To Study the Effect of Chronic Kidney Disease on Hearing Function of the Patients in a Tertiary Care Centre of North India

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ABSTRACT

BACKGROUND

Chronic kidney disease (CKD) encloses a continuum of pathophysiological processes associated with deranged kidney function and a progressive decrease in glomerular filtration rate (GFR). There are many anatomic similitudes between cochlea and kidney at an ultra-structural level and antigenic level along with comparable physiological mechanisms, specifically, the active fluid and electrolytes transport in the cochlea and the kidney. The purpose of the present study was to determine the proportion, type and degree of hearing loss in patients with renal disease and its comparison according to the stage of CKD.

METHODS

The study was conducted on 60 patients of chronic kidney disease labelled as stage 3, 4 and 5 on the basis of GFR. An audiogram charted by pure tone audiometry was used to find the degree of hearing loss and its comparison in patients with moderate, severe and end stage CKD was done. The data was collected and analysed statistically.

RESULTS

The mean age of patients was 55.58 +/- 11.36 years and the mean duration of CKD was 15.61 months. 90 % patients of CKD had sensorineural hearing loss while 10 % had hearing sensitivity within normal limits. In the present study, mild degree hearing loss and high frequency hearing loss was found to be predominant constituting 68.3 % (n = 41) and 58.3 % (n = 35) respectively. Mild degree of hearing loss was a predominant finding irrespective of the stage and duration of CKD.

CONCLUSIONS

Sensorineural hearing loss was found predominantly amongst the CKD patients in our study population. Mild degree hearing loss was predominant but there was no correlation between stage of CKD and degree of hearing loss. While there was a significant correlation between degree of hearing loss with duration and haemodialysis amongst the non-diabetic CKD patients.

KEYWORDS

Chronic Kidney Disease, Sensorineural Hearing Loss

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BACKGROUND

Chronic kidney disease is a collective term covering a number of primary disease processes that results in structural or functional kidney abnormalities, or both persisting for at least 3 months.[1] Diabetic nephropathy, glomerulonephritis, hypertension associated CKD, autosomal dominant polycystic kidney disease and other cystic and tubulointerstitial nephropathy are one of the leading causes of CKD.[2] The prevalence of chronic kidney disease has increased substantially in the past few years due to the huge rise in the number of people suffering from diabetes mellitus and systemic hypertension which are major risk factors for CKD.[3] About 10 % of the world's population is affected by various forms of kidney disease making it a global public health challenge.[4] The incidence of end stage renal disease (ESRD) in India is around 229 per million population, and more than one lakh new patients undergo renal replacement programmes annually in India.[5,6] Chronic renal failure (CRF) affects many organs. The complications of CRF are due to the disease or effects of medications used for its treatment. Accumulation of uremic toxins and prolonged haemodialysis will affect almost every tissue, including auditory system.[7]

Each kidney comprises about a million functional nephrons responsible for filtering blood plasma. About 1200 ml of blood enters the kidneys every minute and is filtered of materials such as wastes, drugs, excess water and ions. Via this process of urine formation, the kidneys regulate the blood's pH by excreting H+ and conserving HCO3 -, also the levels of ions like sodium, potassium, calcium, chloride and phosphate. The kidneys also maintain blood volume by either conserving or excreting water. Disruption in the kidneys' function therefore leads to imbalance of electrolytes and accumulation of these waste substances in the blood. This subsequently causes damage to tissues and organ systems.[8] Hence, chronic renal failure affects many organs. The complications of CRF are due to the disease or effects of medications used for its treatment. Accumulation of uremic toxins and prolonged haemodialysis will affect almost every tissue, including auditory system.

Hearing Loss Can Be of Three Types

Conductive Hearing Loss

It is caused by any disease process interfering with the conduction of sound from the external ear to the stapediovestibular joint.

Sensorineural (SN) Hearing Loss

It results from the lesions of the cochlea (sensory type) or eighth cranial nerve and its central connections (neural type).

Mixed Hearing Loss

In this type, elements of both conductive and sensorineural deafness are present in the same ear.

