Section: Nephrology/ Otorhinolaryngology

Original Research Article

HEARING IMPAIRMENT IN END-STAGE RENAL DISEASE PATIENTS UNDERGOING HAEMODIALYSIS IN A TERTIARY CARE HOSPITAL: A COMPARATIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: End-stage renal disease is associated with systemic biochemical, vascular, and electrolyte disturbances that can involve the inner ear. The cochlea and kidney share structural and transport-related similarities, making auditory dysfunction an important but under-recognised complication in patients receiving haemodialysis. **Objectives:** To assess the prevalence, pattern, and severity of hearing loss among patients with end-stage renal disease undergoing haemodialysis and to compare auditory findings with age- and gender-matched controls.

Materials and Methods: This comparative observational study included 100 participants, comprising 50 patients with end-stage renal disease receiving maintenance haemodialysis and 50 controls. Eligible participants underwent clinical evaluation, otoscopic examination, pure tone audiometry, and biochemical assessment. Hearing status, type of hearing loss, severity, pure tone average, and correlations with clinical and biochemical variables were analysed.

Results: The mean age was 39.4 ± 8.1 years in the haemodialysis group and 38.9 ± 7.8 years in controls. Hearing loss was observed in 60.0% of haemodialysis patients compared with 16.0% of controls. Sensorineural hearing loss was the predominant pattern, accounting for 83.3% of affected ESRD patients. Mild and moderate hearing loss constituted the largest severity groups. Mean average pure tone threshold was significantly higher in haemodialysis patients than controls. Duration of haemodialysis, blood urea, and serum creatinine showed significant positive correlations with average pure tone threshold.

Conclusion: Hearing impairment was substantially higher among patients with end-stage renal disease undergoing haemodialysis than among controls. Sensorineural hearing loss predominated, and increasing dialysis duration and renal biochemical derangement were associated with poorer auditory thresholds. Routine audiological screening should be integrated into haemodialysis care.

Keywords: End-stage renal disease; Haemodialysis; Hearing loss; Sensorineural hearing loss; Pure tone audiometry; Chronic kidney disease.

INTRODUCTION

Chronic kidney disease progresses to end-stage renal disease (ESRD) when renal function becomes insufficient to maintain metabolic, electrolyte, acid-base, and endocrine balance without renal replacement therapy. Haemodialysis improves survival in ESRD, yet these patients continue to experience multisystem complications related to uraemic toxins, vascular instability, electrolyte shifts,

oxidative stress, and repeated osmotic changes during dialysis sessions. Auditory dysfunction is one such complication that receives less routine clinical attention, despite its effect on communication, treatment adherence, social interaction, and quality of life. The biological plausibility of hearing impairment in renal disease is supported by the close anatomical and physiological relationship between the kidney and the inner ear.[1,2] The stria vascularis and renal tubular epithelium share active ion transport mechanisms, basement membrane characteristics, and vulnerability to metabolic insults. Histopathological observations in renal failure have described cochlear changes involving the stria vascularis, spiral ganglion, and labyrinthine structures.[3] Early clinical studies demonstrated that patients with chronic renal failure can develop high-frequency auditory deficits even in the absence of conventional otological risk factors.[4,5] The aetiology of hearing loss in ESRD is multifactorial. Uraemia, electrolyte imbalance, hypertension, diabetes, anaemia, microvascular compromise, ototoxic drug exposure, and altered endolymph homeostasis all contribute to cochlear stress. Haemodialysis itself introduces rapid changes in blood pressure, plasma osmolality, and fluid composition, which can influence inner-ear fluid dynamics. Earlier observations reported threshold fluctuations following haemodialysis, especially at low frequencies, while other studies found no uniform deterioration after dialysis, indicating that the relationship remains clinically debated.[6,7] Subsequent studies among haemodialysis populations have reported variable prevalence rates of hearing impairment, with sensorineural hearing loss being the dominant pattern.[8-13] These variations arise from differences in age distribution, dialysis duration, comorbid disease burden, audiometric protocols, and definitions of hearing loss. Recent reviews continue to emphasise that hearing impairment in CKD is common, underdiagnosed, and suitable for detection by pure tone audiometry.[14] In resource-limited tertiary care settings, structured audiological screening among ESRD patients is important because early recognition permits counselling, hearing rehabilitation, avoidance of ototoxic exposure, and closer monitoring of modifiable biochemical risk factors. Standardised testing also helps distinguish renal-related sensorineural loss from background age-related or environmental hearing impairment. The present study was conducted to determine the prevalence of hearing loss among ESRD patients undergoing haemodialysis, to assess the pattern and severity of hearing impairment, to compare pure tone audiometric findings with age- and gender-matched controls, and to examine the relationship between hearing threshold and selected clinical and biochemical parameters.

