

Original Research Article

Hearing assessment in chronic kidney disease patients: a cross-sectional study

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Received: 01 April 2020

Revised: 14 April 2020

Accepted: 15 April 2020

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ABSTRACT

Background: It is well known that chronic kidney disease (CKD) causes different systemic and otorhinolaryngologic manifestations due to the accumulation of waste products, osmotic alteration, and antigenic similarity between basement membrane of the glomerulus and stria vascularis of the inner ear.

Methods: The study subjects were divided into two groups, 50 CKD patients and 50 healthy volunteers in age group 15-60 years. All CKD patients and controls were subjected to hearing assessment using standard pure tone audiometry.

Results: For low frequency hearing loss increased from stage 2 and 3 to stage 4 and 5, and for high frequency hearing loss among stage 2 and 3 CKD patients was mild to moderate (65.22%) in nature and hearing loss increased in intensity (i.e. severe to profound) in stage 4 and 5 of CKD patients. Dialysis patients were having more severe hearing loss in comparison to non dialysis patients. Hearing loss was negatively correlated with the eGFR. And positively correlated with the duration of the disease (CKD).

Conclusions: Our study highlights the pattern of hearing loss in people suffering from chronic kidney disease who were either on dialysis or not on dialysis. Early identification can prevent further deterioration of hearing in patients suffering from chronic kidney disease.

Keywords: Chronic kidney disease, Estimated glomerular filtration rate, Hearing loss

INTRODUCTION

Chronic kidney disease (CKD) is defined as the presence of kidney damage, manifested by abnormal albumin excretion or decreased kidney function, quantified by measured or estimated glomerular filtration rate (eGFR), that persists for more than three months.^{1,2} CKD affects many system of our body like cardiovascular system, musculoskeletal system, neurological system and many others. Sensory neural hearing loss (SNHL) has been reported in the patient of CKD with considerably higher incidence compared to the general population, which is upto 77% cases for mild hearing loss and 46% have a

moderately severe hearing loss.^{3,4} The etiopathogenesis mechanism reported includes osmotic alteration, resulting in loss of hair cells, the collapse of the endolymphatic space, edema and atrophy of specialized auditory cells and in some complication of hemodialysis has been emphasized.⁵⁻⁷ Another etiopathology lies in antigenic similarity between basement membrane of the glomerulus and stria vascularis of the inner ear and hemodialysis may also be a contributing factor in the hearing loss of CKD patients.^{8,9} Presence of hearing loss, estimation of type and degree constitute one of the most common method used to investigate the effect of renal disease on auditory system. The degree of hearing loss may give an

indication of the extent of auditory function, whereas the type of hearing loss may distinguish between lesion in outer and middle ear and cochlear and neuronal. The objectives of this study were to assess severity of hearing loss with stage of CKD, duration of CKD, and of dialysis.

METHODS

This cross-sectional study entitled “hearing assessment in chronic kidney disease patients” was carried out in Department of Otorhinolaryngology, Swaroop Rani Nehru Hospital (SRNH) MLN Medical College Prayagraj. We have followed our stringent inclusion and exclusion criteria. We included the patients who are of age 25-55 years, diagnosed as case of CKD, no history of noise trauma, no history of ototoxic drug intake and excluded the patients of CKD with uremic encephalopathy, pre-existing long standing middle ear pathology like chronic suppurative otitis media (CSOM), otosclerosis, overt congenital anomalies of external ear/middle ear or inner ear like congenital/hereditary hearing loss with or without syndromic abnormalities. We had also excluded syndromic CKD patients with hearing loss. We divided recruited patients into 2 groups of which in Group A CKD patient were included and in Group B normal controls were taken. Pure tone audiometry was done on all the patients and the healthy volunteers for the frequencies of 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. We differentiated our patients according to hearing disability 1995 act, India, which defines mild hearing loss (HL) and moderate HL as 26-40 dB and 41-60 dB in better ear respectively, whereas severe and profound HL as 61-70 dB and 71-90 dB in better ear respectively.

For staging of the CKD patients, we calculated the estimate glomerular filtration rate (eGFR) using modification of diet in renal disease (MDRD) formula according to which, stage 1 and 2 is defined as eGFR ≥90 ml/min per 1.73 m² with persistent albuminuria and eGFR between 60 to 89 ml/min per 1.73 m² respectively. Whereas stage 3, 4, and 5 are defined as eGFR between 30 to 59 ml/min per 1.73 m², 15 to 29 ml/min per 1.73 m², <15 ml/min per 1.73 m² or end stage renal disease respectively.¹⁰

SPSS statistical software, was used for analyses, including chi square test, correlation and regression. Multivariable logistic regression and 95% confidence intervals (CIs) for associations with CKD.