Hearing of an individual can be tested by clinical and audiometric tests. In conductive hearing loss, audiometry shows bone conduction better than air conduction with air-bone gap. Greater the air-bone gap, more is the conductive loss. In sensorineural hearing loss, there is no gap between air and bone conduction curve on audiometry.[9]

Although there is a significant difference in gross anatomy of kidney and cochlea but many similarities exist between the stria vascularis of the cochlea of the inner ear and the renal nephron. They may have a common antigenicity. The nephron and the stria vascularis of the cochlea have epithelial structures and a vascular supply that are in close contact. Both epithelial structures have enzymatic systems that depend on Na+/K+ adenosine triphosphatases and have carbonic anhydrase.[10] In addition to antigenic similarity, the cochlea and kidney have similar physiological mechanisms, namely, the active transport of fluid and electrolytes achieved by the stria vascularis in the cochlea and the glomeruli in the kidney.[11,12] The inner ear is a complex system that is dependent on homeostasis of water and electrolytes. Defect in cationic gradient of endolymphatic fluid will alter hearing properties. Endolymphatic hydrops is another mechanism of hearing loss in CRF.[13] Moreover, in patients with established CKD, multiple risk factors have been hypothesized to cause hearing loss including the use of ototoxic medications, hypertension and diabetes, particularly in association with hypertension, electrolyte disturbances, and haemodialysis itself.[14-16]

Sensory neural hearing loss is common among CRF patients. Hearing loss can affect quality of life and restrict participation in activities of daily living. Early identification can prevent further deterioration of hearing and improve the quality of life in patients suffering from chronic renal failure.

Aims and Objectives

1. To assess hearing loss in CKD patients.
2. To assess the degree and type of hearing loss with the severity of CKD.

METHODS

Stage	Definition	Description	Prevalence	Clinical Presentation
1	Kidney damage with normal or high GFR > 90	Mild CKD	6.5 %	Asymptomatic
2	Kidney damage and GFR 60 - 90			
3 A	GFR 45 - 59	Moderate CKD	4.5 %	Usually asymptomatic anaemia in some patients at 3B Most are non-progressive or progress very slowly
3 B	GFR 30 - 44			
4	GFR 15 - 29	Severe CKD	0.4 %	First symptoms often at GFR < 20 Electrolyte problems likely as GFR falls
5	GFR < 15 or on dialysis	Kidney failure		Significant symptoms and complications usually present Dialysis initiation varies but usually at GFR < 10

Table 1. Staging of CKD Calculated by Cockcroft Gault Formula

This study was an observational, cross sectional study conducted on 60 diagnosed patients of CKD aged 18 - 70 years visiting OPD/indoor/emergency of SGRDIMSR, Vallah, Sri Amritsar. The study was carried out on patients from 1st January 2019 to 31st December 2020 after approval from hospital ethical committee and informed consent was obtained from the patients or their relatives.

CKD was labelled on the basis of GFR which was calculated by Cockcroft-Gault formula where CrCl (ml/min) = (140-age in years) × weight in kg × (0.85 if female) ÷ (72 × serum creatinine in mg/dl).[17]

Patients of CKD were subjected to detailed general examination and systemic evaluation. Following laboratory parameters were obtained as a part of routine investigations – Complete blood count (CBC), renal function test (RFT), serum electrolytes (Na^+, K^+), calcium, phosphorus, liver function test (LFTs), urine complete, UACR (urinary albumin creatinine ratio), HbA1C, random blood sugar (RBS), electrocardiogram (ECG), ultrasonography (USG) abdomen.

Patients were also subjected to audiometric assessment wherein pure tone audiometry was done using 'AD1629 by interacoustics audiometer. Patient was seated in a 40 dB A (SLM meter calibrated) room with headphones. Air conduction thresholds were measured for tones of 250, 500, 1000, 2000, 4000 and 8000Hz and bone conduction thresholds for 250, 500, 1000, 2000 and 4000 Hz. Pure tones were delivered, the intensity of which was increased by 10 dB or decreased by 5 dB starting with the better ear. As per response of the patient via hand raising on each heard tone, audiogram was made where right ear was represented by red and left ear by blue colour. Masking was done by employing narrow-band noise to the non-test ear while testing for both air conduction and bone conduction.

