hearing (44.4%). patients who were diagnosed with diabetes mellitus for 5 to 10 years had maximum percentage with moderate hearing loss (50%). Finally patients who were diabetic for greater than 10 years had maximum percentage with severe (26.7%) and profound (20%) hearing loss.

DISCUSSION

Occurrence of hearing loss in Diabetes Mellitus patients is known since 1857 when Jordao reported hearing loss in patients with Diabetes[5,6]. The relationship between diabetes mellitus and sensorineural hearing loss is complex and debatable since many years. Some studies say hearing

Table 5: Age cat *Hearing loss mild to profound control group

Crosstab[a]			Hearing loss		Total
			Mild to profound	Mild to profound	
Age cat	<35 years	Count	11	1	12
		% within age cat	91.7%	8.3%	100.0%
		% within hearing loss mild to profound	30.6%	7.1%	24.0%
	36-45 years	Count	13	0	13
		% within age cat	100.0%	0.0%	100.0%
		% within hearing loss mild to profound	36.1%	0.0%	26.0%
	46-55 years	Count	3	4	7
		% within age cat	42.9%	57.1%	100.0%
		% within hearing loss mild to profound	8.3%	28.6%	14.0%
	56-65 years	Count	7	7	14
		% within age cat	50.0%	50.0%	100.0%
		% within hearing loss mild to profound	19.4%	50.0%	28.0%
	66-75 years	Count	2	2	4
		% within age cat	50.0%	50.0%	100.0%
		% within hearing loss mild to profound	5.6%	14.3%	8.0%
Total		Count	36	14	50
		% within age cat	72.0%	28.0%	100.0%
		% within hearing loss mild to profound	100.0%	100.0%	100.0%

[a]Group=Control

Chi-Square tests[a]	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	14.628	4	0.006
N of valid cases	50		

[a]Group=Control

Result: There is a significant correlation with age and SNHL ain controls.

Table 6: Age cat * hearing loss control group

Crosstab[a]			Hearing loss				Total
			Wnl	Minimal	Mild	Moderate	
Age cat	<35 years	Count	10	1	1	0	12
		% within age cat	83.3%	8.3%	8.3%	0.0%	100.0%
		% within hearing loss	32.3%	20.0%	20.0%	0.0%	24.0%
	36-45 years	Count	12	1	0	0	13
		% within age cat	92.3%	7.7%	0.0%	0.0%	100.0%
		% within hearing loss	38.7%	20.0%	0.0%	0.0%	26.0%
	46-55 years	Count	1	2	2	2	7
		% within age cat	14.3%	28.6%	28.6%	28.6%	100.0%
		% within hearing loss	3.2%	40.0%	40.0%	22.2%	14.0%
	56-65 years	Count	6	1	1	6	14
		% within age cat	42.9%	7.1%	7.1%	42.9%	100.0%
		% within hearing loss	19.4%	20.0%	20.0%	66.7%	28.0%
	66-75 years	Count	2	0	1	1	4
		% within age cat	50.0%	0.0%	25.0%	25.0%	100.0%
		% within hearing loss	6.5%	0.0%	20.0%	11.1%	8.0%
Total		Count	31	5	5	9	50
		% within age cat	62.0%	10.0%	10.0%	18.0%	100.0%
		% within hearing loss	100.0%	100.0%	100.0%	100.0%	100.0%

[a]Group=Control

Chi-Square tests[a]	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	23.940	12	0.021
N of valid cases	50		

[a]Group=Control

Result: There is a significance correlation. As age of the control increases the hearing loss also increases.

Table 7: Hearing loss* sex

Crosstab			Sex		Total
			Female	Male	
Hearing loss	Wnl	Count	6	6	12
		% within hearing loss	50.0%	50.0%	100.0%
		% within sex	23.1%	19.4%	21.1%
	Minimal	Count	0	5	5
		% within hearing loss	0.0%	100.0%	100.0%
		% within sex	0.0%	16.1%	8.8%
	Mild	Count	3	5	8
		% within hearing loss	37.5%	62.5%	100.0%
		% within sex	11.5%	16.1%	14.0%
	Moderate	Count	11	8	19
		% within hearing loss	57.9%	42.1%	100.0%
		% within sex	42.3%	25.8%	33.3%
	Severe	Count	3	5	8
		% within hearing loss	37.5%	62.5%	100.0%
		% within sex	11.5%	16.1%	14.0%
	Profound	Count	3	2	5
		% within hearing loss	60.0%	40.0%	100.0%
		% within sex	11.5%	6.5%	8.8%
Total		Count	26	31	57
		% within hearing loss	45.6%	54.4%	100.0%
		% within sex	100.0%	100.0%	100.0%

Chi-Square tests	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	6.283	5	0.280
N of valid cases	57		

