

A Prospective Study of Auditory Functions in Patients Undergoing Dialysis

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ABSTRACT

Introduction

Hearing loss, as a side effect of chronic renal failure (CRF), is ignored though the incidence of sensorineural hearing loss (SNHL) among CRF patients is considerably higher than in general population. The present study was conducted in this context as an attempt (i) To find out the occurrence of SNHL viz-a-viz severity of hearing impairment in CRF patients undergoing hemodialysis. (ii) To assess HL at different frequencies in CRF patients. (iii) To study correlation between severity of HL and demographic features. (iv) To assess the factors affecting HL in CRF patients.

Materials and Methods

190 patients (age 15-70 years) who underwent hemodialysis were subjected to audiological evaluation with pure tone audiometry and impedance audiometry.

Results & Conclusion

Hearing loss has been studied in 190 CRF patients with prevalence of 61.5%. High frequency hearing loss (HL) was detected in CRF patients and only few patients had SNHL at lower frequencies. Duration of disease in CRF patients was not related to HL and there was no significant correlation between SNHL and gender; however, there was a positive correlation of SNHL with (i) stage of disease ($p = 0.016$), and (ii) age of patient ($p = 0.003$). Further, raised blood urea and serum creatinine levels couldn't predict occurrence of SNHL. Furthermore, there was no significant correlation between magnitude of HL and duration of hemodialysis and, therefore, dialysis treatment by itself doesn't alter hearing.

Conclusion

SNHL is common among CRF patients undergoing hemodialysis hence auditory screening using pure tone audiometry should be done routinely.

Keywords

Chronic Kidney Disease (CKD); Chronic Renal Failure (CRF); Hemodialysis (HD); Pure Tone Audiometry (PTA); Impedance Audiometry; Sensorineural Hearing Loss (SNHL); Blood Urea Nitrogen (BUN)

With recent advents in the field of medicine, treatment of chronic renal failure patients has changed the outcome to great extent. Morbidities have started surfacing as longevity of patients and control of renal ailments has improved. In spite of advances in treatment of CKD including hemodialysis, impairment in hearing is still a major concern in this patient. The incidence of SNHL among CRF patients is considerably higher (prevalence of 20-40%) than in general population. Various studies show that the incidence of HL in patients with CRF undergoing dialysis is within the range of 20-75% (Bazzi et al and Sahin and Varim),^{1,2} 20-80% (Krishnan and Ranjit),³ 46% (Ozturan and Lam)⁴ and 40% (Bergstrom et al).⁵ There are several potential factors that have been postulated in literature to contribute to the pathogenesis of HL in CKD patients. It is in this

backdrop the current research project was done to ascertain the adverse impact that dialysis causes on hearing capacity of humans.

This present study was, therefore, carried out with following objectives:

- (i) To find out the occurrence of SNHL viz-a-viz severity

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- of hearing impairment in CRF patients undergoing hemodialysis.
- (ii) To assess HL at different frequencies in CRF patients.
 - (iii) To study correlation between severity of HL and demographic features.
 - (iv) To assess the factors affecting HL in CRF patients.

Materials and Methods

This is a hospital based cross-sectional study done in a multi-specialty hospital in Vijayapura (Karnataka) during the period September 2016 - October 2018. 190 subjects with chronic renal failure (CRF) undergoing hemodialysis were assessed for audiological evaluation through otological work up which included:

- (i) Otoscopy (visualization of auditory canal and tympanic membrane)
- (ii) Pure tone audiometry
- (iii) Impedance audiometry
- (iv) Biochemical tests (Renal Function Test). Patients on aminoglycosides were not considered for the study.

Subjects with perforation of tympanic membrane, tympanosclerosis and otosclerosis were not included in the research study after otoscopic examination. Subjects (patients) were classified into:

- (i) Three age groups (15-30, 31-50 and 51-70 years)
- (ii) Duration of disease in three groups (<2 years, 2.1 - 4 years and >4 years), and
- (iii) Hemodialysis in two groups (≤ 2 years and > 2 years).

Informed consent was obtained from all individual participants included in the study. All procedures performed in this study were in accordance with the ethical standards of the institution and Ethical approval was taken from the Institutional Ethical Committee for the purpose of the study.

