Original article

Etiological evaluation of hearing loss in chronic renal failure

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Abstract:

Background: Hearing loss is common in patients with chronic renal failure,but its cause is controversial with several potential mechanisms that have been postulated in literature.

Objectives: To assess the degree and type of hearing loss in patients with chronic renal failure and to evaluate the relationship between various etiological factors and hearing loss in these patients.

Materials and methods: 60 adults aged 18-60 years,with nonsyndromic chronic renal failure were included in a prospective comparative study and categorised based on average pure tone threshold into 2 groups of 30 each i.e. Group 1/"Hearing Loss" group with >25db sensorineural hearing loss (which was further subclassified) and Group 2/"Non-Hearing Loss" group with ≤25dB hearing loss.History relevant to the study was obtained followed by examination.Investigations such as pure tone audiometry, haemoglobin, renal parameters and serum electrolytes were done.

Results: Statistically significant ($p<0.05$) higher mean duration of chronic renal failure and hemodialysis was noted in Group1.Serum sodium and potassium levels were lower in group 1; however only the association between sodium levels and hearing loss was strongly significant ($p<0.001$). Blood urea and serum creatinine levels were higher in group 1,but this was statistically not significant. Within Group 1, majority (56.7%) had high frequency hearing loss.

Conclusion: High frequency hearing loss in chronic renal failure is related to the duration of the disease, duration of hemodialysis and internal homeostasis, namely hyponatremia. Early detection can prevent further deterioration of hearing by minimising exposure to ototoxic agents, noise or haemodialysis changes wherever possible.

Keywords: Audiometry, Hearing Loss, Kidney Failure, Renal Dialysis

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Introduction

Hearing loss (HL) is common in patients with chronic renal failure (CRF), but its cause is controversial. [1] Despite differences in metho-dologies and indices of auditory function, existence of hearing loss has been a common thread. The higher incidence of hearing loss among patients with CRF has long been established and is constantly being verified by new studies.[2] The general consensus in audiometric findings among patients with CRF claims a high frequency hearing loss with a notch at 6 kHz.[3]

Hearing loss is a more commonly reported finding than vestibular dysfunction.[2] Certain studies have reported that the lesion in this form of HL is found in the cochlea[4] while other studies have identified retrocochlear involvement in addition to cochlear pathologic abnormalities.[1] Many similarities exist between the stria vascularis of the cochlea of the inner ear and the renal nephron. They may have a common antigenicity. The nephron and the stria vascularis of the cochlea have epithelial structures and a vascular supply that are in close contact. Both epithelial structures have enzymatic systems that depend on Na^+/K^+–adenosine triphosphatases, and have carbonic anhydrase. Different pharmacologic agents can cause both nephrotoxic and ototoxic effects.[5]

There are several potential mechanisms for HL in CRF that have been postulated in literature, including deranged haemoglobin, electrolytes, blood urea, serum creatinine, hypertension, ototoxic medication,[4,6] effects of the hemodialysis treatment itself,[7,8] plasma viscosity and vitamin D deficiency.[1,3]This study was thus undertaken with the aims of assessing the degree and type of hearing loss in patients with chronic renal failure and to evaluate the relationship between suggested etiological factors in the causation of hearing loss in these patients.

Materials and methods

A prospective comparative study was conducted from November 2013 to October 2014 at our institution, with the approval of the Institute ethics committee and in accordance with ethical standards.

60 consenting adults of both sexes aged 18-60 years, diagnosed with nonsyndromic CRF were included in the study. Those with conductive hearing loss, history of ototoxic drug intake, infections (otitis media, mumps, herpes zoster, syphilis, meningitis, encephalitis), endocrinopathies (diabetes mellitus, hypothyroidism), noise exposure, congenital hearing loss, blood dyscrasias, head injury, intracranial pathology or vastly varying results between both ears on audiological assessment were excluded from the study.

Patients were categorised into 2 groups of 30 each i.e. Group 1/"Hearing Loss"(HL) group and Group 2/"Non-HL" group according to pure tone audiometry. HL was defined as an average pure tone threshold >25 dB when measured at frequencies of 250, 500, 1000, 2000, 4000 and 8000 Hz. Details of age, sex, duration of CRF, duration of hemodialysis and hypertension were recorded. Routine physical examination and investigations such as haemoglobin, serum electrolytes, blood urea and serum creatinine were conducted. Hearing loss was further classified into mild (26-40dB), moderate (41-70dB), severe (71-90dB) and profound (>91dB) types at the different frequency ranges i.e. low (250, 500 Hz), mid (1000, 2000 Hz) and high (4000, 8000 Hz).

