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Original article

Hearing Assessment of Chronic Renal Failure (CRF) Patients

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Abstract

Objective: To determine the effect of chronic renal failure disease and hemodialysis on auditory system compared to normal control persons. **Method:** The current study comprised 50 patients (28 men and 22 women) with chronic renal failure receiving haemodialysis, with ages ranging from 6 to 65 years, and 50 controls (six men and thirty-four women), with ages ranging from 34.8 to 11.71 years (15-60years). Each individual underwent testing using brainstem auditory evoked potential, tympanometry, and pure tone audiometry (ABR). Tympanometric values, auditory evoked potentials, and the means of air and bone conduction at each frequency were computed for the study groups. **Results:** Pure tone audiometry was significantly higher among patients with chronic renal failure at all pure tone audiometry frequencies as compared with healthy controls with a statistically significant p-values(p value 0.0004, 0.0004, 0.0006, 0.0006, 0.0005, and 0.0009) and more obvious at high frequencies. **Conclusion:** According to this study, hearing loss was more common in haemodialysis patients with chronic renal failure. Most patients exhibited a mild sensorineural hearing loss that was mostly noticeable at higher frequencies. This study also showed that, in contrast to healthy controls, those with end-stage chronic renal failure

receiving haemodialysis have delayed neuronal conduction throughout the auditory circuit.

1. Introduction:

Chronic renal failure is a characteristic steady decline in renal function. The primary issue is the progressive loss of nephrons, which causes an electrolyte imbalance, metabolic acidosis, disruption of calcium metabolism, accumulation of toxins, persistent decline in glomerular filtration rate, and an increase in blood urea and creatinine. It causes Hearing loss, neuropathy, bleeding diathesis, abnormal calcium metabolism, and haematological issues will all affect these people. [1]

There is antigenic similarities between the cochlea and kidney[2], discovered that the stria vascularis in the cochlea and the glomeruli in the kidney are in charge of the active transfer of fluid and electrolytes.[3] The systemic metabolic, hydroelectrolytic, and hormonal changes associated with CRF have been shown to have an impact on the cochlea in the past. [4]. The processes of hearing loss in CRF may be influenced by a number of variables, such as the condition's severity and prognosis, electrolyte imbalances, ototoxic medicines, age, concurrent illnesses like diabetes mellitus and hypertension, and hemodialysis.[5]. Studies examining the impact of renal failure on hearing have frequently found SNHL in patients with CRF [6]. Incidence of hearing loss in CRF patients vary significantly across nations. [7], it was reported to be 63.5% in India, 67% in Nigeria, [8], 46% in Iran. [9], and 63.6% in Croatia, [10]. The prevalence of hearing loss was higher in earlier studies (between 70% and 75%) [11].

This discrepancy may result from variations in patient ages, techniques of determining hearing loss, or the length of CRF and hemodialysis.[12].Aim of the work was to determine the effect of CRF disease and hemodialysis on auditory system compared to normal control persons.

2. Patients and Methods:

The fifty patients in this study group, 28 men and 22 women, had an average age of 38.62 17.91 years (6-65 years). The hospital connected to Beni-Suef University's nephrology department gathered cases with the diagnosis of chronic renal failure requiring hemodialysis. Between July 2019 and March 2020, this study was carried out at the Beni-Suef University Hospital's Audiology Outpatient Clinic.

Inclusion criteria: Patients with CRF on hemodialysis, age up to 65 years and both males and females were included.

Exclusion criteria: Patients with a history of neurological, vascular, or autoimmune disease, middle ear disease, prior ear surgery, hereditary hearing loss, oral ototoxic medications, prolonged noise exposure, head injury, or kidney transplantation.

Ethics: The study was performed after approval of local ethical committee of Beni suef university hospital Approval No: FMBSUREC / 16062019/ Hussein. Written informed consent from every patient was taken before.

Equipment: Audiometer (Inter acoustics AD629), immitancemeter (MAICO;MI 24), sound treated room(locally made) and brainstem auditory-evoked potentials (BAEPs) (Interacoustic Eclipse EP15).