Mild	26 - 40 dB
Moderate	41 - 55 dB
Moderately severe	56 - 70 dB
Severe	71 - 91 dB
Profound	More than 91 dB

Table 2. Degree of Hearing Loss was Assessed as per WHO Classification

Patients of chronic kidney disease of any aetiology aged 18 - 70 years were included in the study. Patients with ear trauma, intake of ototoxic drugs, history of otologic diseases, chronic noise exposure, family history of hearing loss and patients above 70 years of age (presbycusis) were excluded from the study.

Statistical Analysis

1. This study enrolled 60 patients.
2. Sample size was calculated at 95 % confidence limit.

The results obtained from the study were statistically analysed using Statistical Package for Social Sciences (SPSS Statistics-20.0 version). The observations were tabulated as frequency, percentage and mean ± SD. Association among different variables were calculated using chi-square test. Results were considered significant if P value obtained was below 0.05 and highly significant if it was below 0.001.

RESULTS

Most patients were in the age group of 61 - 70 years while the mean age of patients was 55.58 +/- 11.36 years. In the present study, 48.3 % were males and 51.7 % were females. Most of the patients were of stage 5 CKD constituting 65 % (n = 39) in our study group followed by stage 4, stage 3B and stage 3A constituting 23.3 %, 6.7 % and 5 % respectively. 41.7 % patients had history of diabetes and 58.3 % were non-diabetics in our study group. Majority of patients had 7 - 12 months duration of CKD constituting 36.7 % of the study population with mean duration of CKD being 15.61 months. Majority of patients didn't undergo any session of haemodialysis constituting 56.7 % while 43.3 % underwent haemodialysis.

Sensorineural hearing loss was present in 90 % (n = 54) patients while 10 % (n = 6) had hearing sensitivity within normal limits as shown in Table 3.

Hearing Loss	Number of Ears (n = 120)	Percentage (%)
None	12	10
SNHL	108	90
Conductive HL	0	0
Total	**120**	**100**

Table 3. Distribution According to the Type of Hearing Loss

Majority of the patients had mild degree of hearing loss constituting 68.3 % (n = 41) followed by 11.7 % having none, 8.3 % having moderate, 5.8 % having moderate to severe, 3.3 % having severe and 2.6 % having profound degree of hearing loss as shown in Table 4.

Degree of Hearing Loss	Number of Ears (n = 120)	Percentage (%)
None	14	11.7
Mild	82	68.3
Moderate	10	8.3
Mod-severe	7	5.8
Severe	4	3.3
Profound	3	2.6
Total	**120**	**100**

Table 4. Distribution According to the Degree of Hearing Loss

*mild= 26-40 dB, moderate= 41-55 dB, mod-severe= 56-70 dB, severe= 71-91 dB, profound= more than 91 dB

In the present study, mild degree of hearing loss was found predominant. It was present in 100 % ears in patients of stage 3A CKD, 50 % in stage 3B, 68.8 % and 76.9 % in stage 4 and 5 respectively. No hearing loss was found in 33.3 % ears in patients of stage 3B and 12.5% of stage 4. Moderate intensity hearing loss was found in 18.8 %, 16.7 % and 7.7 % ears of stage 4, 3B and 5 respectively. 3.8 % had moderate to severe and 11.5 % had severe hearing loss in stage 5. The P value was 0.352, which is not significant. Mild degree of hearing loss was found predominant even amongst the non-diabetic study population. It was present in 100 % ears in patients of stage 3A CKD, 50 % in stage 3B, 83.3 % and 59.6 % in stage 4 and 5 respectively. No hearing loss was found in 19.2 % ears of patients of stage 5. Moderate intensity hearing loss was found in 7.7 % in stage 5 while 50 % of patients of stage 3B, 16.7 % patients

of stage 4 and 5.8 % of stage 5 showed moderate to severe hearing loss. 5.8 % and 1.9 % ears of stage 5 patients had profound and severe hearing loss respectively. The P value was 0.554, which is not significant.

