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Audiological profile of chronic kidney disease patients on conservative management versus haemodialysis

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Abstract

Background: Chronic Kidney Disease (CKD) is understood to be associated with hearing loss. The treatment modality adopted for CKD is also known to play a role in this.

Objective: The purpose of the present study was to evaluate the audiological profile of CKD patients on treatment i.e. conservative management and haemodialysis .

Materials and methods: Eighty patients who visited a tertiary hospital in Karnataka with diagnosis of CKD were included in the study, of which 40 were on conservative management and 40 on haemodialysis. All patients underwent thorough ENT examination followed by Pure Tone Audiogram and tympanogram. The data was statistically analysed using unpaired student T test.

Results: Sensorineural hearing loss (SNHL) was found in 58.8 % in conservative and 68.8% in haemodialysis group. High frequency hearing loss and 'A' type of tympanogram was the most frequent finding in both groups. The duration of the disease had no significant effect on hearing loss and middle ear function in both groups. Prevalence of SNHL was 79.4% in diabetics, 38.9% in hypertensives and 68.2% in those with both comorbidities.

Conclusion: The audiological profile of CKD patients undergoing conservative management and haemodialysis was found to be similar. High frequency Sensorineural hearing loss was the most frequent finding, however middle ear function remained unaffected in CKD patients irrespective of the treatment modality.

Keywords: Chronic renal disease, Conservative treatment, Hearing loss, Pure tone audiogram, Renal dialysis, Sensorineural hearing loss.

Introduction

The kidney and the cochlea share many similarities from anatomical, physiological, pharmacological, pathological, immunological to the ultra-structural level.[1-3] In 2017 the global prevalence of CKD was 9.1% (697.5 million cases).[4] According to a report by the World Health Organization, in the year 2018 approximately 432 million adults were disabled by hearing loss and they estimated that this number will rise to 900 million by the year 2050.[5] Bazzi et al found the incidence of sensorineural hearing loss in CKD patients to be 77%.[6] Comorbidities like diabetes mellitus and hypertension are now the main cause of end-stage renal failure worldwide.[7] Both diabetes and hypertension are independent risk factors for hearing loss. Diabetes causes micro and macro vascular complications - thickening of stria vascularis, capillaries, lateral wall of cochlear, loss of spiral ganglion and demyelination of auditory nerve that causes hearing loss.[8] High blood pressure may cause haemorrhage in the inner ear leading to sudden or progressive hearing loss.[9] Arterial hypertension may induce tissue hypoxia by increasing blood viscosity and thereby reducing capillary blood flow.[10] It may also lead to ionic changes in cellular potentials thereby causing hearing loss.[11]

It has been found that reduced kidney function is associated with reduced cochlear function leading to sensorineural hearing loss (SNHL). However, there is limited literature on the effect of reduced kidney function on the middle ear. Bergstorm L et al found that myringosclerosis occurs in CKD patients on long-term treatment, which contributes to middle ear dysfunction thereby leading to conductive hearing loss (CHL).[12] Caldas et al found that the incidence of myringosclerosis in CKD patients was higher than in normal subjects.[13] This suggests that patients with renal disease can present with hearing loss due to effects on both inner and middle ear. Most studies in literature have focused on the association of kidney disease with inner ear (leading to SNHL) alone.

The effect of CKD on middle ear function has not been studied so far. Whether the treatment for CKD or the presence of comorbidities has any bearing on the inner and middle ear function is also not known. Therefore, the present study was undertaken to find out the effect of changes in middle and inner ear due to chronic kidney disease on the audiological profile of patients on conservative management and those on haemodialysis and also to determine the effect of duration of disease and comorbidities on the audiological profile of these patients.