HL was comparatively studied with the above mentioned variables. Hearing impairment was classified according to pure tone average taken in WHO classification as:

- (i) mild (26-40 db),

- (ii) moderate (41-60 db),
- (iii) severe (61-80 db),
- (iv) profound (> 81 db)⁶

Hearing loss was also divided, according to frequency into (i) low, (ii) mid and (iii) high frequencies.

Results

Demographic profile of patients: During the study period of two years, a total of 190 patients, subjected to dialysis, were assessed for hearing impairment. The demographic characteristics of the subjects are depicted in Table I.

Table I: Age and sex distribution of patients undergoing hemodialysis

AGE (YEARS)	TOTAL NUMBER (%)	MALE	FEMALE
15-30	40 (21.05)	28 (21.05)	12 (21.05)
31-50	80 (42.10)	56 (42.10)	24 (42.10)
51-70	70 (36.85)	49 (36.04)	21 (36.84)
Total	190 (100)	133 (100)	57 (100)

The study, on a total of 190 patients treated with hemodialysis, included 133 males (70%) and 57 females (30%). Though the age range of patients was 15-70 years, yet the entire patient population was classified into three age groups: (i) 15-30 years (40), (ii) 31-50 years (70) and (iii) 51-70 years (80).

Before undergoing hemodialysis, the diastolic BP of patients was between 90-110 mm Hg (mean 103.6). The study group was consuming diuretic (Furosemide) on everyday basis in the range of 40-200 mg (average 102.42 mg).

Prevalence of SNHL among CRF patients undergoing Hemodialysis: Hearing loss (HL) is considered as average pure tone threshold > 26 db for measurement of pure tone average at frequencies of 0.5, 1.0 and 2.0 kHz.⁶ Out of 190 patients undergoing dialysis 120 (61.57%)

patients had SNHL and it was absent in 70 (38.43%) patients.

Sensorineural hearing loss at different frequencies: Hearing impairment at speech frequency was registered in 17% patients (10% bilateral and 7% unilateral) while

at 4000 Hz it was observed in 53.5 % individuals (47.5% bilateral and 6% unilateral). Still further, at 8000 Hz frequency SNHL was recorded in 63.1% (60.1% bilateral and 3% unilateral) patients (Table II).

Table II : SNHL in CRF patients undergoing hemodialysis at different frequencies.

FREQUENCIES (HZ)	BILATERAL (%)	UNILATERAL (%)	TOTAL (%)
500-2000	10.0	7.0	17.0
4000	47.5	6.0	53.5
8000	60.1	3.0	63.1

Table III : Sensorineural hearing loss and duration of illness ($\chi^2 = 2.25$, $p = 0.324$)

DURATION OF ILLNESS (YEARS)	HEARING LOSS				TOTAL	
	ABSENT		PRESENT			
	N	%	N	%	N	%
<2 years	37	44.7	44	55.0	81	100
2.1-4.0 years	22	30.1	48	70.0	70	100
>4 years	11	28.0	28	72.2	39	100
Total	70	36.0	120	64.0	190	100

N= Number of patients

As far as degree of SNHL among different frequencies is concerned, at 4000 Hz frequency mild degree of HL was recorded in 46% against the moderate HL in 6.5% subjects while moderately severe in 10 % subjects. SNHL was further recorded at high frequency of 8000 Hz in 63.1% patients, among which 50% patients had mild degree of SNHL while 12.6 % patients were found to have moderate SNHL, as against 0.5 % patients having moderately severe SNHL. Thus, HL at 8000Hz was noticeable in 114 patients bilaterally (228 ears) and 6 patients (6 ears) unilaterally. To sum up, HL was registered in 120 patients (234 ears out of 380 ears) making

an overall SNHL 61.57%. The inference from these results depicts that maximum number of patients undergoing hemodialysis had sensorineural hearing loss (SNHL) at high frequencies and only few patients had SNHL at lower frequencies i.e., 8000 Hz > 4000 Hz > 2000 Hz > 1000 Hz > 500 Hz.