In the present study, out of 26 patients in haemodialysis group, majority had mild hearing loss constituting 76.9 % followed by 7.7 % having moderate followed by 15.4 % having no hearing loss. While in non-haemodialysis group, mild hearing loss was present in 66.7 % followed by 16.7 % having moderate hearing loss, 12.5 % showed severe hearing loss and 4.2 % showed moderate to severe hearing loss. The P value is 0.060 and hence non-significant. Among the non-diabetics, out of 26 patients in haemodialysis group majority had mild hearing loss constituting 76.2 % followed by 19 % having no hearing loss and 4.8 % had moderate hearing loss. In non-haemodialysis group, mild hearing loss was present in 50 % followed by 21.4 % having moderate hearing loss, 10.7 % had profound hearing loss, 7.1 % had moderate and no hearing loss each and 3.6 % had severe hearing loss as shown. The P value is 0.002 and hence significant as shown in Table 5.

	Degree of Hearing Loss													P Value
HD	None		Mild		Moderate		Mod-Severe		Severe		Profound		Total	0.002 Significant
	N	%	N	%	N	%	N	%	N	%	N	%	N	
HD-Yes	8	19 %	32	76.2 %	2	4.8 %	0	0 %	0	0 %	0	0 %	42	
HD-No	2	7.1 %	14	50 %	2	7.1 %	6	21.4 %	1	3.6 %	3	10.7 %	28	
Total	**10**	**14.3 %**	**46**	**65.7 %**	**4**	**5.7 %**	**6**	**8.6 %**	**1**	**1.4 %**	**3**	**4.3 %**	**70**	

Table 5. Correlation of Degree of Hearing Loss with Haemodialysis among Non-Diabetics

In the present study, out of 50 diabetics, 72 % had mild degree of hearing loss followed by moderate hearing loss in 12 %, no hearing loss in 8 %, severe hearing loss in 6 % and mod-severe hearing loss in 2 %. Amongst the non diabetics, 65.7 % had mild degree of hearing loss, followed by no hearing loss in 14.3 %, mod-severe hearing loss in 8.6 %, moderate hearing loss in 5.7 %, profound hearing loss in 4.3 % and severe hearing loss in 1.4 %. The P value is 0.123 and hence not significant as shown in Table 6.

	Degree of Hearing Loss													P Value
	None		Mild		Moderate		Mod-Severe		Severe		Profound		Total	0.123 Not Significant
	N	%	N	%	N	%	N	%	N	%	N	%	N	
Diabetics	4	8 %	36	2 %	4	12 %	1	2 %	3	6 %	3	0 %	50	
Non-Diabetics	10	14.3 %	46	65.7 %	6	5.7 %	6	8.6 %	1	1.4%	0	4.3 %	70	
Total	**14**	**11.7 %**	**82**	**68.3 %**	**10**	**8.3 %**	**7**	**5.8 %**	**4**	**3.3 %**	**3**	**2.5 %**	**120**	

Table 6. Correlation of Degree of Hearing Loss with Diabetic Status

78.6% ears of patients with < = 6 months duration of CKD showed mild hearing loss, 14.3 % showed no hearing loss and 7.1 % showed moderate hearing loss. While 9.1 %, 81.8 % and 9.1 % of patients with 7 - 12 months duration of CKD showed none, mild and moderate hearing loss respectively. In patients with duration of 13 – 24 months of CKD, 20 % showed severe, 10 % showed moderate to severe, 10 % showed moderate and 5 % showed mild hearing loss whereas 10 % had hearing sensitivity within normal limits. In patients with > 24months of duration of CKD, 9.1 % had profound hearing loss, 18.2 % had moderate to severe, while 9.1 % and 63.6 % showed moderate and mild hearing loss respectively. The P value was 0.383, and hence is non-significant. 70 % patients with <= 6 months duration of CKD showed mild hearing loss and 30 % showed no hearing loss. While 13.3 %, 76.7 % and 10 % of patients with 7 - 12 months duration of CKD showed none, mild and moderate hearing loss respectively. In patients with duration of 13 - 24 months of CKD, 10 % showed profound, severe and moderate to severe hearing loss each while 30 % showed moderate and 40 % showed mild hearing loss. In patients with > 24 months of duration of CKD 20 % hearing loss, 30 % had moderate to severe, while 50 % had mild hearing loss. The P value was 0.001, and hence is highly significant as shown in Table 7.