Materials and Methods

A cross sectional observational study was conducted between July 2019 to June 2020 on 80 patients diagnosed with CKD in a tertiary care hospital in Karnataka state, India, after obtaining clearance from the Institutional Ethics Committee. Patients above the age of 18 years diagnosed with CKD were included in the study. The following criteria was followed for the diagnosis of CKD: either of the following present for > 3 months [14]

1) Markers of kidney damage (one or more) : - Albuminuria (Albumin excretion rate $\geq$30 mg/24 hours; Albumin-to-creatinine ratio$\geq$30 mg/g), electrolyte and other abnormalities due to tubular disorders, abnormalities detected by histology, urine sediment

abnormalities, structural abnormalities detected by imaging, history of kidney transplantation.

2) Decreased GFR (glomerular filtration rate):GFR < 60 ml/min/1.73m^2

Patients who had undergone ear, nose and throat surgeries in the past, those who had history of ear discharge or ear pain, history of ototoxic medications, chronic smokers, those with chronic sinusitis and allergic rhinitis were excluded from the study.

A detailed history and thorough ENT examination was carried out. All patients were subjected to Pure Tone Audiometry and Tympanometry. The pure tone thresholds was obtained with a calibrated Interacoustics AC 40 clinical audiometer with TDH-39 (Telephonic Dynamic Headphone) supra-aural headphones and a (radio ear) B-71 bone vibrator to obtain air-conduction and bone-conduction pure-tone thresholds respectively. Tympanometry was performed with a calibrated middle ear analyzer, Clarinet, Inventis using a 226 Hz probe.

Data obtained was statistically analyzed using IBM SPSS version 23 program running on Windows operating system. P

value less than 0.05 was considered significant. To assess the data, unpaired student T - test was used.

Results & Discussion

Eighty patients with CKD were included in the study, out of which 40 were on conservative treatment and 40 on haemodialysis. Of these, 48 were males and 32 were females; the M: F ratio was 1.5: 1. Majority of the patients, 41.25% (N = 33) were aged between 40 to 60 years. The mean age was 46 years. There were 17 patients (21.25%) above the age of 60 years. Majority of the patients 58.8% (N = 47) had no ear complaints. Tinnitus was the most common complaint and was found in 28.8% (N=23), hearing loss in 10% (N=8) and aural fullness in 2.5% (N=2) patients. On otoscopic examination, the most common finding was normal tympanic membrane (Table 1).

Otoscopic Findings		Conservative (N=No. Of Ears)	Haemodialysis (N=No. Of Ears)
Normal Tympanic Membrane		68	62
Retraction	Grade I	10	16
	Grade II	1	0
Thinned Out Tympanic Membrane		1	2
Total Number Of Ears		80	80

Table 1: Otoscopic findings between the conservative and hemodialysis group

From the data obtained (Table 2) it was found that majority of the patients had pure sensorineural hearing loss i.e. 58.8% (N=47) in conservative group while 6.3% (N=5) had pure conductive hearing loss. In the haemodialysis group, 68.8 % (N=55) had pure sensorineural hearing loss whereas 8.8% (N=7) had pure conductive hearing loss. In both groups, the most common finding in tympanometry was ‘A’ type curve which was suggestive of normal middle ear function. However, tympanogram findings did not correlate with the audiogram findings in both groups. In the conservative group, 18 ears had CHL (pure CHL: N=5, mixed hearing loss: N=13) while 20 ears showed abnormal tympanogram which included ears with normal hearing as well as those with SNHL. In the haemodialysis group, 12 ears had CHL (pure CHL: N=7, mixed hearing loss: N=5) while in 26 ears abnormal tympanogram was found which indicates that

ears without conductive loss also had abnormal finding in middle ear. From the table II, it was found that there was no significant difference in the audiological profile (PTA p value - 0.199 & tympanogram p value - 0.329) between the two groups. The duration of CKD did not show any significant effect on the PTA or tympanogram findings as shown in Table 2.