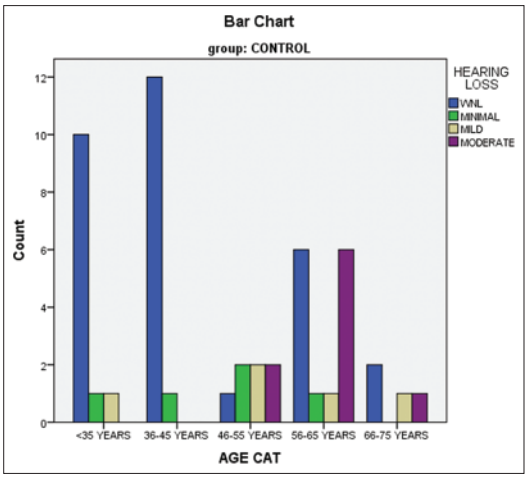
Result: There is no significant correlation.

Table 8: Hearing loss duration diabetes mellitus category

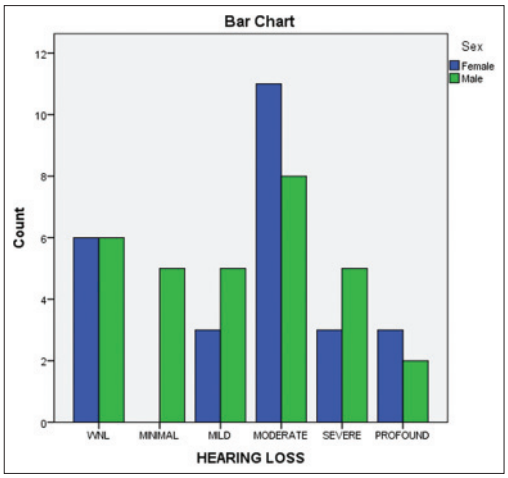
Crosstab			Duration DM CAT			Total
			<5 years	5-10 years	>10 years	
Hearing loss	Wnl	Count	8	1	3	12
		% within hearing loss	66.7%	8.3%	25.0%	100.0%
		% within duration DM CAT	44.4%	4.2%	20.0%	21.1%
	Minimal	Count	0	4	1	5
		% within hearing loss	0.0%	80.0%	20.0%	100.0%
		% within duration DM CAT	0.0%	16.7%	6.7%	8.8%
	Mild	Count	2	3	3	8
		% within hearing loss	25.0%	37.5%	37.5%	100.0%
		% within duration DM CAT	11.1%	12.5%	20.0%	14.0%
	Moderate	Count	6	12	1	19
		% within hearing loss	31.6%	63.2%	5.3%	100.0%
		% within duration DM CAT	33.3%	50.0%	6.7%	33.3%
	Severe	Count	1	3	4	8
		% within hearing loss	12.5%	37.5%	50.0%	100.0%
		% within duration DM CAT	5.6%	12.5%	26.7%	14.0%
	Profound	Count	1	1	3	5
		% within hearing loss	20.0%	20.0%	60.0%	100.0%
		% within duration DM CAT	5.6%	4.2%	20.0%	8.8%
Total		Count	18	24	15	57
		% within hearing loss	31.6%	42.1%	26.3%	100.0%
		% within duration DM CAT	100.0%	100.0%	100.0%	100.0%

Chi-Square tests	Value	df	Asymp. sg. (2-sided)
Pearson Chi-Square	22.643	10	0.012
N of valid cases	57		

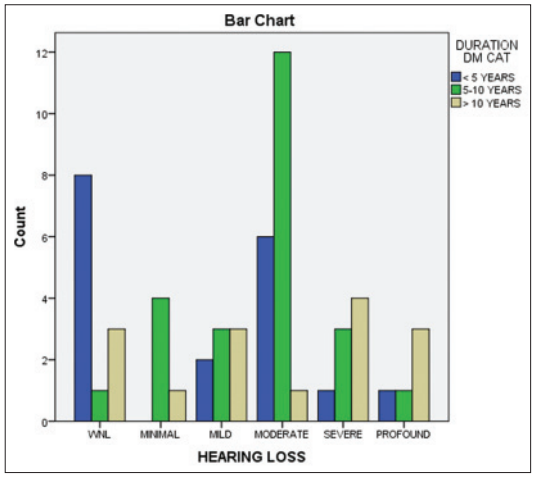
Result: There is a significant association. It is clearly seen in the table that as duration of diabetes increases, the predisposition to SNHL also increases.



