

Evaluation of the prevalence of hearing loss and associated patterns in hemodialysis patients: A cross-sectional study in Iran

Evaluación de la prevalencia de hipoacusia y patrones asociados en pacientes en hemodiálisis: un estudio transversal en Irán

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Abstract

Objective: There are many similarities between renal nephrons and the cochlear duct in the ear. On the other hand, the prevalence, extent, and patterns of hearing loss associated with chronic kidney disease (CKD) reported by different studies are significantly different. Therefore, this study aimed to determine the prevalence of hearing loss and associated patterns in patients undergoing dialysis.

Methods: In this cross-sectional study, patients undergoing hemodialysis referred to Khatam al-Nabia Hospital in Zahedan, Iran in 2020, were studied. The samples that met the inclusion and exclusion criteria were entered into the study by census method, and finally, 60 people were examined. After recording demographic information, patients underwent an audiometric evaluation, and the information was assessed and recorded by a specialist.

Results: Out of 60 patients, in terms of hearing loss, 24 patients (40%) were healthy, and 36 patients (60%) were unhealthy; also, the most common type of hearing loss in patients was sensorineural hearing loss in the right ear (32 patients, 88.9%) and left ear (32 patients, 91.4%), respectively. Besides, in patients with right and left ear involvement, the mean duration of renal failure in mild and moderate hearing loss was 65.76 ± 49.17 , 42.10 ± 37.78 , 63.10 ± 45.92 , and 43.90 ± 43.61 months, respectively, which demonstrated a statistically significant difference. ($P < 0.05$).

Conclusion: Hearing loss is common in patients with chronic kidney disease, and an increase in the duration of kidney disease can directly affect hearing loss in patients undergoing hemodialysis.

Keywords: Hearing loss, renal insufficiency, chronic, audiometry, Iran.

Resumen

Objetivo: Existen muchas similitudes entre las nefronas renales y el conducto coclear del oído. Por otro lado, la prevalencia, el alcance y los patrones de la pérdida de audición asociada a la enfermedad renal crónica (ERC) comunicados por distintos estudios son significativamente diferentes. Por lo tanto, este estudio tenía como objetivo determinar la prevalencia de la pérdida de audición y los patrones asociados en pacientes sometidos a diálisis.

Métodos: En este estudio transversal se estudiaron los pacientes sometidos a hemodiálisis remitidos al Hospital Khatam al-Nabia de Zahedan (Irán) en 2020. Las muestras que cumplían los criterios de inclusión y exclusión se introdujeron en el estudio mediante el método de censo, y finalmente se examinaron 60 personas. Tras registrar la información demográfica, los pacientes se sometieron a una evaluación audiométrica, y la información fue evaluada y registrada por un especialista.

Resultados: De los 60 pacientes, en cuanto a la pérdida de audición, 24 pacientes (40%) estaban sanos, y 36 pacientes (60%) no estaban sanos; además, el tipo de pérdida de audición más común en los pacientes era la pérdida de audición neurosensorial en el oído derecho (32 pacientes, 88,9%) y en el izquierdo (32 pacientes, 91,4%), respectivamente. Además, en los pacientes con afectación del oído derecho e izquierdo, la duración media de la insuficiencia renal en la pérdida de audición leve y moderada fue de $65,76 \pm 49,17$, $42,10 \pm 37,78$, $63,10 \pm 45,92$ y $43,90 \pm 43,61$ meses, respectivamente, lo que demostró una diferencia estadísticamente significativa. ($P < 0.05$).

Conclusiones: La pérdida de audición es frecuente en los pacientes con enfermedad renal crónica, y un aumento de la duración de la enfermedad renal puede afectar directamente a la pérdida de audición en los pacientes sometidos a hemodiálisis.

Palabras clave: Pérdida auditiva, insuficiencia renal crónica, audiometría.

Introduction

The incidence of chronic kidney disease (CKD) has increased significantly in the last few years due to the significant increase in the number of diabetes and hypertension patients, which are the main risk factors for CKD¹. Patients with advanced CKD require kidney transplantation or dialysis to survive². Dialysis has been shown to affect the function of almost all parts of the body system. Sensorineural hearing loss (SNHL), which has a more significant effect on high frequencies than low frequencies, has been diagnosed in patients with CKD^{3,4}.