MATERIALS AND METHODS

Study design and setting

This comparative observational study was conducted over a period of six months, from October 2025 to March 2026, at Dr. YSR Kidney Research Centre and Super Speciality Hospital, Palasa. The study included patients with end-stage renal disease receiving maintenance haemodialysis and an age- and gender-matched control group. It was designed to evaluate auditory status through clinical otorhinolaryngological assessment and pure tone audiometry, along with documentation of relevant biochemical parameters. All participants were assessed using routine clinical, nephrology, and audiological evaluation procedures followed in tertiary care practice.

Study population

A total of 100 participants were included. The study group consisted of 50 ESRD patients aged 20-50 years who were receiving haemodialysis. The control group included 50 apparently healthy individuals matched for age and gender. Participants were enrolled after obtaining informed consent. Demographic details, clinical history, duration of chronic kidney disease, duration of haemodialysis, and relevant systemic history were recorded using a structured questionnaire.

Eligibility criteria

Patients with ESRD on haemodialysis who provided consent and were able to undergo audiological testing were included. Participants with prolonged occupational or recreational noise exposure, family history of hearing loss, previous ear disease, ear surgery, recent ototoxic drug exposure within three months, active ear infection, and critical illness preventing reliable hearing assessment were excluded. These exclusions were used to reduce confounding from non-renal causes of hearing impairment.

Audiological assessment

All participants underwent otoscopic examination before audiometry to exclude external ear canal obstruction or active middle-ear pathology. Pure tone audiometry was performed in a suitable test environment by standard clinical procedure. Air-conduction and bone-conduction thresholds were assessed, and hearing loss was classified as sensorineural, conductive, or mixed according to the air-bone gap and threshold pattern. The degree of hearing loss was categorised as mild, moderate, moderately severe, severe, or profound based on pure tone average thresholds.

Biochemical assessment

Blood urea, serum creatinine, bicarbonate, serum sodium, serum potassium, and plasma glucose were documented for comparison between the haemodialysis and control groups. These variables were selected because uraemia, electrolyte changes, and metabolic imbalance have been implicated in

auditory dysfunction among renal failure patients.[6,9,12,14]

Statistical analysis

Data were entered and analysed using SPSS version 20. Continuous variables were expressed as mean ± standard deviation, and categorical variables were expressed as frequency and percentage. Group comparisons for continuous variables were performed using the independent t-test, while categorical variables were compared using the chi-square test. Pearson correlation coefficient was used to assess the relationship between average pure tone threshold and selected clinical or biochemical variables. A p-value less than 0.05 was considered statistically significant.

Ethical considerations

The study approved by Institutional Ethics Committee, Government Medical College and Government General Hospital, Srikakulam (IEC2025D/GMC&GGH/SKLM/181025/06).

Written informed consent was obtained from all participants before inclusion in the study. Confidentiality of participant information was strictly maintained throughout data collection, analysis, and reporting. Audiological findings requiring clinical attention were communicated to the treating team for further counselling, evaluation, and appropriate management.

RESULTS

A total of 100 participants were included, with 50 patients in the ESRD on haemodialysis group and 50 age- and gender-matched controls. The mean age was comparable between the haemodialysis group and controls. Male predominance was observed in both groups, with no statistically significant difference in gender distribution. Among ESRD patients, the mean duration of CKD was 42.6 ± 20.4 months, and the mean duration of haemodialysis was 28.4 ± 16.7 months. Blood urea, serum creatinine, serum potassium, and plasma glucose were significantly higher in the haemodialysis group, whereas serum bicarbonate and sodium levels were lower compared with controls. [Table 1]

Table 1: Baseline demographic and biochemical profile of study participants

Variable	ESRD on haemodialysis group (n=50)	Control group (n=50)	p-value
Mean age, years	39.4 ± 8.1	38.9 ± 7.8	0.754
Male, n (%)	31 (62.0)	29 (58.0)	0.683
Female, n (%)	19 (38.0)	21 (42.0)	0.683
Mean duration of CKD, months	42.6 ± 20.4	—	—
Mean duration of haemodialysis, months	28.4 ± 16.7	—	—
Blood urea, mg/dL	126.8 ± 34.5	31.2 ± 7.8	<0.001
Serum creatinine, mg/dL	8.9 ± 2.1	0.9 ± 0.2	<0.001
Serum bicarbonate, mEq/L	18.7 ± 3.8	24.1 ± 2.5	<0.001
Serum sodium, mEq/L	135.2 ± 5.4	139.0 ± 3.6	0.002
Serum potassium, mEq/L	5.1 ± 0.8	4.2 ± 0.5	<0.001
Plasma glucose, mg/dL	112.6 ± 28.4	98.2 ± 14.6	0.002