Graph 3: Age correlation to hearing loss pattern in controls



Graph 4: Sex correlation to hearing loss



Graph 5: Correlation of duration of diabetes and hearing loss

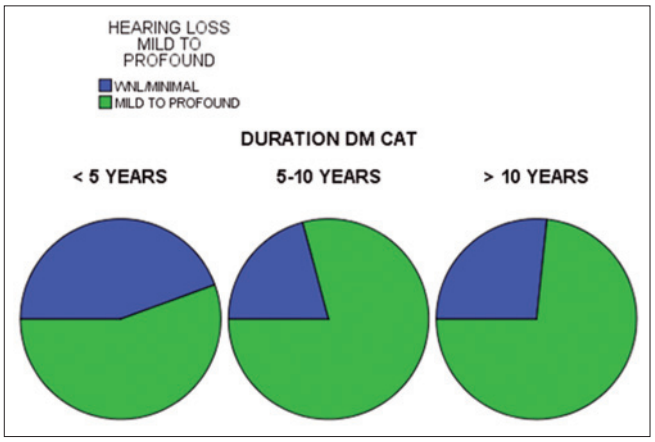


Figure 4: Duration of diabetes and hearing loss

Table 9: Hearing loss *BMICAT

Crosstab			BMICAT			Total
			<24.9	25-34.9	35-44.9	
Hearing loss	Wnl	Count	4	6	2	12
		% within hearing loss	33.3%	50.0%	16.7%	100.0%
		% within BMICAT	18.2%	20.7%	33.3%	21.1%
	Minimal	Count	2	2	1	5
		% within hearing loss	40.0%	40.0%	20.0%	100.0%
		% within BMICAT	9.1%	6.9%	16.7%	8.8%
	Mild	Count	6	2	0	8
		% within hearing loss	75.0%	25.0%	0.0%	100.0%
		% within BMICAT	27.3%	6.9%	0.0%	14.0%
	Moderate	Count	6	10	3	19
		% within hearing loss	31.6%	52.6%	15.8%	100.0%
		% within BMICAT	27.3%	34.5%	50.0%	33.3%
	Severe	Count	3	5	0	8
		% within hearing loss	37.5%	62.5%	0.0%	100.0%
		% within BMICAT	13.6%	17.2%	0.0%	14.0%
	Profound	Count	1	4	0	5
		% within hearing loss	20.0%	80.0%	0.0%	100.0%
		% within BMICAT	4.5%	13.8%	0.0%	8.8%
Total		Count	22	29	6	57
		% within hearing loss	38.6%	50.9%	10.5%	100.0%
		% within BMICAT	100.0%	100.0%	100.0%	100.0%

Chi-Square tests	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	9.324	10	0.502
N of valid cases	57		

Result: There is no significant correlation.

Table 10: Hearing loss *FBS

Crosstab			FBS			Total
			<150	150-200	>200	
Hearing loss	Wnl	Count	3	7	2	12
		% within hearing loss	25.0%	58.3%	16.7%	100.0%
		% within FBS	13.6%	26.9%	22.2%	21.1%
	Minimal	Count	3	1	1	5
		% within hearing loss	60.0%	20.0%	20.0%	100.0%
		% within FBS	13.6%	3.8%	11.1%	8.8%
	Mild	Count	3	4	1	8
		% within hearing loss	37.5%	50.0%	12.5%	100.0%
		% within FBS	13.6%	15.4%	11.1%	14.0%
	Moderate	Count	9	7	3	19
		% within hearing loss	47.4%	36.8%	15.8%	100.0%
		% within FBS	40.9%	26.9%	33.3%	33.3%
	Severe	Count	2	4	2	8
		% within hearing loss	25.0%	50.0%	25.0%	100.0%
		% within FBS	9.1%	15.4%	22.2%	14.0%
	Profound	Count	2	3	0	5
		% within hearing loss	40.0%	60.0%	0.0%	100.0%
		% within FBS	9.1%	11.5%	0.0%	8.8%
Total		Count	22	26	9	57
		% within hearing loss	38.6%	45.6%	15.8%	100.0%
		% within FBS	100.0%	100.0%	100.0%	100.0%

Chi-Square tests	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	5.031	10	0.889
N of valid cases	57		

Result: There is no significant correlation.

Table 11: Hearing loss *RBS

Crosstab			RBS		Total
			150-200	>200	
Hearing loss	Wnl	Count	2	10	12
		% within hearing loss	16.7%	83.3%	100.0%
		% within RBS	8.3%	30.3%	21.1%
	Minimal	Count	3	2	5
		% within hearing loss	60.0%	40.0%	100.0%
		% within RBS	12.5%	6.1%	8.8%
	Mild	Count	4	4	8
		% within hearing loss	50.0%	50.0%	100.0%
		% within RBS	16.7%	12.1%	14.0%
	Moderate	Count	12	7	19
		% within hearing loss	63.2%	36.8%	100.0%
		% within RBS	50.0%	21.2%	33.3%
	Severe	Count	2	6	8
		% within hearing loss	25.0%	75.0%	100.0%
		% within RBS	8.3%	18.2%	14.0%
	Profound	Count	1	4	5
		% within hearing loss	20.0%	80.0%	100.0%
		% within RBS	4.2%	12.1%	8.8%
Total		Count	24	33	57
		% within hearing loss	42.1%	57.9%	100.0%
		% within RBS	100.0%	100.0%	100.0%

