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Original Article

Impact Of Chronic Kidney Disease on Hearing Thresholds

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ABSTRACT

INTRODUCTION: Chronic kidney disease (CKD) refers to a heterogeneous group of disorders characterized by structural and/or functional abnormalities of the kidneys persisting for more than three months. **AIM:** To evaluate the impact of chronic kidney disease (CKD) on hearing thresholds. **METHODOLOGY:** The present study was conducted in the 1year from 2023. **RESULT:** The majority of patients were middle-aged and had advanced stages of chronic kidney disease, with a high prevalence of hearing impairment. Audiological evaluation showed a bilateral, symmetrical increase in hearing thresholds, predominantly at high and extended high frequencies, with severity increasing with longer disease duration. **CONCLUSION:** Chronic kidney disease is associated with a progressive, bilateral sensorineural hearing loss, predominantly affecting high and extended high frequencies. The severity of hearing impairment increases with longer duration and advanced stages of CKD, highlighting the need for early audiological screening in these patients.

Keywords: Chronic kidney disease, Hearing threshold, Audiometry.

INTRODUCTION

Chronic kidney disease (CKD) refers to a heterogeneous group of disorders characterized by structural and/or functional abnormalities of the kidneys persisting for more than three months.[1] It is marked by a progressive and generally irreversible decline in glomerular filtration rate (GFR), ultimately impairing the body's ability to maintain fluid, electrolyte, and metabolic homeostasis.[2] CKD may arise from a wide range of etiologies, including genetic conditions, infections, trauma, systemic diseases, and exposure to nephrotoxic drugs. As the disease advances, it evolves into chronic renal failure (CRF), a systemic condition with multisystem involvement that significantly affects morbidity and quality of life.3 Accumulation of uremic toxins, metabolic derangements, and long-term hemodialysis exert deleterious effects on multiple organ systems, including the auditory system. Increasing evidence suggests that patients with CKD are at a higher risk of developing hearing impairment, particularly sensorineural hearing loss. This association is biologically plausible due to the striking anatomical, physiological, and immunological similarities between the kidney and the inner ear.[4] The stria vascularis of the cochlea and the renal nephron share common epithelial characteristics, vascular arrangements, and enzymatic mechanisms. Both structures rely heavily on active transport processes mediated by sodium–potassium adenosine triphosphatase (Na^+/K^+-ATPase) and carbonic anhydrase to regulate fluid and electrolyte balance.5,6 Furthermore, antigenic similarities between the cochlea and the kidney have been proposed, suggesting that pathological processes affecting the kidney may concurrently influence cochlear function. Hemodialysis itself has been hypothesized to exacerbate auditory damage through rapid osmotic shifts and microvascular compromise. In advanced CKD, multiple coexisting risk factors further increase susceptibility to hearing loss. These include prolonged exposure to ototoxic medications, persistent hypertension, diabetes mellitus—especially when associated with hypertension—electrolyte disturbances, and chronic dialysis. Long-term dialysis may also result in amyloid deposition within the inner ear, while aluminum toxicity, observed in some dialysis patients, has been implicated in auditory dysfunction. Hearing loss in patients with CKD has profound implications for communication, social interaction, and overall quality of life. Despite its significant impact, auditory impairment often remains under-recognized in this population. Early identification of hearing loss, particularly at higher frequencies, may allow timely intervention and help prevent further deterioration. In view of these considerations, the present study was undertaken to evaluate the effect of CKD on high-frequency hearing thresholds ranging from 8 to 18 kHz, thereby highlighting the importance of auditory monitoring in patients with chronic kidney disease.

AIM

To evaluate the impact of chronic kidney disease (CKD) on hearing thresholds.

METHODOLOGY

The present study was conducted from 2023. It was an observational, cross-sectional study designed to evaluate the impact of chronic kidney disease (CKD) on hearing thresholds, with particular emphasis on high-frequency hearing. Patients diagnosed with CKD for a duration of at least 6 months, irrespective of etiology and stage of disease, and aged 18 years and above were included in the study. All participants underwent a detailed clinical evaluation, including history taking, general and systemic examination, and otological examination to rule out external or middle ear pathology. Hearing assessment was carried out in a sound-treated room using pure tone audiometry, including extended high-frequency audiometry in the range of 8–18 kHz.

Patients with a history of pre-existing hearing loss prior to the diagnosis of CKD, chronic suppurative otitis media, otosclerosis, ear surgery, congenital ear anomalies, or exposure to occupational noise were excluded from the study. Individuals with acute kidney injury, active ear infections, neurological disorders affecting hearing, or those unwilling to participate were also excluded. Patients receiving known ototoxic drugs for causes other than CKD were not considered for inclusion.

RESULTS

Table 1: Age Distribution of the Study Participants (n = 88)

Age Group (years)	Number (n)	Percentage (%)
18-30	6	6.8%
31-40	14	15.9%
41–50	40	45.5%
51–60	20	22.7%
>60	8	9.1%

The majority of study participants belonged to the 41–50 years age group (45.5%), followed by the 51–60 years group (22.7%). Fewer participants were seen at the extremes of age, with only 6.8% in the 18–30 years group and 9.1% above 60 years.