Hearing loss was more frequent among patients with ESRD undergoing haemodialysis than among controls. Hearing loss was observed in 30 patients in the haemodialysis group, giving a prevalence of 60.0%, compared with 8 participants in the control group, accounting for 16.0%. This difference was statistically significant. Among ESRD patients with hearing loss, sensorineural hearing loss was the predominant pattern, followed by mixed and conductive hearing loss. Most affected patients had mild to moderate hearing loss. [Table 2]

Table 2: Prevalence, pattern, and severity of hearing loss

Parameter	Category	Frequency	Percentage (%)	p-value
Hearing status in ESRD group	Normal hearing	20/50	40.0	<0.001
	Hearing loss	30/50	60.0	
Hearing status in control group	Normal hearing	42/50	84.0	
	Hearing loss	8/50	16.0	
Pattern of hearing loss in ESRD group	Sensorineural hearing loss	25/30	83.3	—
	Conductive hearing loss	2/30	6.7	
	Mixed hearing loss	3/30	10.0	
Severity of hearing loss in ESRD group	Mild	12/30	40.0	—
	Moderate	11/30	36.7	
	Moderately severe	5/30	16.7	
	Severe	2/30	6.6	
	Profound	0/30	0.0	

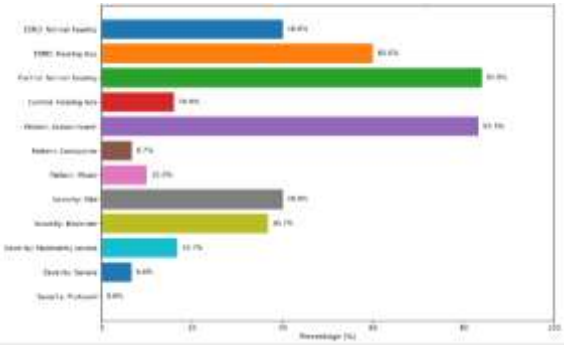

Figure 1: Prevalence, Pattern and Severity of Hearing Loss

Pure tone audiometry showed significantly higher hearing thresholds among ESRD patients undergoing haemodialysis compared with controls. The mean right ear PTA was 31.8 ± 12.4 dB in the haemodialysis group and 17.6 ± 5.8 dB among controls. Similarly, the mean left ear PTA was 32.6 ± 12.1 dB in ESRD patients and 18.1 ± 5.9 dB in controls. The average PTA was also significantly higher in the haemodialysis group. [Table 3]

Table 3: Comparison of pure tone audiometry findings between groups

PTA parameter	ESRD on haemodialysis group	Control group	p-value
Right ear PTA, dB	31.8 ± 12.4	17.6 ± 5.8	<0.001
Left ear PTA, dB	32.6 ± 12.1	18.1 ± 5.9	<0.001
Average PTA, dB	32.2 ± 11.8	17.9 ± 5.4	<0.001

Correlation analysis showed that average PTA threshold had a significant positive correlation with duration of haemodialysis, blood urea, and serum creatinine. Serum bicarbonate showed a significant negative correlation with PTA threshold. Serum sodium, potassium, and plasma glucose did not show statistically significant correlations with average PTA threshold (Table 4). Overall, hearing impairment was significantly more common among ESRD patients undergoing haemodialysis than among controls. Sensorineural hearing loss was the major audiological pattern, and mild to moderate impairment formed the largest proportion. Higher PTA thresholds were significantly associated with longer duration of haemodialysis and biochemical markers of renal dysfunction.