	Degree of Hearing Loss													P Value
Duration (Months)	None		Mild		Moderate		Mod-Severe		Severe		Profound		Total	0.001 (Highly Significant)
	N	%	N	%	N	%	N	%	N	%	N	%	N	
<=6	6	30 %	14	70 %	3	0 %	0	0 %	0	0 %	0	0 %	20	
7-12	4	13.3 %	23	76.7 %	3	10 %	0	0 %	0	0 %	0	0 %	30	
13-24	0	0 %	4	40%	1	10 %	3	30 %	1	10 %	1	10 %	10	
>24	0	0 %	5	50%	0	0 %	3	30 %	0	0 %	2	20 %	10	
Total	**10**	**14.3 %**	**46**	**65.7 %**	**4**	**5.7 %**	**6**	**8.6 %**	**1**	**1.4 %**	**3**	**4.3 %**	**70**	

Table 7. Correlation of Degree of Hearing Loss with Duration of CKD in Non-Diabetics

DISCUSSION

90 % CKD patients had sensorineural hearing loss in our study. This data was found to be in accordance with a study conducted by Balasubramanian et al. in 2018 wherein 80 % of the study population had hearing loss while 20 % had hearing sensitivity within normal limits.[18] In study conducted by da Costa et al. in 2017, hearing loss was present in 53.75 % ears.[19]

In the present study, mild degree hearing loss was found to be predominant constituting 68.3 %, while profound hearing loss was least common constituting 2.6 % of the ears with hearing loss. In a study conducted by Doshad et al. in 2014, the sensorineural hearing loss was mild degree in 64.28 % of patients constituting as majority and moderate degree in 32.14 % and severe degree in 3.57 % of the study population.[20] In 2015, Jamaldeen et al. conducted a study showing mild degree hearing loss in majority of patients constituting 23.3 % followed by moderate degree hearing

loss in 8.3 %, the least common being profound hearing loss constituting 0.8 %.[21] It was found to be in close association with our study.

In the present study mild degree of hearing loss was a predominant finding irrespective of stage of CKD in both diabetics and non-diabetics. Among the diabetics, it was present in 100 % ears in patients of stage 3A CKD, 50 % in stage 3B, 68.8 % and 76.9 % in stage 4 and 5 respectively. Among the non-diabetics, it was present in 100 % ears in patients of stage 3A CKD, 50 % in stage 3B, 83.3 % and 59.6 % in stage 4 and 5 respectively. There was no significant correlation between degree of hearing loss and stage of CKD among diabetics and non-diabetics in our study population. Balasubramanian et al. conducted a study in 2018 wherein prevalence of hearing loss in the 2nd stage was 2%, hearing loss in the 3rd stage was 24 %, the 4th stage was 14 %, and hearing loss in CKD 5th stage was 26 %.[18]