Thus, as per the frequencies hearing loss is further classified into:

- (i) Low frequency hearing loss (250-500Hz)
- (ii) Mid frequency hearing loss (1000-2000 Hz)
- (iii) High frequency hearing loss (4000-8000 Hz)

SNHL and duration of illness: On the basis of duration of disease, SNHL was present in 44 (55.3%) and absent in 37 (44.7%) patients who had disease for <2 years of duration and were subjected to hemodialysis. Between 2-4 years duration 48 (70%) patients had SNHL and 22 (30.1%) were normal. More than 4 years duration 28(72.2%) patients had SNHL and 11 (28%) were normal. These results indicate that maximum number of CRF patients undergoing dialysis had disease for more than 4 years of duration. Relation between duration of illness and SNHL is depicted in Table III. No association was found between SNHL and disease duration (p value = 0.324).

Tympanometry curve distribution among dialysis patients: A type curve is seen in 90.5% on tympanometry, A_s typecurve in 3% and A_d curve in 6.5% on right side

while A type curve in 86%, A_s curve in 8% and A_d curve in 6.0% on left side (Table IV). Reflexes were not present in 66.5 %, present in 26% and elevated in 7.5% of subjects ipsilaterally and contralaterally in both ears (Table V). No statistically significant correlation was found between tympanometry findings and disease duration, blood variables and hemodialysis.

Table IV : Tympanometry curve among dialysis patients

TYMPANOMETRY	RIGHT (%)	LEFT (%)
A	90.5	86.0
A _s	3.0	8.0
A _d	6.5	6.0

Table V : Acoustic reflexes among dialysis patients

EAR	REFLEXES	IPSILATERAL	CONTRALATERAL
Right	Present	26.0	26.0
	Absent	66.5	66.5
	Elevated	7.5	7.5
Left	Present	26.0	26.5
	Absent	66.5	66.5
	Elevated	7.5	7.5

Table VI : Age related to SNHL ($\chi^2 = 8.729$, $p = 0.003$)

DURATION OF ILLNESS (YEARS)	HEARING LOSS				TOTAL	
	ABSENT		PRESENT			
	N	%	N	%	N	%
≤ 50 years	51	42.5	69	57.5	120	100
> 50 years	19	27.14	51	72.9	70	100
Total	70	36	120	64	190	100

N = Number of patients

Factors affecting SNHL in CRF patients undergoing hemodialysis:

Though the age range of patients (15-70 years) was initially classified into three groups, yet in view of the less prevalence and severity of the disease in young populations, the patient age was classified into 2 groups, ≤ 50 years and > 50 years for assessing SNHL. A perusal of the data shows that patient, ≤ 50 years consisted a total of 120 patients of which 69 (57.5%) patients had SNHL and 51 (42.5%) did not have hearing loss. Patients > 50 years of age comprised of a total of 70 patients of which 51 (72.9%) had SNHL while it was absent in 19 (27.1%) patients. Relation between age and SNHL is shown in table 6. There is statistically significant correlation between age and SNHL (p value = 0.003).

As ageing is a major risk factor for hearing impairment

even in healthy adults, the trend was more predominant in 65years and above. However, our study group comprised mostly of people who were lesser than 65 years.

In total 37 CRF patients were under stage 2 disease of which 13 (35.3%) had SNHL and 24 (64.7%) did not have hearing loss. In stage 3, there were a total of 39 patients of which 23 (61%) had SNHL and 16 (39%) were devoid of any SNHL. In stages 4 and 5 there were a total of 59 and 55 patients respectively among which 55 (87.5%) in stage 4 and 29 (52.7%) in stage 5 had SNHL, while 4 (12.5%) patients in stage 4 and 26 (47.3%) in stage 5 were not diagnosed to have SNHL. Relation between sensorineural hearing loss is presented in table VII. There is statistically significant association between the stage of disease (CKD) and sensorineural hearing loss (p value =0.016).