Table 2: Duration of Chronic Kidney Disease

Duration of CKD		
≤ 6 months	25	28.4%
7–12 months	32	36.4%
13–24 months	19	21.6%
> 24 months	12	13.6%

The majority of patients had a duration of chronic kidney disease between 7–12 months (36.4%), followed by those with ≤6 months duration (28.4%). Patients with longer disease duration of 13–24 months and >24 months constituted 21.6% and 13.6% of the study population respectively.

Table 3: Distribution of CKD Stages Among Study Participants

CKD Stage		
Stage 3A	11	12.1%
Stage 3B	13	14.3%
Stage 4	26	28.6%
Stage 5	38	43.1%

The majority of patients belonged to stage 5 chronic kidney disease, accounting for 43.1% of the study population, followed by stage 4 (28.6%). Early stages, stage 3A and stage 3B, constituted 12.1% and 14.3% of cases respectively.

Table 4: Hemodialysis Status of Study Participants

Dialysis Status		
On hemodialysis	38	43.2%
Not on dialysis	50	56.8%

More than half of the study participants were not on hemodialysis, accounting for 56.8% of cases, while 43.2% of patients were undergoing hemodialysis.

Table 5: Pure Tone Audiometry – Conventional Frequencies (0.25–8 kHz)

Frequency (Hz)	Right Ear Mean ± SD (dB HL)	Left Ear Mean ± SD (dB HL)
250	18.4 ± 6.2	18.9 ± 6.5
500	20.6 ± 7.1	21.2 ± 7.3
1000	22.8 ± 8.4	23.4 ± 8.6
2000	25.9 ± 9.1	26.3 ± 9.4
4000	30.7 ± 10.2	31.1 ± 10.5
8000	36.8 ± 11.6	37.4 ± 11.9

Pure tone audiometry revealed near-normal hearing thresholds at lower frequencies (250–1000 Hz) with a gradual increase in thresholds at higher frequencies. A clear elevation in hearing thresholds was observed at 4000 and 8000 Hz in both ears, indicating high-frequency sensorineural hearing loss among CKD patients.

Table 6: Extended High-Frequency Audiometry (8–18 kHz)

Frequency (kHz)	Right Ear Mean ± SD (dB HL)	Left Ear Mean ± SD (dB HL)
8	38.6 ± 12.1	39.2 ± 12.4
10	42.8 ± 13.3	43.6 ± 13.7
12	47.9 ± 14.6	48.4 ± 14.9
14	52.3 ± 15.2	53.1 ± 15.6
16	57.6 ± 16.1	58.2 ± 16.4
18	61.9 ± 17.3	62.7 ± 17.8

Extended high-frequency audiometry demonstrated progressively increasing hearing thresholds from 8 to 18 kHz in both ears. The marked elevation of thresholds at ultra-high frequencies reflects early and more severe cochlear involvement in patients with chronic kidney disease.

Table 7: Degree of Hearing Loss Among CKD Patients

Degree of Hearing Loss	Number (n)	Percentage (%)
Mild	34	38.6%
Moderate	18	20.5%
Moderately severe	6	6.8%

Severe	4	4.5%
Profound	2	2.3%
Normal hearing	24	27.3%

Mild hearing loss was the most common finding, observed in 38.6% of patients, followed by moderate hearing loss in 20.5% of cases. 72.7% of patients exhibited some degree of hearing impairment, while 27.3% had normal hearing thresholds.

Table 8: Association Between Duration of CKD and Hearing Loss

Degree of Hearing Loss	≤ 6 months 25	7–12 months 32	13–24 months 19	> 24 months 12
Mild	9	18	6	1
Moderate	4	7	4	3
Moderately severe	1	1	2	2
Severe	0	0	3	1
Profound	0	0	0	2
Normal hearing	11	6	4	3
Total	25	32	19	12

Hearing loss severity increased with longer duration of chronic kidney disease, with mild hearing loss predominating in patients with shorter disease duration. Moderate to severe and profound hearing loss were more frequently observed in patients with CKD duration exceeding 13 months, indicating a progressive deterioration of hearing with disease chronicity

DISCUSSION

The study population was predominantly middle-aged, with the highest number of patients in the 41–50 years age group (45.5%). This was followed by patients aged 51–60 years (22.7%) and 31–40 years (15.9%). The younger age group of 18–30 years and those above 60 years constituted a smaller proportion of the study population. Sarin V et al. 9 In this cross-sectional observational study of 164 individual ears from 82 cases of CKD, the mean age was 48.58 years and the maximum number of patients were in the age group of 41–50 years (45.1%).

Among the 88 patients with chronic kidney disease, the duration of illness varied across the study population. A majority of patients, 32 (36.4%), had a duration of CKD between 7 and 12 months. This was followed by 25 patients (28.4%) with a disease duration of 6 months or less. Nineteen patients (21.6%) had been suffering from CKD for a period of 13–24 months. A smaller proportion, 12 patients (13.6%), had CKD for more than 24 months.