Majority of the patients in the present study had mild degree of hearing loss among both diabetic and non-diabetic study group irrespective of the haemodialysis status. In the diabetic group, out of 26 patients in haemodialysis group, majority had mild hearing loss constituting 76.9 % while in non-haemodialysis group mild hearing loss was present in 66.7 % of the patients. There was no significant correlation between haemodialysis and degree of hearing loss among diabetic population of our study group. Among the non-diabetics, out of 26 patients in haemodialysis group, majority had mild hearing loss constituting 76.2 % while in non-haemodialysis group mild hearing loss was present in 50 % of the patients. There was a significant correlation between haemodialysis and degree of hearing loss among non-diabetics in our study group. A study conducted by Doshad et al. in 2014 the hearing sensitivity of 63 non diabetic patients of CKD on haemodialysis were studied to know the effect of haemodialysis on the threshold for hearing. The hearing loss was of mild degree in majority of patients constituting 64.28 % and moderate degree in 32.14 % and severe degree in 3.57 % of patients. It was found to be consistent with our study.[20] A statistically significant ($P < 0.05$) higher mean duration of CKD and mean duration of sessions of haemodialysis was seen in patients with HL in a study conducted by Somashekara et al. in 2015.[22]

In our study, majority of patients had mild degree of hearing loss irrespective of their diabetic status. Out of 50 diabetics, 72 % had mild degree of hearing loss while amongst the non diabetics, 65.7 % had mild degree of hearing loss. There was no significant difference between diabetics and non diabetics in terms of degree of hearing loss in our study. Thimmasettaiah et al. conducted a study in 2012 showing maximum cases with moderate type of SN deafness in both diabetics and non-diabetics, with higher degree of hearing loss in diabetics.[23] Jankar DS et al. in 2013 showed that hearing loss in diabetics was significantly impaired than the non-diabetic study population.[24] It was not consistent with our study.

In the present study, majority of patients had mild degree of hearing loss irrespective of duration of CKD. 78.6 % of patients with <= 6 months duration of CKD, 71.4 % patients with 7 - 12 months duration of CKD, 70 % patients with duration of 13 - 24 months of CKD and 66.7 % patients with > 24 months duration of CKD showed mild hearing loss. There was no significant correlation (P value = 0.383) between duration of CKD and degree of hearing loss among the diabetic study group. Among the non-diabetic study group, 70 % patients with <= 6 months, 76.7 % patients with 7 - 12 months, 40 % with 13 - 24 months and 50 % with > 24 months duration of CKD showed mild hearing loss. There was a highly significant (P value = 0.001) correlation between degree of hearing loss and duration of CKD in non-diabetic study population. There has been no studies conducted on the parameter of correlation of degree of hearing loss with duration of CKD in diabetics and non-diabetics which makes our study quite distinct, however there have been quite a few studies exclaiming consideration of correlation of degree of hearing loss with duration CKD irrespective of diabetic status like Peyvandi et al. in 2013 conducted a study showing that patients who were a case of CKD with less than 1 year duration, no hearing loss was found, whereas the ones in whom duration of CKD was more than 2 years, all cases had some degree of hearing loss. Also, the severity of hearing loss increased with the increase in duration of CKD and the correlation was found to be statistically significant.[25] Doshad et al. conducted a study in 2014 showing increase in incidence of hearing loss with increase in duration of CKD.[20]

CONCLUSIONS

Sensorineural hearing loss was found predominantly amongst the CKD patients in our study population constituting 90 %. Mild degree hearing loss was present in majority of the patients constituting 68.3 % of the patients. There was no correlation between degree of hearing loss and stage of CKD in both diabetics and non-diabetics patients in the study group. There was highly significant ($P < 0.001$) correlation between degree of hearing loss and duration of CKD among non-diabetic study population. Non-diabetic patients who underwent haemodialysis showed significant correlation with degree of hearing loss with P value of 0.002.

Thus, our study shows that health care professionals should have high index of suspicion for otorhinolaryngological diseases in patients of CKD. Regular screening for sensorineural hearing loss should be incorporated into regular management of CKD patients. A collaboration between a physician and otorhinolaryngologist can improve quality of care of a patient of CKD.

Limitations of the Study

There are some limitations of our study. Small sample size being the major limitation leading to restricting the generalisation of results to population in general. Since this study was conducted in a tertiary care centre majority of patients presented in CKD stage 3 and onwards after referral from other centres, thereby not representing the true general population. The aetiology of CKD was not taken into

consideration, which may individually affect the auditory function mandating the need for more studies in future.

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