Table VII : Hearing loss and stage of disease

STAGE OF DISEASE	HEARING LOSS				TOTAL	
	ABSENT		PRESENT		N	%
	N	%	N	%		
2	24	64.7	13	35.3	37	100
3	16	39.0	23	61.0	39	100
4	4	12.5	55	87.5	59	100
5	26	47.3	29	52.7	55	100
Total	70	36.0	120	64.0	190	100

N = Number of patients

There is a statistically no significant relation between the levels of hemodialysis (p =0.727), serum urea (p=0.480), serum creatinine (p=0.945), serum potassium (p= 0.970),

serum sodium (p=0.555), serum chloride (p=0.960), serum calcium (p=0.069) and serum phosphorus (p=0.852) with SNHL. Relation between laboratory values and SNHL shown in Table VIII.

Table VIII : Blood parameters of CRF patients undergoing dialysis and their effect on SNHL

S. NO.	BLOOD PARAMETERS EFFECTS	HEARING LOSS				P VALUE
		ABSENT (N = 70)		PRESENT (N = 120)		
		MEAN	SD (I)	MEAN	SD (I)	
1	Hemoglobin (Hb)	8.90	2.346	9.06	1.850	0.727
2	Blood urea	95.50	39.510	102.30	35.920	0.480
3	Serum creatinine	7.18	3.719	7.12	3.267	0.945
4	Serum	5.18	0.930	5.17	0.857	0.970
5	Serum Sodium	133.40	6.822	134.56	7.725	0.555
6	Serum chloride	102.91	6.400	102.01	6.631	0.960
7	Serum calcium	8.456	1.150	8.92	1.104	0.069
8	Serum phosphorus	5.080	1.641	5.02	1.279	0.852

Though HL in CKD patients had a significant relation with age of the patient and stage of the disease, yet there is no significant correlation between SNHL and sex, GFR ($p=0.2$) and diastolic blood pressure ($p=0.3$).

Subjects undergoing dialysis were classified in accordance to the duration of dialysis into 2 groups: (i) ≤ 2 years and (ii) >2 years. Out of 190 patients subjected to dialysis, 90

(47.36%) patients had a duration of dialysis less than 2 years and 100 (52.64%) patients were treated for more than 2 years. Out of 90 patients and ≤ 2 years duration HL was found in 50 patients and 40 patients did not show any HL. In 100 patients with hemodialysis >2 years, SNHL was detected in 70 patients and 30 had normal hearing (Table IX).

Table IX : Duration of dialysis and prevalence of hearing loss

DIALYSIS DURATION	HEARINGLOSS				TOTAL	
	ABSENT		PRESENT		N	%
	N	%	N	%		
≤ 2 yr	40	44.4	50	55.5	90	100
2 yr	30	30.0	70	70.0	100	100
Total	70	37.0	120	62.7	190	100

N = Number of patients

Though all 190 patients underwent hemodialysis, yet there was no significant correlation between SNHL severity and dialysis duration and therefore, treatment by itself does not alter hearing.

Discussion

Hearing loss as being sensorineural (SNHL) is reported in studies evaluating the effect of renal dysfunction on hearing capacity. In the present study out of 190 patients with chronic renal failure (CRF), the prevalence of SNHL was noted only in 61.57% patients. These results were supported by studies carried out by Ali Asgar Peyandi et al⁷ who found 46% end stage renal disease (ESRD) patients had SNHL and Gaur et al⁸ showing an overall prevalence of SNHL to be 73.07%. In other studies, the incidence of SNHL in CRF patients on regular hemodialysis ranges from 20-75%,⁷ 20-80%,³ 75%,⁹ 46%,⁷ and 40%.⁵ Impairment of hearing has been reported more than vestibular dysfunction. Thus, Kusakari et al¹⁰ found that 60% of 229 patients on hemodialysis had hearing loss, 36% had vestibular dysfunction and 26% had a combination of both. In the present study, SNHL was noted maximum at high frequencies, followed by mid and low frequencies in a decreasing order. Same pattern of SNHL was observed in a prospective study conducted by Sredharan et al¹¹ in 25 CRF patients, 18% had SNHL at low frequencies, 32% had SNHL at mid frequencies and the remaining of them had at high frequencies. In the present study, a higher frequency hearing loss was noted in 53.5 – 63.1% patients. Almost similar results were obtained by Ozturan and Lam,⁴ and Johnson and Mathog.¹² Though past studies have revealed correlations between duration of the disease, blood parameters and hearing, yet Henrich et al¹³ concluded that SNHL is common in renal failure but it does not deteriorate with continuation of treatment. In the present study, SNHL was present in 44 (55.3%) and absent in 37 (44.7%) patients who had a disease for less than 2 years duration. In patients with duration of disease between 2 and 4 years, 48 (70%) patients had SNHL and 22 (30.1%) patients were normal. In case of duration of disease more than 4 years, 28 (72.2%) patients had SNHL and 11(28%) were normal.