Chi-Square tests	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	9.464	5	0.092
N of valid cases	57		

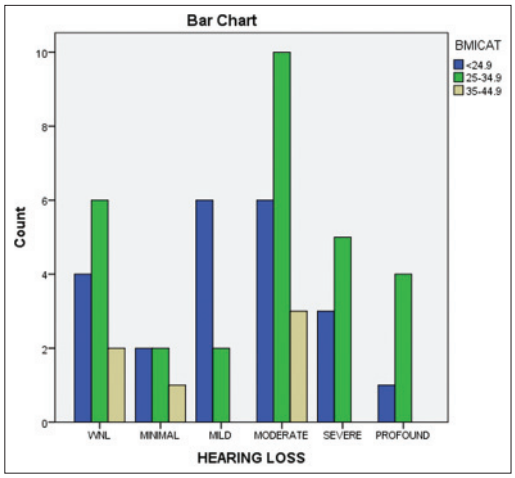
Result: There is no significant correlation.

Table 12: Hearing loss *HbA1C

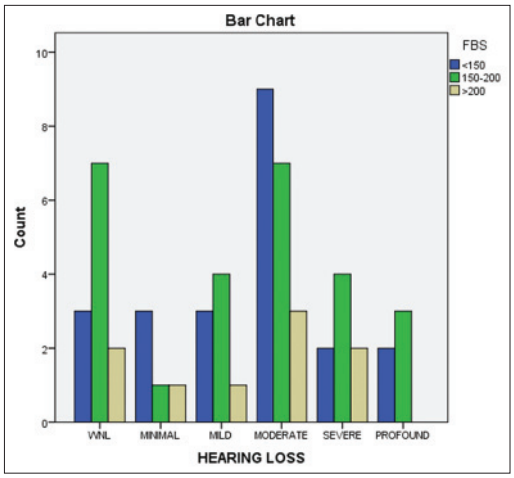
Crosstab			Hba1C			Total
			<9.9	10-13.9	>14	
Hearing loss	Wnl	Count	7	4	1	12
		% within hearing loss	58.3%	33.3%	8.3%	100.0%
		% within Hba1C	28.0%	14.3%	25.0%	21.1%
	Minimal	Count	3	0	2	5
		% within hearing loss	60.0%	0.0%	40.0%	100.0%
		% within Hba1C	12.0%	0.0%	50.0%	8.8%
	Mild	Count	3	4	1	8
		% within hearing loss	37.5%	50.0%	12.5%	100.0%
		% within Hba1C	12.0%	14.3%	25.0%	14.0%
	Moderate	Count	8	11	0	19
		% within hearing loss	42.1%	57.9%	0.0%	100.0%
		% within Hba1C	32.0%	39.3%	0.0%	33.3%
	Severe	Count	3	5	0	8
		% within hearing loss	37.5%	62.5%	0.0%	100.0%
		% within Hba1C	12.0%	17.9%	0.0%	14.0%
	Profound	Count	1	4	0	5
		% within hearing loss	20.0%	80.0%	0.0%	100.0%
		% within Hba1C	4.0%	14.3%	0.0%	8.8%
Total		Count	25	28	4	57
		% within hearing loss	43.9%	49.1%	7.0%	100.0%
		% within Hba1C	100.0%	100.0%	100.0%	100.0%

Chi-Square tests	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	16.675	10	0.082
N of valid cases	57		

Result: There is no significant correlation.



Graph 6: Hearing loss and BMI



Graph 7: Hearing loss and FBS

Table 13: Hearing loss *creatinine category cases

Crosstab			Creatinine CAT			Total
			<1.5	1.5-3	>3	
Hearing loss	Wnl	Count	8	3	1	12
		% within hearing loss	66.7%	25.0%	8.3%	100.0%
		% within creatinine CAT	19.5%	23.1%	33.3%	21.1%
	Minimal	Count	2	2	1	5
		% within hearing loss	40.0%	40.0%	20.0%	100.0%
		% within creatinine CAT	4.9%	15.4%	33.3%	8.8%
	Mild	Count	7	1	0	8
		% within hearing loss	87.5%	12.5%	0.0%	100.0%
		% within creatinine CAT	17.1%	7.7%	0.0%	14.0%
	Moderate	Count	15	3	1	19
		% within hearing loss	78.9%	15.8%	5.3%	100.0%
		% within creatinine CAT	36.6%	23.1%	33.3%	33.3%
	Severe	Count	5	3	0	8
		% within hearing loss	62.5%	37.5%	0.0%	100.0%
		% within creatinine CAT	12.2%	23.1%	0.0%	14.0%
	Profound	Count	4	1	0	5
		% within hearing loss	80.0%	20.0%	0.0%	100.0%
		% within creatinine CAT	9.8%	7.7%	0.0%	8.8%
Total		Count	41	13	3	57
		% within hearing loss	71.9%	22.8%	5.3%	100.0%
		% within creatinine CAT	100.0%	100.0%	100.0%	100.0%

Chi-Square tests	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	6.913	10	0.734
N of valid cases	57		

Result: There is no significant correlation.