From the table 3, it was found that SNHL and 'A' type tympanogram were the most common findings in patients with comorbidities. The prevalence of SNHL was found to be 79.4% in those with diabetes mellitus, 38.9% in those with hypertension and 68.2% in those with both diabetes and hypertension. Even in patients without comorbidities, SNHL was more common (67.4%) with normal tympanogram. From the study it was found that there was no statistically significant difference in the effect of comorbidities on audiological profile of CKD patients between the two groups. (Table 3)

The prevalence of hearing loss in patients with chronic renal disease varies from 28% to 80%.[15-18] In the present study the prevalence of hearing loss was found to be 82.5% (N=132). The kidney and the inner ear being embryologically related, the presence of microvilli, similar active fluid and electrolyte using Na K pump, presence of carbonic anhydrase in striae vacularis of the cochlea and nephron are some of the proposed explanations for hearing loss in CKD patients. [6,19]

Groups		Pure Tone Audiogram (PTA) (N=no. of ears)				p value	TYMPANOGRAM (N=no. of ears)					p value
		CHL	MIXED HL	NORMAL	SNHL		A	Ad	As	B	C	
Conservative		N=5 [6.3%]	N=13 [16.3%]	N=15 [18.8%]	N=47 [58.8%]	.199	N=60 [75%]	N=4 [5%]	N=8 [10%]	N=4 [5%]	N=4 [5%]	.329
Haemodialysis		N=7 [8.8%]	N=5 [6.3%]	N=13 [16.3%]	N=55 [68.8%]		N=54 [67.5%]	N=7 [8.8%]	N=4 [5%]	N=7 [8%]	N=8 [10%]	
Conservative duration of disease(in years)	<1	N=2 4.8%	N=4 9.5%	N=5 11.9%	N=31 73.8%		N=33 78.6%	N=1 2.4%	N=6 14.3%	N=0	N=2 4.8%	
	1-2	N=3 8.8%	N=8 23.5%	N=7 20.6%	N=16 47.1%		N=23 67.6%	N=3 8.8%	N=2 5.9%	N=4 11.8%	N=2 5.9%	.388
	>2	N=0	N=1 25%	N=3 75%	N=0	.038	N=4 100%	N=0	N=0	N=0	N=0	
Haemodialysis duration of disease (in years)	<1	N=1 10%	N=0	N=0	N=9 90%		N=8 80%	N=1 10%	N=1 10%	N=0	N=0	
	1-2	N=4 11.1%	N=4 11.1%	N=3 8.3%	N=25 69.4%	.099	N=19	N=6	N=1	N=5	N=5	.171
	>2	N=2 5.9%	N=1 2.9%	N=10 29.4%	N=21 61.%		N=27 79.4%	N=0	N=2 5.9%	N=2 5.9%	N=3 8.8%	

CHL - Conductive hearing loss, HL - Hearing loss, SNHL - Sensorineural hearing loss, A - Normal tympanogram, B - Middle ear effusion,

As - Ossicular sclerosis, Ad - Ossicular discontinuity, C – Eustachian tube dysfunction

Table 2: Audiological profile between the conservative and haemodialysis group and effect of duration on audiological profile.

Comorbidities	Groups	Pure tone audiogram(PTA) (N=no. of ears)				P value	TYMPANOGRA (N=no. of ears)					P value
		CHL	Mixed HL	Normal	SNHL		A	Ad	As	B	C	
DM	Conservative	N=0	N=5 31.3%	N=1 6.3%	N=10 62.5%	.068	N=13 81.3%	N=0	N=1 6.25%	N=1 6.25%	N=2 12.5%	.202
	Haemodialysis	N=0	N=1 5.5%	N=0	N=17 94.4%		N=10 55.65	N=3 16.7%	N=1 5.6%	N=1 5.6%	N=3 16.7%	
DM &HTN	Conservative	N=0	N=3 18.8%	N=1 6.3%	N=12 75%	.568	N=10 62.5%	N=2 12.5%	N=4 25%	N=0	N=0	.108
	Haemodialysis	N=2 7.1%	N=4 14.3%	N=4 14.3%	N=18 64.3%		N=18 64.3%	N=1 3.6%	N=2 7.1%	N=3 10.7%	N=4 14.3%	
HTN	Conservative	N=0	N=2 12.5%	N=7 43.8%	N=7 43.8%	.118	N=10 62%	N=2 12.5%	N=4 25%	N=0	N=0	.011
	Haemodialysis	N=4 20%	N=0	N=9 45%	N=7 35%		N=16 80%	N=0	N=0	N=4 20%	N=0	
NIL	Conservative	N=5 15.6%	N=3 9.4%	N=6 18.8%	N=18 56.3%	.093	N=27 84.4%	N=0	N=0	N=3 9.4%	N=2 6.3%	.021
	Haemodialysis	N=1 7.1%	N=0	N=0	N=13 92.9%		N=10 71.4%	N=3 21.4%	N=1 7.1%	N=0	N=0	

