

Sensorineural Hearing Loss in CKD Patients

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Abstract: The functions of kidneys in the human body mainly involve metabolism, excretion of waste materials, blood pressure regulation, and blood cell production. Any insult to the structural and functional integrity of the kidneys over some time can lead to acute/chronic kidney disease (CKD). CKD occurs when an abnormal nephrology system leads to a reduction in the glomerular filtration rate (GFR) to a value $<60 \text{ mL/min/1.73 m}^2$, for ≥ 3 months. **Study design:** Non-randomised, Case control study. **Study site:** Gouri Devi Hospital and Research Institute. **Results:** Majority of the patients (36.7%) in Controls Group were in the age group of 21-30 years followed by 23.3% patients from the age group of 31-40 years and 20% patients each from the age group of 41-50 and 51-60 years. The mean age of the patients was 36.8 ± 12.03 . Majority of the patients (33.3%) in Cases Group were in the age group of 51-60 years followed by 30% patients from the age group of 41-50 years, 20% patients from the age group of 31-40 years and 16.7% patients from the age group of 21-30 years. The mean age of the patients was 43.3 ± 11.58 years. The degree of hearing loss in left ear was higher in Cases Group as compared to Controls Group. 5 (16.7%) patients each had hearing loss for ≤ 7 days and ≥ 1 year while 10 (33.3%) patients each had hearing loss for 8-29 days and 1-11 months. It was observed that there is higher incidence of SNHL in patients with low eGFR. There was significant association of eGFR with degree of SNHL.

Keywords: CKD: Chronic Kidney disease, SNHL: Sensorineural hearing loss, GFR: Glomerular filtration rate, KF: Kidney function, HI: Hearing impairment

1. Introduction

The functions of kidneys in the human body mainly involve metabolism, excretion of waste materials, blood pressure regulation, and blood cell production. Any insult to the structural and functional integrity of the kidneys over some time can lead to acute/chronic kidney disease (CKD). CKD occurs when an abnormal nephrology system leads to a reduction in the glomerular filtration rate (GFR) to a value $<60 \text{ mL/min/1.73 m}^2$, for ≥ 3 months¹. There is found to be an association between CKD and hearing impairment in many types of research. It has been identified that there are structural similarities between the nephron and stria vascularis in the labyrinth of the inner ear, where they share Type IV collagen in the basement membrane.² The mechanism and correlation of sensorineural hearing loss (SNHL) in CKD are unclear but a few theories have been suggested such as genetic disorders such as Alport's syndrome, hypoperfusion causing ischemia, and toxic levels of body metabolites leading to toxicity to the structures in the inner ear. Projections suggest that by 2050, nearly 2.5 billion individuals will experience some degree of hearing impairment, with the burden disproportionately affecting low- and middle-income countries (LMICs), where 80% of cases remain unaddressed. Other factors with similar associations could be diabetes, hypertension, and medications that have ototoxic and nephrotoxic effects.³ Apart from all these causes, CKD patients undergoing hemodialysis have shown a higher incidence of SNHL.⁴ The prevalence of SNHL among CKD patients in India is between 28% and 77%.⁵ Patients with CKD show various otorhinolaryngological manifestations among which sensorineural hearing loss (SNHL) is the commonest. The kidney and cochlea have anatomical, physiological, pharmacological and pathological similarities with common antigenicity. Their development is regulated by similar genetic factors and is influenced by similar immunological factors.

Emerging evidence suggests a pathophysiological link between CKD and sensorineural hearing loss (SNHL), likely due to shared electrolyte transport mechanisms, structural similarities between the kidney and cochlea, and common risk factors such as ototoxic medications, hypertension, and electrolyte imbalances.

This association is biologically plausible due to the striking anatomical, physiological, and immunological similarities between the kidney and the inner ear. Human temporal studies have observed cochlear damage in patients with end stage renal disease.⁶ The risk of hearing loss is significantly higher in patients with chronic kidney disease. Dialysis may sometimes result in change in auditory functions. In previous studies, prevalence of hearing loss was increased in renal failure and there was a positive correlation between hearing loss and electrolyte abnormalities in hemodialysis patients.⁷ Change in plasma viscosity, hypocalcaemia, hemoglobin level, serum level of calcium, potassium, urea and creatinine are the risk factors for the development of hearing loss in dialysis patient. Hence the present study was done at our tertiary care centre to assess sensorineural hearing loss in CKD patients. Therefore, the clinicians should be encouraged to include questions about hearing functions in their preventive care protocols, to refer all patients reporting hearing loss to a hearing health professional for evaluation and recommend that patients avoid further treatment with ototoxic medications to preserve their hearing ability.