Table 14: Creatinine CAT *hearing loss mild to profound in controls

Crosstab[a]			Hearing loss mild to profound		Total
			Wnl/minimal	Mild to profound	
Creatinine CAT	<1.5	Count	31	14	45
		% within creatinine CAT	68.9%	31.1%	100.0%
		% within hearing loss mild to profound	86.1%	100.0%	90.0%
	1.5-3	Count	1	0	1
		% within creatinine CAT	100.0%	0.0%	100.0%
		% within hearing loss mild to profound	2.8%	0.0%	2.0%
	>3	Count	4	0	4
		% within creatinine CAT	100.0%	0.0%	100.0%
		% within hearing loss mild to profound	11.1%	0.0%	8.0%
Total		Count	36	14	50
		% within creatinine CAT	72.0%	28.0%	100.0%
		% within hearing loss mild to profound	100.0%	100.0%	100.0%

[a]Group=Control

Chi-Square tests[a]	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	2.160	2	0.340
N of valid cases	50		

[a]Group=Control

Result: Not significant

Table 15: Creatinine CAT *hearing loss controls

Crosstab[a]			Hearing loss				Total
			Wnl	Minimal	Mild	Moderate	
Creatinine CAT	<1.5	Count	26	5	5	9	45
		% within creatinine CAT	57.8%	11.1%	11.1%	20.0%	100.0%
		% within hearing loss	83.9%	100.0%	100.0%	100.0%	90.0%
	1.5-3	Count	1	0	0	0	1
		% within creatinine CAT	100.0%	0.0%	0.0%	0.0%	100.0%
		% within hearing loss	3.2%	0.0%	0.0%	0.0%	2.0%
	>3	Count	4	0	0	0	4
		% within creatinine CAT	100.0%	0.0%	0.0%	0.0%	100.0%
		% within hearing loss	12.9%	0.0%	0.0%	0.0%	8.0%
Total		Count	31	5	5	9	50
		% within creatinine CAT	62.0%	10.0%	10.0%	18.0%	100.0%
		% within hearing loss	100.0%	100.0%	100.0%	100.0%	100.0%

[a]Group=Control

Chi-Square tests[a]	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	3.405	6	0.757
N of valid cases	50		

[a]Group=Control

Result: Not significant

Table 16: Hearing loss and hypertension

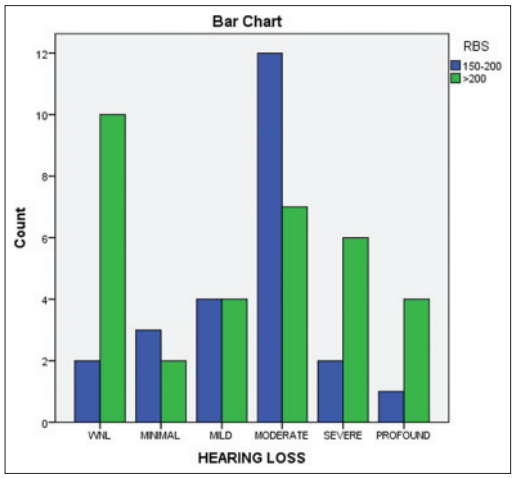
Hearing loss mild to profound *Hypertension Crosstabulation

Group				Hypertension		Total
				No	Yes	
Diabetics	Hearing loss mild to profound	Wnl/minimal	Count	11	6	17
			% within hearing loss mild to profound	64.7%	35.3%	100.0%
			% within Hypertension	31.4%	27.3%	29.8%
		Mild to profound	Count	24	16	40
			% within hearing loss mild to profound	60.0%	40.0%	100.0%
			% within Hypertension	68.6%	72.7%	70.2%
	Total		Count	35	22	57
			% within hearing loss mild to profound	61.4%	38.6%	100.0%
			% within Hypertension	100.0%	100.0%	100.0%
Control	Hearing loss mild to profound	Wnl/minimal	Count	25	11	36
			% within hearing loss mild to profound	69.4%	30.6%	100.0%
			% within Hypertension	71.4%	73.3%	72.0%
		Mild to profound	Count	10	4	14
			% within hearing loss mild to profound	71.4%	28.6%	100.0%
			% within Hypertension	28.6%	26.7%	28.0%
	Total		Count	35	15	50
			% within hearing loss mild to profound	70.0%	30.0%	100.0%
			% within Hypertension	100.0%	100.0%	100.0%