Methods: Following procedures were performed on each patient as well as on healthy controls: A thorough history taker, otologic examination, and a fundamental audiological evaluation, together with signed informed consent before study participation: Air conduction threshold was examined with the Inter Acoustics "AD629" at frequencies between 250 and 8000 Hz, as well as at octave intervals, While employing narrow band noise for contralateral masking and frequencies between 500 and 4000 Hz to measure bone conduction threshold. In speech audiometry, Arabic phonetically balanced (PB) monosyllabic words were utilised to determine Arabic spondaic words' speech reception threshold (SRT) and word discrimination score (WDS%) (Soliman et al., 1985). Low probe tone tympanometry using imitationmetry MAICO "MI 24" (226 Hz). Auditory evoked potentials from the interacoustic Eclipse "EP 25" in the brainstem Electrodes for recording and technique: The lower midfrontal region served as the location for the ground electrode, the vertex of the scalp as the location for the active electrode, and the left (Al) and right (A2) mastoids as the location for the reference electrodes. Using a skin-preparation gel to rub the skin raw, Ag/AgCl electrodes filled with conductive paste were applied to the skin. Electrode impedances were less than 5 k and interelectrode impedances were less than 2 k. b) Stimulus characteristics: A click stimulus with an intensity of 80 dBnHL was provided at a rate of 21.1 stimuli per second in rarefaction polarity. Average click potentials of 1200 were discovered. To guarantee that the waveforms could be replicated, two recordings were collected. The interpeak latencies of waves I-V, I-III, and III-V Interpeak Latencies (IPLs) were examined with BAEPs as well as the absolute latencies of waves I, III, and V. 6. Biochemical assessments: Ca, K, Na, and P's biochemical characteristics were noted.

3. Results:

The current study included 50 patients with chronic renal failure on hemodialysis. They all presented to Audio-Vestibular outpatient clinic at Beni-Suef University hospital. Fifty healthy controls were taken, and they were age and sex matched. Both groups were subjected to detailed history taking, otologic examination, basic audiological evaluation, brainstemauditory-evoked potentials and biochemical evaluations.

Table (1) demonstrated Age, sex, and duration of hemodialysis among studied population: both groups were matched regarding their age and sex with non-statistically significant difference, (p values 0.341, 0.055) for age and sex, respectively. The mean duration of hemodialysis in the cases group was ranged from one to twelve years with an average duration of (5.39 ± 3.0) years.

Table (1): Age, sex, and duration of hemodialysis among studied population; (N= 100):

		NormalN= 50	**CasesN= 50**	**P-value**
Age, (years)	**Mean ±SD**	34.08 ±11.71	38.62 ±17.91	0.341
	Max – Min	60 – 15	65 – 6	
Sex, N (%)	**Male**	16 (32)	28 (56)	0.055
	Female	34 (68)	22 (44)	
Duration of hemodialysis	**Mean ±SD**	NA	5.39 ±3.0	--
	Max – Min		12.0 – 1.0	

NA: not applicable

Table (2) Showed the pure tone audiometry results (PTA) at different frequencies. PTA was significantly higher among patients with chronic renal failure at all PTA frequencies as compared with healthy controls with a statistically significant p-values.

PTA		**NormalN= 50**	**CasesN= 50**	***p-value***
250 HZ	**Mean ± SD**	22.9 ± 3.1	24.9 ± 3.3	0.004*
	Max - Min	25 – 15	45 – 20	
500 HZ	**Mean ± SD**	21.1 ± 3.7	25.5 ± 4.6	0.004*
	Max - Min	25 – 10	50 – 20	
1 KHZ	**Mean ± SD**	20.5 ± 2.9	26.8 ± 7.5	0.006*
	Max - Min	25 – 10	50 – 5	
2 KHZ	**Mean ± SD**	19.7 ± 4.3	28.4 ± 10.7	0.006*
	Max - Min	25 – 10	70 – 15	
4KHZ	**Mean ± SD**	19.8 ± 4.9	34.4 ± 16.2	0.005*
	Max - Min	25 – 10	85 – 15	
8 KHZ	**Mean ± SD**	21.5 ± 4.3	41.6 ± 18.6	0.009*
	Max - Min	25 – 10	85 – 15	

Table (3) illustrate the distribution of the studied participants according to hearing impairment in both Rt. & Lt. In the Rt. Ear, 36% of cases had no hearing impairment, 48% had mild impairment, 4% had moderate impairment and 12% had moderate to severe impairment, while all participants in the control group had normal hearing (p-value <0.001).In the Lt. Ear, 38% of cases had no hearing impairment, 40% had mild impairment, 16% had moderate impairment and 6% had moderate to severe impairment, while all participants in the control group had normal hearing (p-value <0.001).