2. Materials and Methods

Study site: Study was conducted in the departments of Otorhinolaryngology and Nephrology, Gouri Devi Hospital and Research Institute.

Study population: 30 cases seen during the study period with diagnosed chronic renal failure, admitted in the department of nephrology, having complaints of hearing loss and

fulfilling the inclusion and exclusion criteria were enrolled sequentially in this study.

30 controls were healthy patients who attended the ENT outpatient department with complaints other than hearing loss and meeting our inclusion and exclusion criteria were enrolled in this study.

Controls Group: Healthy Volunteers without Hearing Loss

Cases Group: Patients with Chronic Renal Disease and Hearing Loss

Study design: Non-randomised, Case control study

Sample size

With reference to the study of Lasisi AO et al 6, sample size was calculated using the formula: $n = [z^2 p(1-p)] / d^2$

Where: Z = table value of alpha error from Standard Normal Distribution table (1.96)

Power (p) = 80%

Precision error of estimation (d) = 0.07

$n = [1.96 \times 1.96 \times 0.8 (0.2)] / 0.7 \times 0.7 = 29.46$

30 patients per group were required and therefore the sample size for our study is 60.

Inclusion criteria (for cases)

- Age range 20-60 years
- Hearing impairment after occurrence of renal failure (elevated BUN,
- serum creatinine with oliguria)

Exclusion criteria (for cases)

- History of noise exposure
- Diabetes mellitus
- History of renal transplantation
- Haemodialysis

Criteria for healthy volunteers:

- Age range of 20-60 years
- Normal renal function tests
- No history of noise exposure
- No history of diabetes
- No history of renal transplantation

3. Methods

Sixty patients between the age groups of 20-60 years were included in this study. Thirty patients were diagnosed cases of Chronic Renal Failure admitted under the department of nephrology in a tertiary care hospital fulfilling the inclusion and exclusion criteria.

Thirty were healthy volunteers who had come to the ENT outpatient department for complaints other than hearing loss.

Method of collection of data

Data for the proposed study was collected in a pre-tested proforma which included parameters like age, sex, diagnosis and detailed history.

Detailed ENT examination was carried out in all cases along with tests for serum creatinine, urine routine examination, tuning fork tests, pure tone audiogram and tympanometry.

For controls a detailed ENT examination along with tuning fork tests, pure tone audiogram and tympanometry was carried out.

The following parameters were studied

Detailed history of cases and controls

Onset and duration of chronic renal failure in cases

Onset and duration of hearing loss in cases (whether onset of hearing loss is after onset of renal failure)

Severity of Chronic Renal Failure

Serum creatinine

eGFR estimation using MDRD formula

Calculation of stage of CKD

Investigations

Complete blood picture

BUN and Serum creatinine

Urine routine and microscopic examination

Fasting and post-prandial blood sugars

Tuning fork tests

Pure tone Audiogram

Tympanometry

Treatment

All cases of chronic renal failure were being managed conservatively on low-salt and low-potassium diet along with fluid restriction. Monitoring of Blood pressure, serum calcium and parathormone levels were done. Metabolic acidosis if present was controlled.

4. Discussion

The kidney is the organ that is most crucial for the removal of toxic chemicals from the body, thus it provides an ideal environment for the vital organs to work properly. Different renal disorders harm the labyrinth, it is because toxic compounds build up in the blood which impairs the inner ear's functions. The nephron is a functioning unit of the kidney and it resembles the stria vascularis found in the inner ear both structurally and functionally.