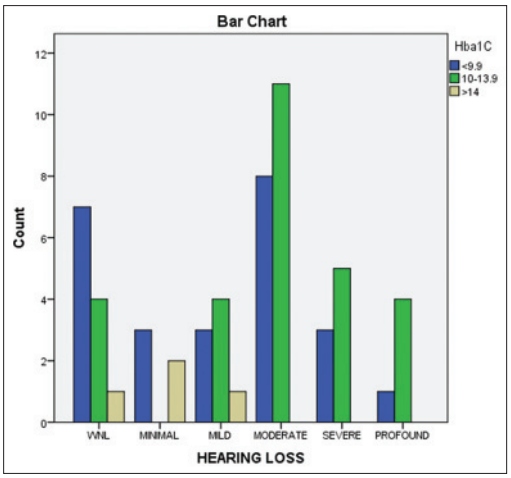
Chi-Square tests

Group		Value	df	Asymp. sig. (2-sided)
Diabetics	Pearson Chi-Square	0.111[a]	1	0.738
	N of valid cases	57		
Control	Pearson Chi-Square	0.019[c]	1	0.891
	N of valid cases	50		

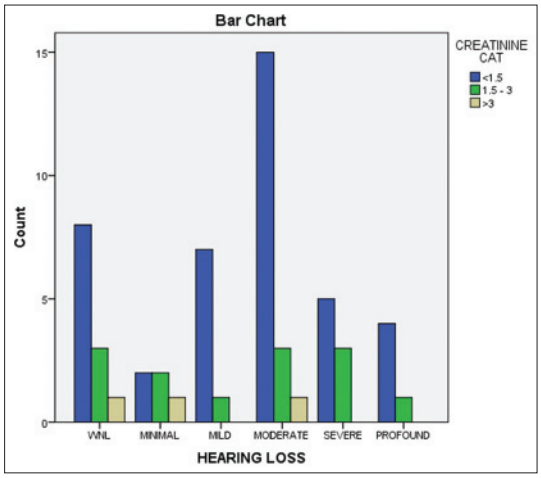
[a].0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.56, [c].1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.20