These results indicate that maximum percentage of SNHL occurred in CRF patients who had a disease of more than 4 years duration. However, no statistically significant correlation was detected between duration of illness and SNHL in the present investigation, a fact well corroborated by the studied of Jamaldeen et al¹⁴ and Krishnan and Ranjit.³ Contrarily, Raad Aboud Aloubad et al¹⁵ and Lasisi et al¹⁶ found a positive correlation between duration of illness and CRF. As far the age of the patient is concerned there is statistically significant correlation between age and SNHL (p value = 0.003). The present investigation gains further support from the earlier studies of Raad Aboud Aloubad et al.¹⁵ Prevalence and degree of hearing loss were higher in aged population; however, this trend was more noticeable in 65 years old and above study group while our study included patients who were mostly young. A perusal of data in table 5 revealed that there is a statistically significant correlation between stage of disease and SNHL (0.016), a fact well supported by Pandey et al¹⁷ and Krishnan and Ranjit.³

Though there are divergent views regarding the role of blood parameters of CKD patients undergoing hemodialysis with SNHL, yet, in consonance with the earlier studies of Samir et al,¹⁸ and Kusakari et al¹⁰ and Johnson et al,¹⁹ in the present investigation also no statistically significant correlation was found between the blood parameters like levels of hemoglobin, serum blood urea, serum creatinine, serum potassium, serum sodium, serum calcium, serum chloride and serum phosphorus with SNHL. Still contrasting views regarding blood parameters vis- a- vis have been presented by different authors (Brookes,²⁰ Alder et al,²¹ Sahin and Varim² and Sreedharan et al.¹¹

The exact role of hemodialysis on HL is unclear but various studies have shown that it is associated with hearing loss. According to authors like Somashekara et al²² high frequency HL seen in CRF patients is related to duration of disease, duration of hemodialysis and internal hemostasis through levels of serum electrolytes and nitrogenous products of metabolism (uremic nephropathy). This view gains further support from the earlier studies of Sahin and Varim² and Bazzi et al¹ who concluded that HL was higher in CRF patients undergoing hemodialysis

for over 10 years. However, Tyler and Tyler²³ suggested that regular dialysis treatment does not seem to effect HL for at least the first five years of treatment. In a noteworthy study contrasting opinion was created by Jamaldeen et al,¹³ who inferred that hemodialysis sessions were inversely proportional to hearing loss but not with duration of disease, suggesting beneficial association between increasing number of dialysis sessions and SNHL.¹⁴ Conversely, duration of disease has no relation with HL in CKD patients on hemodialysis, a fact well supported by our studies also. However, hemodialysis may have an ameliorative effect on HL in CRF patients. The above authors further advocated the beneficial role of hemodialysis vis -a- vis. HL in CKD patients since it tends to bring down the risks of HL as it increases the stabilization and correction of metabolic changes caused by CRF. Hence, appropriate treatment of CKD has to be started at the earliest in order to stop damage to organs (like dysfunction of auditory pathway and inner ear).²⁴

Conclusion

Over a period of time, CRF patients undergo changes in their metabolic variables and hemodynamic status. We can't pinpoint the definite cause responsible for hearing loss in these patients. The raised blood urea and serum creatinine levels do not predict the occurrence of the SNHL. Further, our study revealed that there was no significant correlation between hearing loss severity and hemodialysis duration and therefore, hemodialysis treatment by itself does not alter hearing. It is also inferred that though hemodialysis is not a causative factor for SNHL but there is relationship between SNHL and CRF in high frequencies. Thus, hemodialysis presumably may have an ameliorative effect on hearing loss in CKD patients.

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