HTN - Hypertension, DM - Diabetes Mellitus, NIL-No comorbidities, CHL - Conductive hearing loss, HL - Hearing loss, SNHL - Sensorineural hearing loss, A - Normal tympanogram, B - Middle ear effusion, As - Ossicular sclerosis, Ad - Ossicular discontinuity, C - Eustachian tube dysfunction

Table 3: Shows effect of comorbidities on audiological profile of CKD patients undergoing conservative management and haemodialysis

According to literature, the incidence of high frequency sensorineural hearing loss is significant among CKD patients.[20] However, they can also have a low frequency hearing loss [21] which may disappear after haemodialysis.[22] In the present study, it was found that 63.8% (N=102) had pure sensorineural hearing loss of which majority i.e. 48% (N=49) had a high frequency hearing loss. However, hearing loss was found to have no specific pattern and involved high, mid and low frequencies.

Studies have found that the incidence of hearing loss is more among men than women probably due to industrial noise exposure which affects 4-6 KHz.[23] Since majority of our patients were males (M:F = 1.5:1), it is difficult to interpret the role of gender in hearing loss.

In the present study, 21.25 % (N=17) patients were above 60 years. Studies have found that hearing loss is more in older patients than younger patients with CKD which is probably because duration of CKD also increases with age.[21,24] It is impossible to state that the

accentuation of normal presbycusis in CKD patients is due to the direct effect of uremic neuropathy on the auditory system or due to cardiovascular conditions as an indirect consequence of accelerated ageing.[25]

Majority of the patients in the present study 58.8% (N=47) were asymptomatic. However the most common symptom was found to be tinnitus in 28.8 % (N=23). On otoscopic examination, the most common finding was that of a normal tympanic membrane. Though other findings like tympanic membrane retraction and thinned out tympanic membrane were found, we did not find myringosclerotic patch in any of the ears examined, in contrast to few other studies where the incidence of myringosclerotic patch was found to be higher in CKD patients[13] resulting in conductive hearing loss.

The otoscopic findings correlated well with the tympanogram findings. However the tympanogram findings did not correlate well with the audiogram findings. One possible explanation could be that audiogram is a subjective test of hearing evaluation while tympanogram is an objective test. Since audiogram result depends on patient response it may not always be accurate.

In the present study, it was found that the type of hearing loss among patients undergoing haemodialysis and conservative management was the same. SNHL was present in 58.8% ears in conservative group and 68.8% ears in haemodialysis group. Reddy EK et al found that as duration of CKD increases, there is worsening of hearing loss.[26] Since the present study was a cross-sectional one, this point cannot be commented upon.

Jamaldeen et al found that SNHL was prevalent in 41.7% of the CKD patients undergoing haemodialysis.[16] In the present study, the prevalence of SNHL was found to be 68.8% (N=55) in patients on haemodialysis. Haemodialysis in CKD causes metabolic and electrolyte disturbances in patients. Short term haemodialysis improves SNHL. But it has been observed that more than 250 dialysis can cause SNHL.[27] In a study by Anteunis et al hearing loss improved after dialysis.[28] But there have been studies which stated that hearing loss worsened after long term haemodialysis,[29] which could be as a result of cochlear insufficiency due to hypotension after dialysis.