There are many anatomical, physiological, pharmacological, and pathological similarities between renal tubular cells and cochlear stria of the ear at the ultrastructural level. Both structures have epithelium near the arteries and basement membrane. This is most evident in the capillary endothelium in the Bowman capsule in the kidney's proximal tube and the cochlear stria vascularis. Thus, in addition to antigenic similarity, the cochlea and the kidney have similar physiological mechanisms, i.e., the active transfer of fluids and electrolytes is achieved by the stria vascularis in the cochlea and the glomeruli in the kidney^{3,5-7}. It has previously been reported that the cochlea is affected by systemic-metabolic, hydro electrolytic, and hormonal changes associated with CKD. Several factors may be related to the etiopathogenetic mechanisms of hearing loss in CKD, including factors related to the disease's severity and duration, electrolyte disorders, drug toxicity, age, and comorbid conditions such as diabetes mellitus, hypertension, and hemodialysis^{8,9}. Hearing loss is widespread in patients with CKD compared to the general population¹⁰. The possible mechanism is a common antigenic reaction between the kidneys and labyrinths of the ear due to osmotic changes induced by dialysis and the ototoxic effects of diuretics¹¹. Besides, hearing loss and uremia is associated with each other and can negatively affect a patient's quality of life by restricting communication and creating a risk of social isolation and emotional problems⁴.

Different results have been reported on the effect of hemodialysis on hearing in patients with chronic renal failure; some studies demonstrated that hemodialysis does not affect the hearing of patients^{12,13} and others suggested that this treatment method is effective in inducing hearing disorders. Studies in adults, especially on the effect of hemodialysis, are highly contradictory, indicating the need for further studies in this field. Therefore, considering the cases mentioned above, in this study, we decided to investigate the frequency and types of hearing loss in hemodialysis patients. Early diagnosis of hearing loss, followed by informing the patient and utilizing appropriate treatment, can prevent this complication^{14,15}.

Materials and methods

Selection of patients

In this cross-sectional study, hemodialysis patients referred to Khatam al-Nabia Hospital in Zahedan, Iran, in 2020 were studied. The present study was carried out after the ethics committee's approval and the research committee of Zahedan University of Medical Sciences. Inclusion criteria were 25 to 65 years of age, at least 6 months of hemodialysis treatment, definitive diagnosis of chronic kidney disease by a specialist, lack of previous hearing problems (such as trauma or congenital heart problem) personal consent of the patient. Exclusion criteria were peritoneal dialysis, non-chronic kidney disease (acute kidney disease, etc.), and history of age-related or congenital hearing problems and previous trauma. Accordingly, 60 patients were included in the study. In addition to examining the demographic factors of age and sex, other variables such as hearing loss, involved ear, degree of hearing loss, type of underlying disease, duration of renal failure, duration of dialysis, and several dialysis sessions were assessed a week.

Method of study

Following the researcher's evaluation of demographic information at the hemodialysis site, patients who met the inclusion criteria were transferred to the audiometry ward of Khatam al-Nabia Hospital. The available audiometers were Madsen audiometer model MIDIMATE622 and Madsen tympanometer model ZODIAC 90. An ENT specialist then evaluated the information, and the type of hearing loss (SNHL OR CHL) and the degree of hearing loss (mild, moderate, severe, very severe) were assessed, and the related information was recorded.

Data analysis

Descriptive statistics, including statistical tables and graphs and frequencies in percentages, were used to describe the data, and the Kruskal-Wallis test was used to compare frequencies in groups. The significance level was considered less than 0.05.

Results

In the present study, 60 hemodialysis patients were evaluated. Amongst the studied patients, 33 (55%) were male, and 27 (45%) were female, and the mean age of patients was 48.53 ± 13.08 years. Also, 24 patients (40%) were healthy, and 36 patients (60%) had hearing loss. In terms of hearing loss (HL), 19 patients (31.7%) had moderate HL in the right ear, and 20 patients (33.3%) had mild HL in the left ear (**table I**); Also, the study of hearing loss pattern showed that sensorineural hearing loss (SNHL) in the right ear (32 patients, 88.9%) and left ear (32 patients, 91.4%) was the most common type of hearing loss in patients (**table I**).

Table I: Degree and pattern of hearing loss in patients undergoing hemodialysis.