RESULTS

We had taken 50 cases (Group A) and 50 controls (Group B) for our study. In Group A majority of patients 19 (38%) were in the age group of 51-55 years, and 12 patients (24%) in age group of 51-55 years in Group B while minimum 3 patients, (6%) were in the age group of 31-35 years in Group A and 9 patients, (18%) in the age group of 31-35 years and 41-45 years in Group B.

In this study of 50 CKD patients’ group, 28 patients (56%) were male and 22 patients (44%) were female whereas in control group, 28 patients (56%) were male and 22 patients (44%) were female. In this study within CKD patients - maximum, 23 (46%) patients were of stage 3 and 0 (0%) in stage 1.

Table 1: Association of hearing loss with duration at high frequency.

Duration (in months)	Mild hearing loss N (%)	Moderate hearing loss N (%)	Severe to profound hearing loss N (%)	Total N (%)
0-12	7 (58.33)	3 (25)	2 (16.67)	12 (25.53)
>12	3 (8.57)	11 (31.42)	21 (60)	35 (74.47)
Total	10 (21.27)	14 (29.78)	23 (48.93)	47 (100)

Table 2: Association of hearing loss with duration at low frequency.

Duration (in months)	Mild hearing loss N (%)	Moderate hearing loss N (%)	Severe to profound hearing loss N (%)	Total N (%)
0-12	7 (70)	2 (20)	1 (10)	10 (22.22)
>12	6 (17.14)	16 (45.71)	13 (37.14)	35 (77.78)
Total	13	18	14	45 (100)

Table 3: Association of hearing loss with stage of CKD at low frequency.

CKD stage	Mild to moderate hearing loss N (%)	Severe to profound hearing loss N (%)	Total	Chi square/ p value
Stage 1, 2-3	18 (85.71)	3 (14.29)	21	5.201/0.0226
Stage 4-5	13 (54.16)	11 (45.84)	24	

Table 4: Association of hearing loss with stage of CKD at high frequency.

CKD stage	Mild to moderate hearing loss N (%)	Severe to profound hearing loss N (%)	Total	Chi square/ p value (<0.05)
Stage 1, 2-3	15 (65.22)	8 (34.78)	23	3.61/0.057
Stage 4-5	9 (37.5)	15 (62.5)	24	

Table 5: Hearing loss at low and high frequency in patients on dialysis or not on dialysis.

Severity of hearing loss	Hearing loss in dB (low frequency) (R+L)		Hearing loss in dB (high frequency) (R+L)	
	On dialysis N (%)	Not on dialysis N (%)	On dialysis N (%)	Not on dialysis N (%)
I- mild	2 (12.5)	11 (37.93)	0	10 (30.30)
II (a) - moderate HL	6 (37.5)	12 (41.37)	4 (26.67)	10 (30.30)
II (b) - severe HL	7 (43.75)	6 (20.69)	8 (53.33)	9 (27.27)
III (a) - profound HL	1 (6.25)	0	3 (20)	3 (9.09)
III (b) - total HL	0	0	0	0

Table 1, shows that CKD patients with disease of a period of 12 months or less have mostly mild degree of hearing loss (58.33%) and those who are suffering from the disease for more than 12 months have severe to profound degree of hearing loss (60%) for high frequency respectively. This association was found to be highly statistically significant at 95% confidence interval (CI) and 5% level of significance with chi square value of 13.95 (p value=0.0009).

Table 2, shows that CKD patients with disease of a period of 12 months or less have mostly mild degree of hearing loss (70%) and those who are suffering from the disease for more than 12 months have moderate degree of hearing loss (45.71%) for low frequency respectively. This association was found to be highly statistically significant at 95% CI and 5% level of significance with the chi square value of 15.84, (p value=0.0003).

Table 3, shows that hearing loss increased from stage 2 and 3 to stage 4 and 5. Maximum hearing loss among stage 2 and 3 was mild to moderate in nature and in stage 4 and 5 maximum hearing loss was also mild to moderate in nature. CKD patients suffering from Severe to Profound hearing loss was also found to have increased in stage 4 and 5. Association was found to be statistically significant (p value=0.0226).

Table 4, shows stage wise distribution of CKD patients according to their severity for high frequencies. In this table inference is hearing loss among stage 2 and 3 CKD patients was mild to moderate (65.22%) in nature and hearing loss increased in intensity (i.e. severe to profound) in stage 4 and 5 of CKD patients. This association was found to be statistically insignificant at 95% CI and 5% level of significance (p value=0.057).