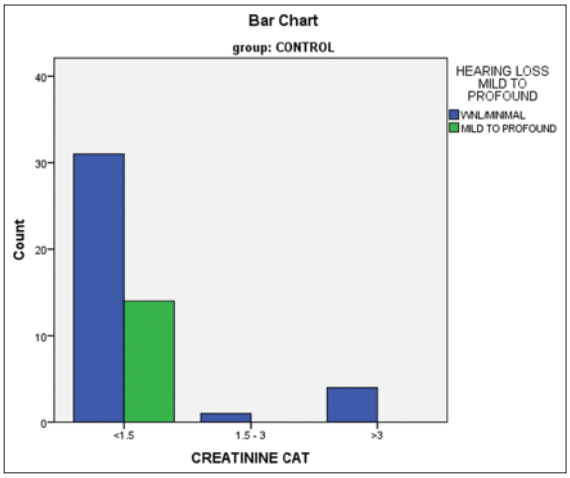
Graph 8: Hearing loss and RBS



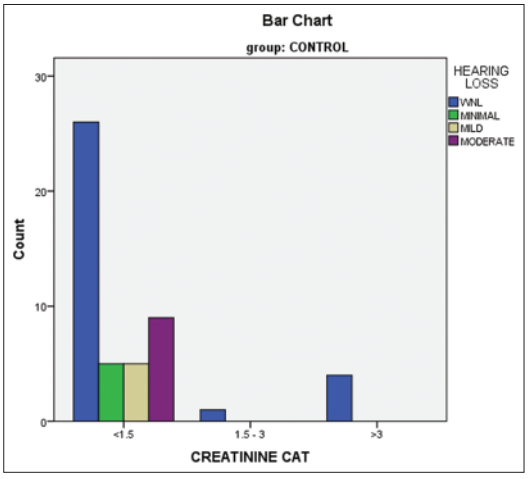
Graph 9: Hearing loss and RBS



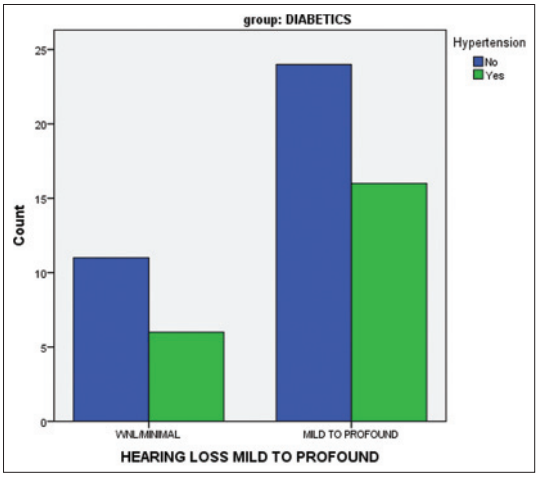
Graph 10: Hearing loss and creatinine



Graph 11: Creatinine and hearing loss in controls



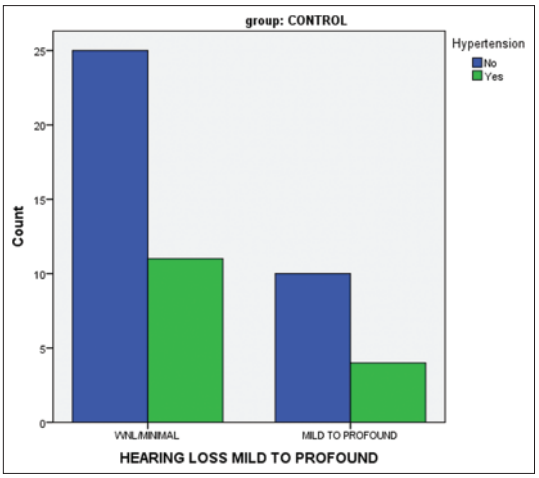
Graph 12: Creatinine and hearing loss patter in controls



Graph 13: Hearing loss and hypertension in diabetics

On comparing hypertensive diabetic patients compared to diabetic patients without hypertension we can conclude that hypertension was not a risk factor for hearing loss in diabetic subjects.

Controls with hypertension did not have a greater incidence of hearing loss as compared to rest of the control group.



Graph 14: Hearing loss and hypertension in control group

loss is associated with diabetes mellitus, some say there is no association between diabetes mellitus and hearing loss. Studies show hearing loss in diabetes can be predicted by the elevated serum creatinine or by high HbA1C.

1. Prevalence of SNHL in Diabetic Patients and Controls (Table 3, Figure 1, 2)

Most of the recent study shows the association of SNHL with diabetes. This study also supports the association of SNHL with diabetes with an incidence of 78.2% as compared to 38% among non diabetics. Among the case group10 patients reportedgradual hearing loss. Rest did not report probably they they could not appreciate the change. Of the 50 controls majority had normal hearing (62%) only 9 controls had moderate hearing loss. Friedman[7] had (55%) hearing loss and Aggarwal[8] had (64.86%) hearing loss.

The hearing loss was characteristically bilaterally symmetrical and progressive with gradual onset, however asymmetry in the hearing loss was also noticed in few patients. All diabetic patients who reported hearing loss had slow progressive hearing loss but Shuen Fu in 2005 reported 68 sudden onset SNHL in diabetes.[9]

Edgar[6] in 1915 was the first to report a high frequency sensorineural hearing loss in diabetic patient. In this study diabetic patients had a higher threshold for high frequency. The hearing loss is more common in higher frequencies in the study done by Kurien M et al[10] in 1989 and Cullen R etal[11] in 1993. But this was not supported by Tay HL[12] in 1995 and he concluded that hearing loss was in mid and low frequencies[4] while Fangchao MA[13] in 1998 found hearing loss in diabetics only in 500 Hz frequency.[14]

2. Age of The Diabetic: (Table 4,5,6,7. Figure 1, 2, 3)

As age of the subjects increase the percentage of severe and profound hearing loss increase.

No patients in the age group 66 to 75 years had normal hearing or minimal hearing loss.

Patients who were less than 35 years (25%) 1 patient had normal hearing and (75%) 3 patients had moderate hearing. This study result is contrast to the study done by

Friedman[7] and Cullen R.[11] Friedman had a sample size of only 20 patients where as our study had 57 cases of different age group.

3. Sex of the Diabetic Patients: (Table 7. Graph 4)

This study did not show any strong correlation between hearing loss and sex of the patients. However study done by Cullen R etal[11] showed that male diabetics had slightly worse hearing when compared to female diabetic patients and Taylor and Irwin[15] observed that female patients with diabetes had significantly greater hearing loss than male patients with diabetes. Majority of the study did not show any variation in sex with hearing.

4. Duration of Diabetes Mellitus (Table 8. Graph 5. Figure 4)

Out of all the variables in diabetic patients which were evaluated for hearing loss duration of diabetes mellitus had high correlation to hearing loss. Older diabetic patients had higher incidence of hearing loss and they had sever grade hearing loss.

This result is supported by Virteniemi J et al[16] 1994 and Fangcha MA, et al[13] 1998. However studies done by Kurien M et al[10] 1989 and Cullen R et al[11] did not show any correlation between duration of diabetes and hearing loss probably it could be due to the lower age group selected. KureinMet al[10] included only patients less than 50 years. Age is a confounding factor for hearing loss, but in diabetics as duration of diabetes increases the decreasing in hearing is more rapid.