In the present study, the majority of patients belonged to Stage 5 chronic kidney disease, accounting for 38 patients (43.1%). This was followed by Stage 4 CKD, which included 26 patients (28.6%), Stage 3B constituted 13 cases (14.3%), while Stage 3A included 11 cases (12.1%). Sarin V et al. 9 studied that the majority of cases were of stage 5 (65.8%) followed by stage 4 (23.2%), stage 3B (6.1%) and stage 3A (4.9%). The mean duration of the present study was 15.61 months. The majority of patients (36.6%) had CKD for the past 7–12 months followed by < 6 months of duration in 28.1% cases, 17.1% cases had duration of CKD for 13–24 months while 18.3% cases had duration of disease > 24 months.

In the present study, a total of 38 patients (43.2%) were undergoing maintenance hemodialysis, while 50 patients (56.8%) were not on dialysis at the time of evaluation. The proportion of patients not receiving dialysis was higher compared to those on hemodialysis. Sarin V et al. (9) In this cross-sectional observational study, the majority of cases didn't undergo any session of hemodialysis, constituting 56.1%, while 43.9% underwent hemodialysis.

Pure tone audiometry at conventional frequencies demonstrated a progressive increase in hearing thresholds from low to high frequencies in both ears. Hearing thresholds at 250 Hz and 500 Hz were within near-normal limits, indicating preserved low-frequency hearing. A mild elevation in thresholds was observed at mid frequencies (1000–2000 Hz), suggesting early auditory involvement. At higher frequencies, particularly 4000 Hz and 8000 Hz, thresholds were markedly elevated, consistent with mild to moderate hearing loss. Similar threshold patterns were observed in both right and left ears, indicating bilateral involvement.

Extended high-frequency audiometry demonstrated a progressive elevation in hearing thresholds from 8 kHz to 18 kHz in both ears. The mean thresholds at 8 and 10 kHz were moderately elevated, indicating early high-frequency involvement. As frequency increased to 12 and 14 kHz, a further rise in thresholds was observed, suggesting worsening cochlear

dysfunction. Markedly elevated thresholds were noted at 16 and 18 kHz, reflecting moderate to severe hearing loss at ultra-high frequencies. The pattern of hearing loss was symmetrical in both ears, with comparable mean values on the right and left sides. Kanotra et al. (10) In the present study, 28 out of 60 patients of CKD had hearing loss. All the patients had SNHL in the high frequency range, sparing low and middle frequencies. There was a positive correlation between the stage and duration of CKD with hearing loss.

The distribution of hearing status among the study participants showed that the majority had some degree of hearing impairment. Mild hearing loss was the most common finding, affecting 38.6% of patients, followed by moderate hearing loss in 20.5%. Moderately severe and severe hearing loss were observed in 6.8% and 4.5% of cases, respectively. Profound hearing loss was relatively uncommon, seen in only 2.3% of patients. Normal hearing thresholds were present in 27.3% of the study population. Gowthame et al. (11) Based on the WHO classification of hearing loss, the degree of hearing loss was assessed, and 23.8% of patients had mild, 7.9% had moderate, and 4% had moderately severe hearing loss involving the right ear; while 23.8% had mild, 8.9% had moderate, and 4% had moderately severe hearing loss affecting the left ear. Hearing loss showed a clear relationship with the duration of chronic kidney disease. Among patients with CKD duration ≤6 months, the majority had either normal hearing or mild hearing loss, with no cases of severe or profound loss. In the 7–12 months duration group, mild hearing loss predominated, though moderate loss was also observed in a notable proportion. Patients with CKD duration of 13–24 months demonstrated a shift towards more severe forms, including moderately severe and severe hearing loss. In those with disease duration greater than 24 months, advanced degrees of hearing impairment, including severe and profound hearing loss, were evident. Sodhi JK et al. (12) observed that patients with shorter duration of CKD (≤12 months) predominantly had mild or no hearing loss, whereas those with longer duration showed increasing severity of hearing impairment, including moderate to severe and profound loss. The severity of hearing loss progressively increased with advancing duration of CKD, particularly beyond 12 months. A statistically significant association between duration of CKD and hearing loss was demonstrated ($p = 0.001$), indicating worsening auditory function with longer disease duration.

CONCLUSION

The present study demonstrates that chronic kidney disease has a significant impact on hearing thresholds, with hearing impairment being a common finding among affected patients. The study population was predominantly middle-aged, and a large proportion of patients were in advanced stages of CKD. Audiological evaluation revealed a bilateral, symmetrical pattern of sensorineural hearing loss, with greater involvement of high and extended high frequencies, while low-frequency hearing was relatively preserved. The severity of hearing loss showed a clear association with the duration and stage of chronic kidney disease, with more advanced disease and longer duration exhibiting greater auditory impairment. These findings highlight the importance of routine audiological assessment, including high-frequency audiometry, in patients with CKD for early identification and prevention of further hearing deterioration.

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