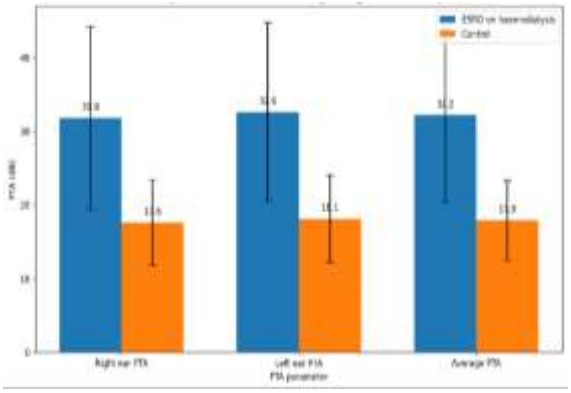

Figure 2: Comparison of pure tone audiometry findings between groups

Table 4: Correlation between clinical/biochemical parameters and average PTA threshold in ESRD patients

Variable	Correlation coefficient (r)	p-value	Interpretation
Duration of haemodialysis	0.46	0.001	Significant positive correlation
Blood urea	0.38	0.006	Significant positive correlation
Serum creatinine	0.41	0.003	Significant positive correlation
Serum bicarbonate	-0.29	0.041	Significant negative correlation
Serum sodium	-0.18	0.211	Not significant
Serum potassium	0.26	0.067	Not significant
Plasma glucose	0.21	0.143	Not significant

DISCUSSION

The present study demonstrated a substantially higher burden of hearing impairment among ESRD patients undergoing haemodialysis compared with age- and gender-matched controls. Hearing loss was identified in 60.0% of haemodialysis patients, whereas only 16.0% of controls had hearing impairment. This difference supports the view that renal failure and its treatment environment are associated with clinically relevant auditory dysfunction. Earlier clinical and pathological studies described a close relationship between renal disease and cochlear injury, with high-frequency deficits frequently reported in chronic renal failure.[5] The present findings are consistent with this biological framework, as the mean pure tone thresholds were significantly higher in both ears among haemodialysis patients. Sensorineural hearing loss was the dominant pattern in the current study, accounting for 83.3% of affected ESRD patients. This observation agrees with previous studies in which sensorineural involvement was the principal audiological abnormality in renal failure and haemodialysis populations.[8-13] Cochlear susceptibility is explained by active electrolyte transport, vascular dependence of the stria vascularis, and exposure to uraemic and osmotic stress. Rapid changes during dialysis can alter fluid balance across the inner-ear compartments, while chronic uraemia

and microvascular injury can produce persistent cochlear dysfunction.[9,12,14] In the present study, mild and moderate hearing loss constituted the largest severity categories. This pattern has practical relevance because early degrees of hearing loss are often unnoticed by patients and clinicians, particularly when the primary clinical focus remains dialysis adequacy, anaemia, blood pressure, vascular access, and biochemical control. The predominance of mild-to-moderate impairment indicates a window for screening, counselling, and hearing conservation before severe disability develops. Duration of haemodialysis showed a significant positive correlation with average PTA threshold. This finding is in agreement with reports that prolonged exposure to the haemodialysis milieu and chronic renal dysfunction are associated with worsening auditory thresholds.[11-14] Blood urea and serum creatinine were also positively correlated with PTA threshold, suggesting that greater biochemical derangement parallels poorer hearing status. Serum bicarbonate showed a negative correlation, indicating that lower bicarbonate levels were associated with higher hearing thresholds. This supports the concept that metabolic imbalance contributes to cochlear vulnerability. However, sodium, potassium, and plasma glucose did not show statistically significant correlations in this dataset. The findings highlight the need for interdisciplinary screening between nephrology and otorhinolaryngology services. Pure tone audiometry is simple, non-invasive, and informative. Incorporating periodic hearing evaluation into haemodialysis care can identify early impairment, guide referral for hearing rehabilitation, and encourage avoidance of additional ototoxic risks.

Limitations

The study was conducted at a single tertiary care centre with a modest sample size, limiting wider generalisation. Extended high-frequency audiometry, otoacoustic emissions, speech discrimination testing, and follow-up after serial dialysis sessions were not included. Comorbidities such as diabetes, hypertension, anaemia, vascular disease, dialysis adequacy, and medication history were not analysed in separate multivariable models, restricting causal interpretation and subgroup analysis.

CONCLUSION

Hearing impairment was significantly more frequent among ESRD patients receiving haemodialysis than among age- and gender-matched controls. Sensorineural hearing loss was the predominant pattern, and most affected patients had mild to moderate impairment. Higher pure tone thresholds were associated with longer duration of haemodialysis and higher renal biochemical markers, particularly blood urea and serum creatinine. These findings support routine audiological screening in haemodialysis units. Early detection offers an opportunity for counselling, hearing conservation, rehabilitation referral, and closer attention to modifiable metabolic factors. Collaborative care involving nephrologists, audiologists, and otorhinolaryngologists strengthens comprehensive management of patients living with ESRD and helps preserve communication ability, treatment participation, and overall quality of life.

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