5. BMI (Table 9. Graph 6)

Study done by Curhan SG[17] and Fransen[18] showed positive correlation between high BMI and hearing loss. This study did not show any positive correlation between higher BMI and hearing loss and diabetic subjects.

6. Blood Sugar Control: (Table 10,11,12. Graph 7,8,9)

Acute control of blood sugar can be assessed with the help of FBS and RBS. Both are highly variable, majority of the patients if they are told that their blood sugars will be checked tend to follow a strict diabetic diet and take their medication correctly. To avoid these variable patients HbA1c was also evaluated at the same time. HbA1c indicates control of blood sugars in the past 3 months.

In this study we did not find a significant correlation between FBS and RBS and hearing loss but there there was a trend towards significant correlation HbA1c with hearing

loss. Similar results were seen in study done by Asma. A et al[19]. However KurienMet al[10] 1989, Cullen R, et al[11] and Tay HL[12]concluded that good control of diabetics reduces the incidence of sensorineural hearing loss.

Fangcha MA, et al[13] concludedinsulin use reduces incidence of hearing loss but Asma. A et al[16] concluded that strict glycemic control or intensive insulin use for a short term did not affect hearing.

7. Serum Creatinine: (Table 13,14,15. Graph 10,11,12)

Our study did not show any significant correlation to hearing loss. Kakarlapudi et al advocates the association of SNHL with worsening serum creatinine in diabetic patients which was attributed to microvascular disease. Our study was of smaller sample size compared to Kakarlapudi et al and also we did not have many patients whose serum creatinine was greater than 3 mg/dl.

Hearing loss in patients with chronic kidney disease was seen in study done by Gatland. G et al.[20]

8. Hypertension and Hearing Loss in Patients with Diabetes Mellitus. (Table 16. Graph 13)

Hypertension is not a confounding factor for hearing loss. On comparing hypertensive diabetic patients compared to diabetic patients without hypertension we can conclude that hypertension was not a risk factor for hearing loss in diabetic subjects. Controls with hypertension did not have a greater incidence of hearing loss as compared to rest of the control group.

Duck SW et al[21] says hypertension in conjunction with insulin-dependent diabetes mellitus causes sensorineural hearing loss.

CONCLUSION

- Sensorineural hearing loss is seen in diabetes mellitus which is gradually progressive and threshold for hearing was greater for higher frequency.
- Age is confounding factor but diabetes mellitus alone is responsible for hearing loss.
- As the duration of diabetes mellitus increases the possibility of patient sensorineural hearing being affected also increases.
- 10 subjects out of the total 45 diabetics with hearing loss reported hearing loss on direct questioning before audiometry.
- Body mass index has negligible effect in hearing loss.
- FBS, RBS and have negligible effect SNHL.
- HbA1c has a trend towards SNHL.
- Serum creatinine has negligible effect in SNHL.
- Hypertension is not a confounding factor for hearing loss. Hypertension in diabetic patients or hypertension alone does not cause hearing loss.

Limitations of Study

1. Small sample size
2. Cases are not classified as Type 1 DM or Type 2 DM by islet cell antibodies like GAD 65 due to cost constraints.

SUMMARY

India has the maximum number of diabetic subjects earning the dubious distinction of being termed the "diabetes capital of the world". Among the various complications hearing loss is the least studied. Standard text book of diabetes doesn't mention whether diabetes mellitus causes hearing loss or not. Whereas just list hearing loss as other complications of hearing loss.

The objective of the study was to assess hearing loss in subjects with diabetes mellitus by clinical and audiometric examination, study type of hearing loss in diabetes mellitus, study audiometric pattern of hearing loss in diabetes mellitus.

57 cases and 50 controls were analyzed for hearing loss. Prospective, comparative, purposive sampling study design was conducted. Detail history, cranial nervous system and ear examination was done. Patient was investigated with FBS, RBS, HbA1c, serum creatinine and pure tone audiometry.

At the start of the research we had a research question.

Are Diabetics More Prone to Hearing Loss When Compared to Their Non-Diabetic Counterparts?

We concluded that diabetics are more prone to hearing loss as compared to their non- diabetic counterparts.

Age is confounding factor but diabetes mellitus alone is responsible for hearing loss. As the duration of diabetes mellitus increases the possibility of patient sensorineural hearing being affected also increases. But short term sugar control and serum creatinine had no correlation with hearing loss. All the patients had gradual hearing loss and were sensourineural type. Threshold for hearing was greater for higher frequency.

Based on this study we could recommend following points to physicians

1. Screen all newly diagnosed diabetic patients with pure tone audiometry.
2. Annually pure tone audiometry to be done routinely even if patient does not report hearing deficit.

3. Hearing aid to be advised before hearing loss becomes severe grade.
4. Early diagnosis and prompt treatment will improve the quality of life of the patient.

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