Out of 17 patients on dialysis low frequency hearing loss was found in 16 whereas high frequency loss was in 15. Among CKD patient's severity (severe to profound) of hearing loss was more (73.33%) in high frequency range

in dialytic patients as compared to non dialytic patients (36.36%). CKD patients who were not put on dialysis showed low frequency loss in 29 patients while high frequency loss was seen in 32 patients. This table also illustrates that for low frequency mild to moderate hearing loss was less in patients on dialysis (50%) as compared to patient not on dialysis (79.30%), whereas severe to profound degree of hearing loss was more in dialysis patient (50%) as compared to patient not on dialysis (20.69%) and this association was found to be statistically significant at 95% CI and 5% level of significance (p value=0.0421). While for high frequency mild to moderate hearing loss was less in dialysis patients (26.67%) as compared to patients not on dialysis (60.6%) and severe to profound hearing loss was more in dialysis patient (73.33%) as compared to patients not on dialysis (36.36%) and this association was found to be statistically significant at 95% CI and 5% level of significance (p value=0.0175) (as shown in Table 5).

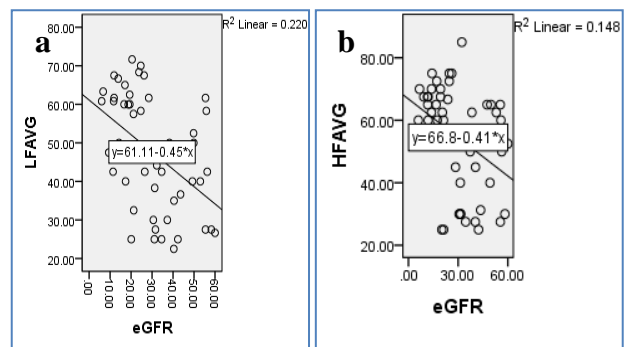


Figure 1 (a and b): For correlation between hearing loss and eGFR.

LFAVG: Low frequency average of air conduction for right and left ear and HFAVG: High frequency average of air conduction for right and left ear.

Figure 1, shows the correlation between estimate eGFR and average frequency of both right and left ear on high and low frequency. Low frequency average and high

frequency average (for air conduction of both right and left ear) are negatively correlated with the eGFR. Correlation at low frequency is stronger ($R^2=0.220$) as compared to higher frequency ($R^2=0.148$) and thus statistically significant (significant <0.05).

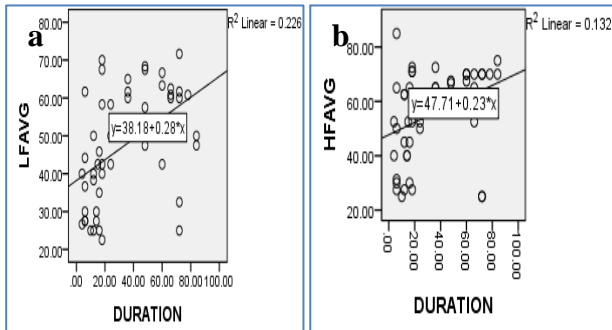


Figure 2 (a and b): For correlation between hearing loss and duration of disease.

LFAVG: Low frequency average of air conduction for right and left ear and HFAVG: High frequency average of air conduction for right and left ear.

Figure 2, depicts the correlation between duration of the disease (CKD) and average frequency of both right and left ear at high and low frequency. Low frequency average and high frequency average (for air conduction of both right and left ear) are positively correlated with the duration of the disease (CKD). Correlation at low frequency is stronger ($R^2=0.226$) as compared to higher frequency ($R^2=0.132$) and this correlation was also found to be statistically significant. p value (significant at <0.01).

DISCUSSION

CKD has been associated with hearing loss when Alport in 1927 first described a case where hearing loss was associated with familial kidney disease, HDR syndrome (hypoparathyroidism, deafness, and renal dysplasia), brachio-oto-renal syndrome, Fabry disease and MELAS syndrome (mitochondrial myopathy, encephalopathy, lactic acidosis, and stroke) are some of the other rare conditions or syndromes in which hearing loss is closely linked to CKD.¹¹⁻¹⁶

In chronic kidney disease it has been established that patients both on dialysis or not on dialysis do suffer from sensorineural hearing loss. It has been ascribed to uremic neuropathy and also to fluid and electrolyte abnormalities. According to Gartland et al low tone sensorineural hearing loss is known to be a feature of endolymphatic hydrops and that hydrops are influenced by fluid balance (the glycerol dehydration test), it is possible that endolymphatic hydrops may be part of the pathological process.⁸ Whereas loss or damage to outer and inner hair cells causes the high tone loss. Bazi et al and Ozturan et al found that the incidence of hearing loss in CKD patients compared to general population is upto

77% having mild hearing loss while 46% have moderately severe hearing loss.^{3,4} Meena et al, reported incidence of moderately severe to severe degree of hearing loss in upto 28% while Pandey et al found that 78.25% of hearing loss in patients with CRF.^{17,18}