Table (3): Hearing Impairment for cases and control groups; (N= 100):

	RT. EAR			**LT. EAR**		
	Cases N= 50	**Normal N= 50**	**p-value**	**Cases N= 50**	**Normal N= 50**	**p-value**
Normal	18 (36.0)	50 (100.0)	<0.001*	19 (38.0)	50 (100.0)	<0.001*
Mild	24 (48.0)	0 (0.00)		20 (40.0)	0 (0.00)	
Moderate	2 (4.0)	0 (0.00)		8 (16.0)	0 (0.00)	
Moderate to Severe	6 (12.0)	0 (0.00)		3 (6.0)	0 (0.00)	

Figure (1) showed that the mean of speech discrimination for the patients with chronic renal failure was significantly lower as compared with healthy controls, (92.92% ±5.01% vs. 98.64 ±1.91%, p<0.001).

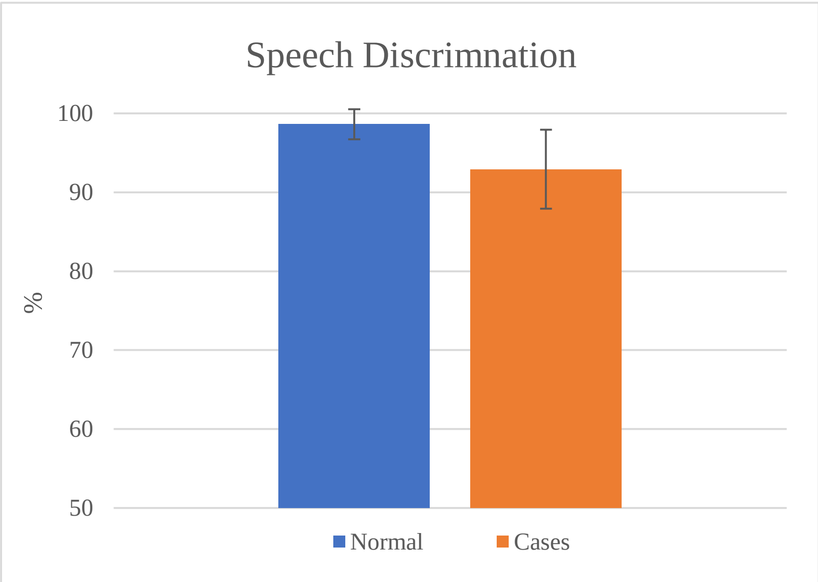


Table (4) showed Auditory Brainstem Responses (ABR) for different three positive waves I, III, V, and three Interwave latencies I-III, I-V and III -V. ABR was significantly increase among patients with chronic renal failure at all ABR absolute latencies and Interwave latencies I-III, I-V as compared with healthy controls with a statistically significant p-values.

Table (4): Auditory Brainstem Response (ABR) for cases and control groups:

ABR		**Normal**	**Cases**	**p-value**
ABR I	**Mean ± SD**	1.33±0.15	1.41±0.21	0.001*
	Min- Max	1.00-1.63	1.00-1.93	
ABR III	**Mean ± SD**	3.37±0.13	3.61±0.27	<0.001*
	Min- Max	3.00-3.69	3.13-4.40	
ABR V	**Mean ± SD**	5.27±0.14	5.56±0.33	<0.001*
	Min- Max	5.00-5.61	5.00-6.47	
ABR I-III	**Mean ± SD**	2.01±0.37	2.18±0.27	<0.001*
	Min- Max	1.11-2.54	1.60-3.00	
ABR I-V	**Mean ± SD**	3.93±0.19	4.15±0.37	<0.001*
	Min- Max	3.52-4.40	3.53-5.40	
ABR III-V	**Mean ± SD**	1.93±0.39	1.97±0.26	0.352
	Min- Max	1.46-2.40	1.53-2.87	

Table (5) showed that A tympanogram was obtained in thirty-four (68%) of the control group, while As tympanogram was obtained in sixteen (32%) of them. In the cases group, A tympanogram was obtained in thirty-five (70%), while as tympanogram was obtained in fifteen (30%). There was no significant difference between both groups regarding results of tympanogram (p value 0.802).

Table (5): Tympanogram of cases and control groups

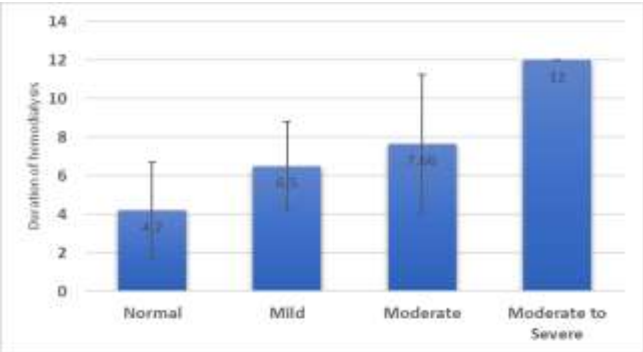
		NormalN= 50	**CasesN= 50**	**P-value**
Tympanogram, N (%)	**As**	16 (32)	15 (30)	0.802
	A	34 (68)	35 (70)	