Some claim that haemodialysis has no effect on SNHL and that regular dialysis neither prevents mild uremic symptoms nor worsens hearing.[6,30] Some studies have shown that SNHL in haemodialysis patients is related to CKD itself, not due to uremic axonopathy.[31] Polybrene used for haemodialysis, volume and pressure changes in endolymph and perilymph,[2] hypotension and hypoxia during haemodialysis,[19] acute mononeuritis multiplex due to rapid, ultra filtration,[32] ototoxic heparin antagonist,[33] aluminium toxicity due to dialysis[34] - all these factors have been attributed to account for accelerated hearing loss in dialysis patients.

Patients who have undergone dialysis more than 3 times a week were found to have hearing loss.[16] Aspiris et al and Gafer et al found that even though post dialysis hearing improved by normalizing the hydroelectric and metabolic changes in endolymph but it is not permanent. They found that long term dialysis worsened hearing.[35,36]

Chen et al found a correlation between sensorineural hearing loss and hypertension in elderly.[37] Yikawe et al reported that the prevalence of hearing loss in hypertensive patients to be 38.5%. They found that the hearing thresholds were elevated for all frequencies tested.[38] In the present study, among the hypertensive patients in the conservative group, 43.8% (N=7) had

hearing loss while in the haemodialysis group 35% (N=7) had hearing loss. It was found that the high frequencies were most commonly affected. No significant difference was found in the audiological profile of patients with hypertension undergoing haemodialysis and conservative management.

The prevalence of SNHL was found to be 67.44% in patients with type 2 Diabetes as per a study conducted by Jyothi AC et al. They also found that the prevalence of SNHL was higher in those with longer duration of Diabetes mellitus and poor glycemic control.[39] In the present study, it was found that among the diabetic patients, 62.5%(N=10) in conservative group and 94.4%(N=17) in haemodialysis group had hearing loss, but the difference was not significant. Studies with long term follow up have shown no correlation (Blue mountain hearing study)[1] while some cross sectional studies have shown correlation between diabetes and hearing loss due to poor glycemic index, a risk factor for hearing loss rather than duration of diabetes.[40] In a study conducted by Kim Beom et al among 2,53,301 adults with diabetes with 4 year follow up, 2,817 had incidental hearing loss and also observed that risk of hearing loss was more in adults with HbA1c more than 5%.[1]

In the present study, the overall prevalence of SNHL in CKD patients with comorbidities was 79.4% in diabetes mellitus, 38.9% in hypertension and 68.2% in those with both diabetes and hypertension. It is known from literature that diabetes and hypertension are individual risk factors for hearing loss. The present study also found that the prevalence of SNHL in CKD patients without comorbidities was 67.4%. This shows that the prevalence of SNHL in CKD patients with and without comorbidities was similar. Patients without comorbidites had a high prevalence of SNHL in the study which could be possibly attributed to age related hearing loss.

Since the present study was a cross sectional study, without follow up the effect of hemodialysis on hearing could not be found out. Patients above the age of 60 were also part of the study hence presbycusis could have influenced the result of the study. According to literature, the severity of hypertension and poor gylcemic index are risk factors for hearing loss in CKD patients which were not taken into account in our study.

Conclusion

The audiological profile of CKD patients undergoing conservative management and haemodialysis was found to be similar. High frequency sensorineural hearing loss was the most frequent finding in CKD patients whether on conservative management or haemodialysis. CKD did not seem to affect the middle ear function in these patients. The duration of CKD did not have any significant effect on the audiological profile. Comorbidities like diabetes and hypertension being independent risk factors for hearing loss, interpretation of their influence on the hearing profile in patients with CKD is beyond the scope of this study. A baseline audiogram testing all frequencies (low to high) should be considered for all patients diagnosed with CKD along periodic follow up to pick up cases of early SNHL so that appropriate preventive measures can be initiated early on in the course of the disease, thereby reducing the burden of hearing disability.

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