Variables		Ear	
		Right (N/%)	Left (N/%)
Degree of hearing loss	Healthy (<20)	24/40%	26/43.3%
	Mild (21-40)	17/28.3	20/33.3%
	Moderate (41-70)	19/31.7%	13/21.7%
	Severe (71-90)	-	1/1.7%
	Total	60/100%	60/100%
The pattern of hearing loss	Conductive (CHL)	3/8.3%	2/5.7%
	Sensorineural (SNHL)	32/88.9%	32/91.4%
	Conductive and Sensorineural (Mix)	1/2.8%	1/2.9%
	Total	36/100%	35/100%

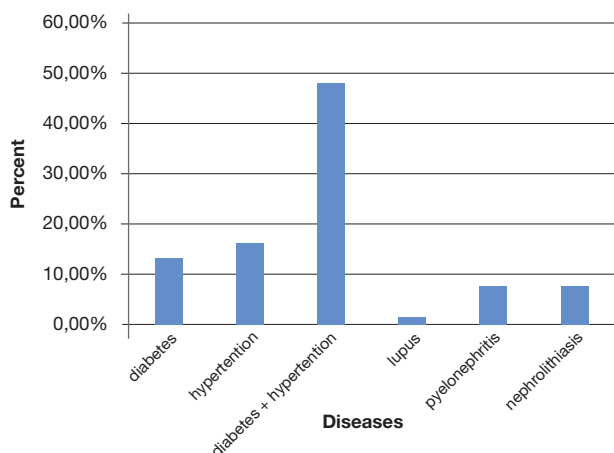
Table II: Results of audiometry test in both ears, mean duration of kidney disease, the mean duration of each dialysis session, and the number of dialysis sessions per week.

Variables		SD± Mean	Min	Max
Audiometry test	Right ear	31.75 ± 20.36	6	70
	Left ear	28.83 ± 17.99	5	80
Duration of kidney disease (months)		44.16 ± 37.62	6	180
Duration of each dialysis session (hours)		3.48 ± 0.62	2	4
Number of dialysis sessions per week		2.80 ± 0.40	2	3

Table III: Association between kidney disease duration and number of dialysis sessions per week, and hearing loss in hemodialysis patients.

Variables			SD± Mean	P-value*
Duration of kidney disease	Right ear	Healthy	30.50 ± 16.99	0.01
		Mild	65.76 ± 49.17	
		Moderate	42.10 ± 37.78	
	Left ear	Healthy	31.11 ± 17.53	0.02
		Mild	63.10 ± 45.92	
		Moderate	43.61 ± 43.90	
Number of dialysis sessions per week	Right ear	Healthy	2.70 ± 0.46	0.34
		Mild	2.88 ± 0.33	
		Moderate	2.84 ± 0.37	
	Left ear	Healthy	2.73 ± 0.45	0.50
		Mild	2.90 ± 0.30	
		Moderate	2.76 ± 0.43	

Figure 1: Frequency distribution of underlying diseases in hemodialysis patients.



According to **table II**, the mean results of the audiometry test of the right and left ears were 31.75 ± 20.36 dB and 28.83 ± 17.99 dB, respectively. Also, the mean duration of kidney disease, duration of each dialysis session, and the number of dialysis sessions per week was determined.

The study of the underlying diseases also showed that most people (29 patients, 48.3%) had both diabetes and hypertension, and 10 patients (16.7%) had high blood pressure (**Figure 1**).

The frequency distribution of involved ears in dialysis patients with HL showed that 2 patients (5.6%) had right ear involvement, 4 patients (11.1%) had left ear involvement, and 30 patients (83.3%) had involvement of both ears. According to **table III**, in patients with right and left ear involvement, renal failure's mean duration was significantly different in mild and moderate hearing loss. (P <0.05). The average number of dialysis sessions per week in mild and moderate hearing loss also showed no statistically significant difference in patients with right and left ear involvement (P >0.05).

Discussion

Kidney nephrons and cochlear ducts have been shown to have a similar epithelium, which includes a sodium-potassium pump that uses ATPase. Carbonic anhydrase is also present in both nephrons and cochlear stria¹⁶. Various pharmacological factors affect both the kidney and the inner ear, including aminoglycoside antibiotics, both ototoxic and nephrotoxic¹⁷. It has also been shown that there is an immunological link between the kidney and the ear, as antibodies produced against nephrons settle in the stria vascularis. The prevalence of cochlear hearing loss in patients with renal failure is more than in ordinary people that their hearing is affected by their age and gender^{18,19}.

This study aimed to evaluate the prevalence of hearing loss and associated patterns in patients with chronic kidney disease and undergoing dialysis. Our results demonstrated mild to moderate hearing loss in the right, and left ear was observed in 60% and 55% of

patients, respectively. About 90% of these patients had sensorineural hearing loss (SNHL) in the right and left ears. Also, the duration of renal failure had significant effects on patients' hearing loss. However, there was no statistically significant relationship between the number of dialysis sessions per week and hearing loss.