Data is presented as mean ±SD for quantitative data

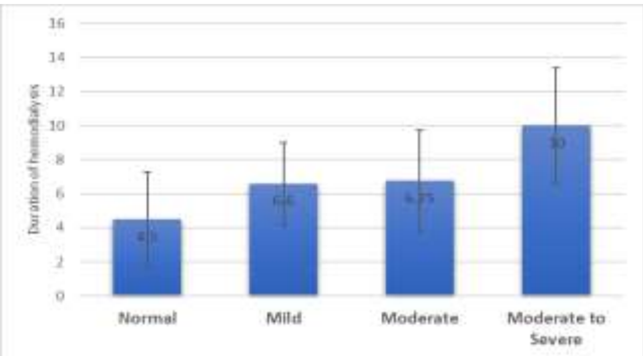
Statistical analysis carried out by independent sample t-test analysis.

*p-value ≤0.05 is considered statistically significant.

Figure (2) The degree of hearing loss was changed from normal hearing to severe hearing loss by increasing the length of hemodialysis, with a statistically significant p-value of 0.003 showing the relationship between the two.



As demonstrated in figure (3); the degree of hearing loss was changed from normal hearing to severe hearing loss by increase the duration of hemodialysis with a statistically significant p-value=0.022.



As illustrated in figure (4); there were a statistically significant mild positive linear correlation between hearing impairment degree and duration of CRF in the Rt. and Lt. Ears; (r= 0.382, p=0.006) and (r=0.392, p=0.005) in the Rt. And Lt. ears respectively.

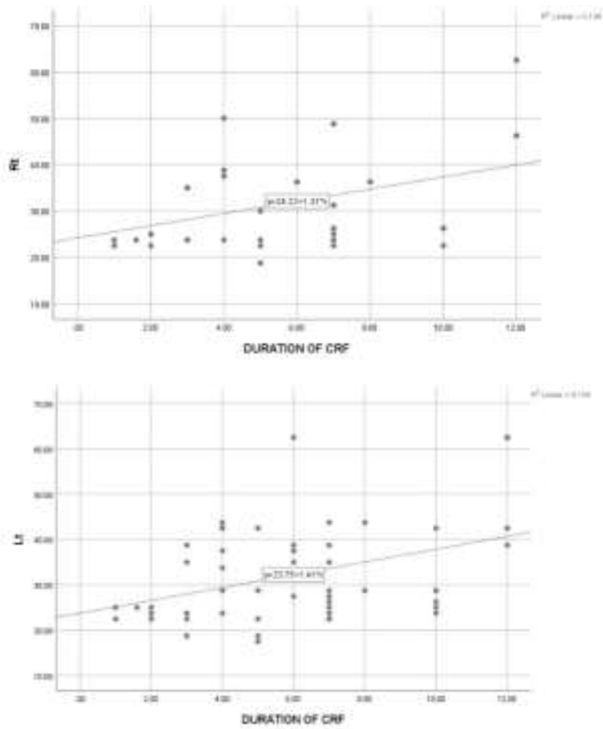


Figure (4): Correlation between hearing impairment degree and duration of CRF

Table (6): Correlation between ABR and duration of hemodialysis in studied patients with chronic renal failure on hemodialysis; (N= 50):

	DURATION OF HEMODIALYSIS IN CASES GROUP	
	r	**P-value**
ABR I	-0.077	<0.001
ABR III	0.028	<0.001
ABR V	0.052	0.053
ABR I-III	0.111	<0.001
ABR I-V	0.081	<0.001
ABR III-V	0.008	<0.001

There was significant negative correlation between ABR wave I and duration of hemodialysis (r= -0.077, P<0.001). There was significant positive correlation between ABR waveIII and duration of hemodialysis (r= 0.028, P<0.001). There was non-significant positive correlation between ABR wave V and duration of hemodialysis (r= 0.052, P= 0.053). **Table (6)**

4. Discussion:

Patients with Alport syndrome were the first to report a link between CKD and hearing loss [13].

However, in instances where syndromes or genetic illnesses are unrelated to the relationship, Similarities between the nephron and the stria vascularis of the cochlea in terms of morphology, physiology, pathology, and pharmacology may be to blame. The association between inner ear damage and renal failure is unquestionably much more than a coincidental observation because the kidney and the cochlea share similar physiologic, ultrastructural, and antigenic properties. [14].