In our study, prevalence of disease increased with the age and similar finding were found in other study like Hill et al, Jamaldeen et al, Vilayur et al.¹⁹⁻²¹ We performed distribution of hearing loss both in diseased and controls. Out of 50 cases, 45 (90%) patients lie in low frequency range, and out of which, maximum patients 18 (40%) lie in the range of moderate degree of hearing loss, whereas in controls maximum patients 8 (63%) lie in the range of mild degree of hearing loss. Although the severe degree of hearing loss was also more in CKD patients, i.e., 13 (28.88%) as compare to controls i.e., 1 (3.70%) but it was less in comparison to moderate degree of hearing loss among CKD patients. In high frequency range, out of these 50 CKD patients, 47 (94%) patients had hearing loss and maximum patients lie in the range of severe degree of hearing loss i.e., 17 (36.17%) patients. The similar findings were found in Stavroulaki et al, they found that mild to moderate hearing loss was more in CKD patients which was 55.5%.⁷ Although they did not separate the CKD patients between low frequency and high frequency ranges.

In our study we have performed a correlation study between eGFR and PTA parameters and our result were comparable to Seo et al, who found that the correlation between eGFR and mean thresholds at low, mid, and high frequency ranges had meaningful negative correlations with eGFR values.²²

We performed a stage wise distribution of CKD patients according to their severity, and we found that for low frequency range in stage 2 and 3 patients, maximum hearing loss was of mild to moderate degree in nature, whereas in stage 4 and 5, maximum hearing loss was also mild to moderate in nature. Although severe to profound hearing loss was also more in stage 4 and 5 patients as compared to stage 2 and 3. For high frequency the degree of hearing loss was maximum in the range of mild to moderate degree in nature (65.22%) , whereas with increasing stage such as stage 4 and 5 the hearing loss was more in severe to profound degree of 62.5%.

Our study is also comparable to study of Balasubramanian et al they found that the prevalence of hearing loss in the stage 2nd, 3rd, 4th, 5th was 2%, 24%, 14%, 26% respectively.²³ Their study showed that 10% had mild hearing loss, 20% had moderate hearing loss, 40% had severe hearing loss, and 36% had profound hearing loss in CKD group. The drawback of their study was that they did not excluded the patients who were diabetic as well as distribution of patients according to their frequencies of hearing loss.

Our study on the patients who were on dialysis or not on dialysis differs from study of Yassin et al, Ozen et al, Gartland et al, they found improvement of hearing with the hemodialysis.^{8,24,25} Whereas Heinrich et al, Mirahmadi and Vaziri, Kligerman et al, Konopka and Zbrog found no effect on hearing with the hemodialysis.²⁶⁻²⁹

In our study we found that on increasing duration of the disease the severity of hearing loss was increased both for high and low frequency. Our study is comparable to the study of Doshad and Kuchhal et al, because they also found that the incidence of sensorineural hearing loss increases with the duration of disease.³⁰

Even we performed a correlation study between the duration of disease and severity of hearing loss and we found that low frequency average and high frequency average of both right and left ear were positively correlated with the duration of the disease (CKD) and Lasisi et al, had the similar results.³¹

This study, apart from its preliminary findings, also reveals the lacunae in our current understanding of hearing loss in CKD. Although there exists no further doubt that hearing loss is prevalent among CKD patients, well-designed studies with larger sample sizes are needed to elucidate the causal relationships between hearing loss in CKD and hearing loss. Another logical question that arises in this context is whether a blanket audiometric screening of all CKD patients would help identify mild hearing loss and prevent progression to severe degrees, especially if a beneficial role for haemodialysis can be definitely established in long-term prospective studies. One more lacuna in is the unavailability of the audiometers that can assess ultra-high frequencies (>8 kHz). Besides, the awareness of hearing loss in CKD patients' needs to be addressed by more research as this could have significant implications for clinical practice.

CONCLUSION

There was significant difference in hearing loss between the patients with CKD and the healthy volunteer group, which was more in the CKD patients. Mild to moderate degree of hearing loss is common in CKD patients. Hearing loss has no specific pattern as it prevails at high and low frequencies. The high-frequency hearing loss was the most common hearing impairment amongst CKD patients, followed by hearing impairment across all frequencies and low-frequency hearing loss. The prevalence of hearing loss increases with the duration of the CKD. Dialysis patients have more severe degree of hearing loss in comparison to patients who are not on dialysis.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Jain S, Upadhyay VP, Aftab M, Singh RS, Dubey AK, Sing HN. Hearing assessment in chronic kidney disease patients: a cross-sectional study. *Int J Otorhinolaryngol Head Neck Surg* 2020;6:847-52.