Along with antigenic similarities⁸, the kidney and cochlea also share similar physiological mechanisms, such as the active transport of water and salt accomplished by the glomeruli in the kidney and stria vascularis in the cochlea. The hormonal, hydroelectrolytic, and systemic metabolic alterations linked to CKD have been proven to have an impact on the cochlea⁹. The severity and time period of the disorder, electrolyte abnormalities, ototoxic medications, age, co-occurring conditions like diabetes mellitus (DM) and hypertension (HTN), and hemodialysis are some of the components that may play a role in the etiopathogenetic mechanisms of hearing loss in chronic kidney disease.¹⁰⁻¹¹

Chronic kidney disease (CKD) is a world health problem. Compared to the general population, people suffering from CKD have a higher incidence of sensorineural hearing loss (SNHL), which ranges from mild hearing loss in 76% of cases,¹² to medium severe loss of hearing in 47% of

individuals who underwent testing.¹³ Variable nations have quite variable rates of loss of hearing among CKD patients.

Majority of the patients (36.7%) in Controls Group were in the age group of 21-30 years followed by 23.3% patients from the age group of 31-40 years and 20% patients each from the age group of 41-50 and 51-60 years. The mean age of the patients was 36.8 ± 12.03 .

Majority of the patients (33.3%) in Cases Group were in the age group of 51-60 years followed by 30% patients from the age group of 41-50 years, 20% patients from the age group of 31-40 years and 16.7% patients from the age group of 21-30 years. The mean age of the patients was 43.3 ± 11.58 years. There was statistical difference in the patients' age of the groups as per Student t-test.

Majority of the patients in Controls Group were male (53.3%) and female patients constituted 46.7% of the group whereas majority of the patients in Cases Group were female (56.7%) and male patients constituted 43.3% of the group. There was no statistical difference between the groups as per Fisher test. Gowthame, K¹⁴ et al cross-sectional study observed of the 101 patients 67 patients (66.3%) were males and 34 patients (33.7%) were females. Ten of them were between the age group of 18 and 30 years (9.9%), 20 belonged to the 31-40 years age group (19.8%), 32 between 41 and 50 years (31.7%), and 39 patients between 51 and 60 years of age (38.6%) with a mean age 45.5 ± 10.2 years. Forty-five patients (44.6%) were diabetic, 31 patients (30.7%) were hypertensive, and eight patients (7.9) had COPD (14%).

Ranga M¹⁵ et al observational, cross-sectional study assessing impact of CKD on hearing thresholds found majority of patients belonged to the 41-50 years age group (45.5%), followed by the 51-60 years group (22.7%) and 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.

In the Controls Group, 2 patients had mixed hearing loss while 1 patient had SNHL in left ear. In the Cases Group, 2 patients had mixed hearing loss while 12 patients had SNHL. There was statistical difference between the groups as per Fisher test.

It was observed that the patient with SNHL in Controls Group was in the age group of 51-60 years and incidence of SNHL in Cases Group increased with increasing age.

The degree of hearing loss in right ear was significantly higher in Cases Group as compared to Controls Group as per Chi-Square test.

The degree of hearing loss in left ear was higher in Cases Group as compared to Controls Group but this difference was statistically not significant as per Chi-Square Test.

5 (16.7%) patients each had hearing loss for ≤ 7 days and ≥ 1 year while 10 (33.3%) patients each had hearing loss for 8-29 days and 1-11 months. Gowthame K¹⁴ et al cross-sectional study showed a total of nine patients (8.9%) who

were diagnosed with Stage 1 CKD, 15 patients (14.8%) had Stage 2, 32 (31.7%) had Stage 3, 25 (24.8%) had Stage 4, and 20 patients (19.8%) had Stage 5 CKD. About 19.8% of the candidates had a duration of disease < 6 months, 21.8% between 6 and 12 months, 32.7% for 1-2 years, and 25.7% of the participants had CKD for more than 2 years. About 25.7% of them were on diuretic agents. About 10.9% of the study population was undergoing hemodialysis. Bilateral ear involvement was seen among 19.9% of the candidates. Meanwhile, 47.5% of the population had no hearing impairment. In the current study, only a few patients with Stages 4 and 5 CKD received diuretics and hemodialysis.

Ranga M¹⁵ et al observational, cross-sectional study found most 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. More than half of the patients were not on hemodialysis, accounting for 56.8% of cases, while 43.2% of patients were undergoing hemodialysis.