The goal of the current investigation was to assess how hemodialysis and CRF illness affected participants' auditory systems in comparison to healthy controls. 50 CKD patients and 50 controls with matching ages and genders had their hearing function assessed. The hearing threshold is found using pure tone audiometry (PTA) at a particular frequency (Liu et al., 2020). The hearing thresholds of CKD patients and healthy controls were evaluated in the current study.

PTA showed that the sick group's hearing threshold was considerably higher than that of the healthy controls at all frequencies (p-values = 0.004, 0.006, 0.005, and 0.009). (250 Hz, 500 Hz, 1 KHz, 2 KHz, 4 KHz, and 8 KHz). Our study's findings are completely compatible with those of other research that found a substantial difference in the hearing thresholds of those with CKD and those without it. The results of this study supported those of Boateng et al. [15], who looked at the prevalence, types, and severity of hearing impairment among CKD patients receiving hemodialysis in Ghana. In this study, 50 CKD patients and 50 controls with similar ages and genders served as the subjects. In that study, the case group outperformed the control group across all test frequencies, and this difference was statistically significant in both ears (0.00 p 0.038) at the 95% confidence level. [15]. The inner ear's reaction to an electrolyte imbalance brought on by hemodialysis or CKD may have been what distinguished CKD sufferers from controls [16]). The reason of hearing loss is still uncertain in each case due to a lack of specific information. PTA revealed an increase in hearing threshold in all patient groups in a unique Indian study that examined how CKD influenced a range of auditory features.[17].

Nevertheless, despite this discrepancy, our results are in line with the literature, where prevalence among CKD patients has been reported to range from 46.0% to 77.0% [7]. In our study, 64% of the CKD group had hearing loss in the right ear and 62% had it in the left ear.

This rate was higher than what Boateng et al. [15] found, who said that 32% of the patient group had hearing loss as a prevalent. The length of hemodialysis in the current study increased the degree of hearing loss from normal hearing to severe hearing loss, with a statistically significant p-value of 0.003. After three hemodialysis sessions, there was a significant decrease in hearing threshold, according to the findings of a study on the effect of hemodialysis on patients with chronic renal failure's ability to hear [8], and there was a connection between the degree of the condition and the serum creatinine levels and the post-treatment pure tone threshold. According to Renda et al., [18], Children with dialysis-dependent chronic kidney disease (CKD) between the ages of 6 and 18 showed a strong correlation between hearing loss and the frequency of hemodialysis. Hemodialysis may hasten the development of hearing loss in CRF patients. This might be due to alterations in the fluid and electrolyte content of the endolymph or a deposition of amyloid substances in the tissues of the inner ear [19]. Hearing loss may be impacted by chronic aluminium poisoning from dialysis [20]. The impact of hemodialysis on hearing ability, however, is still debatable.

In this review, discourse segregation scores (in rates) were fundamentally higher in the non-CKD (controls) people as contrasted and CKD patients (98.64% versus 92.92 % in ordinary and CKD separately). This was predictable with consequences of Gabr et al., [21] who announced 90% discourse segregation score among CKD patients. These outcomes were equivalent to Peyvandi et al., [9] who revealed that most patients had great discourse segregation and discourse separation score in over 78% of cases were over 80%. This is agreeable to proximal contribution of hear-able framework**.**The current review showed the connection of the ABR waves I, III, V, and Interwave latencies I-III, I-V, and III-V with Calcium, there was unimportant relationship in cases bunch for ABR waves and ABR between top dormancy with calcium level, aside from ABR between top dormancy I-V was critical positive relationship in Rt ears as it were. Albeit these relationships exist, they were frail connections as the relationship co-proficient qualities were under 0.3**.**

These discoveries are in concurrence with those of Zeigelboim et al., [22] and Aspris et al., [23] who found no associations between biochemical estimations and varieties in BAEP outright and interpeak latencies. In the concentrate by Jain et al. [17], there was no connection between outright or interpeak latencies and blood calcium or egg whites levels. In any case, Antonelli et al. [24] showed a measurably huge relationship among egg whites and calcium levels. Changes in outright dormancy III and V were connected to the intense impact of dialysis on blood calcium levels, as per Pratt et al[25] .'s exploration. Electrolyte assessment ought to be performed frequently in CKD patients to forestall delays in dysnatremia rectification, which could prompt serious issues and increment the recurrence of dismalness and demise in CKD patients.

5. Conclusion:

The current study offers hard data supporting the previously contested relationship between auditory function and CKD, demonstrating that CKD has a long-term impact on hearing. In all frequencies evaluated, According to our study, CKD patients' hearing thresholds are significantly different from those of the control group. SNHL is frequent in hemodialysis patients with CRF. The hearing threshold is very negatively impacted by the length of dialysis.

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