Similar to the results of the present study, HK Saeed et al., to evaluate sensory hearing loss in patients with chronic renal failure undergoing hemodialysis, showed that 66.1% of patients had sensory hearing loss, and during 12 months of follow-up, 6 other patients were also diagnosed with HL (67.3% in total). Also, the mean hearing threshold at the beginning of the study was 29.2 ± 21.2 dB and at the end of the study was 36.9 ± 17.3 dB, which was a significant difference⁹. Kohansal et al. also observed SNHL in 73.4% of all patients¹³. Additionally, our results were almost consistent with the studies by Sharma et al. (HL in 73.7% of patients)²⁰ and Singh et al. (HL in 70.9% of patients)²¹. However, low frequencies of SNHL have been reported in previous studies on hemodialysis patients in Iran (46%)²² and other countries^{15,23}. This difference may be due to changes in sample size, differences in age, kidney disease duration and hemodialysis, or a hearing assessment procedure.

In another study by Reddy et al., conducted on 200 patients with CKD, 52% of patients had high-frequency hearing loss, 9% had moderate-frequency hearing loss, and 2.5% had low-frequency hearing loss; 2.5% of patients had hearing loss at all frequencies. 61% of patients had bilateral ear involvement, and 5.5% had unilateral involvement²⁴. The findings of this study were similar to the present study, but the frequency of hearing loss in our study, in contrast to this study, was mainly at moderate frequencies in the right ear and low frequencies in the left ear.

Regarding the effect of chronic kidney disease on hearing loss, Risvi et al. reported that hearing deterioration in patients with CKD increases with disease progression and the need for dialysis. Anatomical changes such as endolymphatic system collapse, swelling, and atrophy have been shown to occur in the ear's labyrinth, and these changes have been attributed to osmotic imbalance due to hemodialysis²⁵. A study by Kusakari et al. it was reported that inner ear dysfunction was not associated with hematocrit, levels of blood urea nitrogen, creatinine, and duration of hemodialysis²⁶. According to studies, histopathological changes in the inner ear of patients with CKD undergoing hemodialysis may result in mild loss of cochlear outer hair cells and spiral ganglion cells or complete absence of the organ of Corti. However, these histopathological changes' patterns and importance need to be widely investigated to identify the effect of dialysis on the auditory pathways^{3,27}. In a study, Fidan et al. reported that sensorineural hearing loss was more common in CKD patients requiring dialysis than normal controls and that hemodialysis patients were more affected than peritoneal dialysis patients³. Jamaldeen et al.

also reported that hearing loss was present in 41.7% of patients with CKD, which was significantly higher than the control group. However, contrary to our study results, they stated that hearing loss might be inversely related to the number of hemodialysis sessions, but it is not associated with the disease's duration²⁸. This difference in results may be due to the number of samples in their study, 120 people. Also, Wu et al. showed in their study that CKD patients were at a significantly higher risk for SNHL compared to the non-CKD group. According to their results in the CKD group, the degree of SNHL in patients undergoing hemodialysis was higher than those without hemodialysis. Having CKD for a more extended period was also associated with a significant increase in the frequency of SNHL. The disease's duration was also confirmed as a risk factor in animal models of CKD, in which exacerbation of cochlear impairment overtime was confirmed²⁹. Additionally, some studies have suggested that the causes of hearing loss may be vascular changes and loss of cells in the organ of Corti during hemodialysis, and osmotic, electrolytic, and biochemical changes during dialysis, especially long-term dialysis³⁰. Osmotic oscillations and osmotic pressure during dialysis are greatly important factors that exacerbate hearing loss in these patients³¹. Other important factors that cause the exacerbation of HL in dialysis patients include changes in volume and blood pressure, which impair blood flow to the cochlea and its function³².

In general, apart from the initial findings, this study demonstrated our current understanding of hearing loss in CKD. Although there is no doubt that hearing loss is common among patients with CKD, studies with larger sample sizes are needed to elucidate the association between hearing loss in CKD and hemodialysis. Another question that arises in this regard is whether the audiometric screening of all CKD patients helps identify mild hearing loss and prevent HL severity progression, significantly if the definitive role of hemodialysis can be determined in prospective longitudinal studies. Moreover, the association between hearing loss in CKD and ototoxic medications needs to be assessed by further research as it can have significant clinical implications.

Conclusion

The results showed that hearing loss is common in CKD patients, and most studied patients were diagnosed with sensorineural hearing loss in the right and left ears. There was also a significant relationship between hearing loss and the duration of kidney disease and hemodialysis.

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