It was observed that patients with no SNHL had CRF for lesser duration whereas there was higher incidence of SNHL in patients with CRF for longer duration. As the duration of CRF progressed, patients become more prone to develop hearing loss. 3 out of 5 patients that had severe hearing loss had CRF for more than 5 - ≥ 6 years. There was significant association of duration of CRF with degree of SNHL. Gowthame K¹⁴ et al cross-sectional study found based on the WHO classification of hearing loss, the degree of hearing loss observed 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. a significant P value between the involved ear with the degree of hearing loss with the duration and stage of CKD, use of diuretics, and hemodialysis.

Ranga M¹⁵ et al observational, cross-sectional study assessing impact of CKD on hearing thresholds showed 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. 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. 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. 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 and a positive correlation between the stage and duration of CKD with hearing loss. Fufore M¹ et al

study on Hearing threshold of patients with chronic kidney disease undergoing haemodialysis found an increase in hearing loss with an increase in CKD stage in patients in CKD Stage 5 had a worse hearing report when compared to Stages 3 and 4.

Kanotra S¹⁶ et al prospective cross-sectional study observed a positive correlation between the stage and duration of CKD with hearing loss.

Sodhi JK¹⁷ et al study 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 and a statistically significant association between duration of CKD and hearing loss indicating worsening auditory function with longer disease duration.

Age is risk factor for both CKD and hearing loss, plays a critical role in the increased susceptibility to these health issues. As individuals age, kidney function naturally declines, and hearing loss becomes more prevalent due to age-related degeneration of the auditory system. Diabetes, hypertension, and cardiovascular disease further compound the risk, as these conditions often coexist with CKD and have been linked to vascular damage, which can adversely affect both kidney function and the auditory system. The overlap of these risk factors suggests that individuals with these comorbidities should be closely monitored for both CKD and hearing loss, especially as they age.¹⁸

It was observed that there is higher incidence of SNHL in patients with CKD Stage 5 and as the stage of CKD progressed, patients become more prone to develop hearing loss. All patients with severe hearing loss had CKD Stage 5 with significant association of stage of CKD with degree of SNHL. Gowthame K¹⁴ et al cross-sectional study observed a significant association was found between BERA findings and duration of CKD, stage of CKD, hemodialysis status, and diuretics intake. Follow-up hearing assessments at 3 and 6 months showed no improvement in hearing. Lin C¹⁹ et al reported a correlation between hemodialysis and SNHL with possible mechanisms such as osmotic and electrolyte imbalance in the labyrinth, exposure to dialyzers with deteriorated cellulose acetate membranes, causing cellulose acetate breakdown products to enter the blood which in turn damages the hair cells and lead to hearing loss.

Ranga M¹⁵ et al observational, cross-sectional study showed 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.

It was observed that there is higher incidence of SNHL in patients with serum creatinine level of ≥ 4.5 mg/dL. The mean serum creatinine value of patients with and without

SNHL was 5.27 ± 1.88 and 2.24 ± 1.01 mg/dL respectively and there was significant difference.

It was observed that there is higher incidence of SNHL in patients with A2 and A3 grading of proteinuria. There was significant association of proteinuria with degree of SNHL.

It was observed that there is higher incidence of SNHL in patients with low eGFR. There was significant association of eGFR with degree of SNHL. Kanotra S¹⁶ et al prospective cross-sectional study found significant correlation between the hearing loss and serum urea and creatinine levels.

Strength

All patients diagnosed with CKD irrespective of the stage (from stage I to V) with even mild hearing loss during the early stages could be identified with proper surveillance and rectified immediately.

5. Conclusion

A association between CKD and hearing loss, where hearing deteriorates in the end stages of CKD and prolonged duration of the disease. The limited use of diuretics and a controlled number of hemodialysis can have a positive effect in reducing the risk of hearing loss along with adequate surveillance. This study would like to point out that audiological assessment is one of the important measures to be assessed in a patient with CKD, especially undergoing dialysis.

Patients suffering from long standing renal failure (long duration) had more chances of hearing loss than the healthy volunteers and there is cumulative effect of other risk factors such as haemodialysis, electrolyte imbalance, hypertension, proteinuria, serum calcium and parathormone on SNHL in CRF patients.

Hearing loss is becoming increasingly evident, as the patients tends to live longer because of improved quality of life of CRF patients. The raised serum creatinine level does predict the occurrence of SNHL. A profound hearing loss or a drastic deterioration in hearing with dialysis has a positive effect in reducing the risk of SNHL with proper monitoring of the diuretic dosages and the number of hemodialysis given to patients.

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