Data was analysed using descriptive and inferential statistical methods. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance was assessed at 5% level of significance. Student t test (two tailed, dependent) has been used to find the significance of study parameters on a continuous scale within each group. Chi-square/ Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups. Statistical software SPSS 15.0 was used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc**.**

Results

Mean age of patients in both groups was similar, being 42.8 years in group 1 and 41.4 years in group 2. More males were seen in both groups with a

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higher male: female ratio of 5:1 in the HL group than 2:1 in the Non HL group.

A statistically significant ($p<0.05$) higher mean duration of CRF and mean duration of hemodialysis was seen in the HL group.

Both serum sodium and potassium levels were lower in the HL group.

However only the association between hypon-atremia and hearing loss was found to be strongly statistically significant ($p<0.001$).

Blood urea and serum creatinine were higher in the HL group than the non HL group, but this result did not reach statistical significance. No significant differences were noted between the groups in terms of blood pressure, haemoglobin levels and serum chloride. (Table 1)

Parameter	HL Group		Non HL Group	Significant difference
Mean age (years)	**42.8** (range 18-60)	>	**41.4** (range 20-60)	No
Male : Female ratio	**5:1**	>	**2:1**	No
Mean duration of CRF (months)	**35.9** (range 4-68)	>	**26.7** (range 4-66)	**Yes**
Mean duration of haemo-dialysis (months)	**31.2** (range 4-70)	>	**21.3** (range 3-65)	**Yes**
Hyper-tension (%)	**62.5**	<	**67.4**	No
Mean Haemo-globin (g/dl)	**8.2** (range 5.0-12.9)	>	**8.3** (range 5.8-12.6)	No
Mean Blood Urea (mg/dl)	**141.2** (range 40-348)	>	**130.1** (range 45-332)	No
Mean Serum Creatinine (mg/dl)	**7.9** (range 2.3-16.7)	>	**6.8** (range 2.2-13.9)	No
Mean Serum Sodium (mEq/L)	**124.6** (range 110-135)	<	**140.8** (range 134-156)	**Yes**
Mean Serum Potassium (mEq/L)	**4.5** (range 3.5-5.8)	<	**4.8** (range 3.5-6)	No
Mean Serum Chloride (mEq/L)	**95.0** (range 84-105)	>	**94.5** (range 82-104)	No

Table 1 Comparison of results between Group 1 and 2

Within the hearing loss group, 13.3% had low frequency hearing loss, 30% had mid frequency hearing loss and 56.7% had high frequency hearing loss. All frequencies showed mild to severe hearing loss, with mild loss in 50%, moderate loss in 40%, severe loss in 10% and profound loss in none of the patients. (Fig 1)

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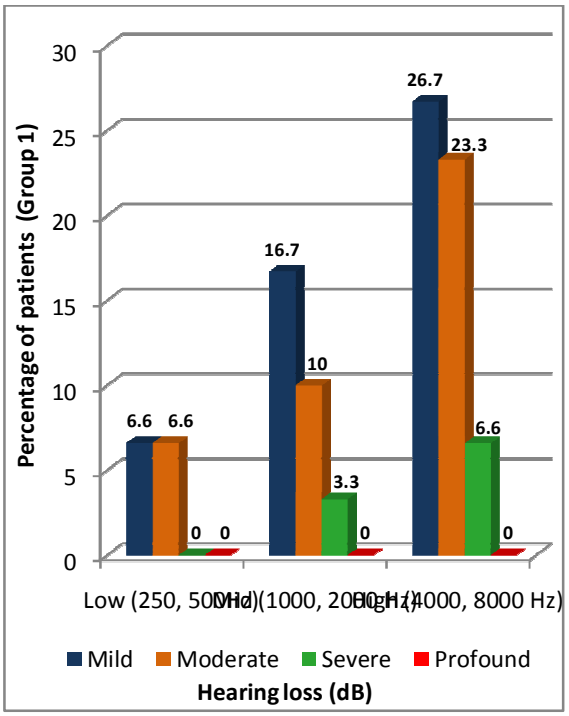

Fig 1 Analysis of hearing loss in Group 1

Discussion

Several potential mechanisms for HL in CRF have been published, including electrolyte disturbances, hypertension, use of ototoxic medications,[4,6] effects of the hemodialysis treatment itself,[7,8] vitamin D deficiency, plasma viscosity, haemoglobin,[1,3] serum creatinine and urea,[9] of which some have been analysed in our study.

The incidence of sensorineural hearing loss among patients with CRF is considerably higher than in the general population.[1] Bazzi et.al. found an incidence of 77% including patients with mild and very mild hearing loss.[7] Moderate to severe hearing loss was seen in 46% of the tested patients in a study by Ozturan et.al,[3] which was similar to the observed incidence of 50% in our study. From the review of literature and from our study it can be concluded that though all frequencies can be affected in CRF, higher frequencies are most susceptible.[3]

Although both serum sodium and potassium were found to be lower among patients in the hearing loss group in our study, only the association between hyponatremia and hearing loss was statistically significant.

Similarly, Yassin et.al. found a correlation between HL and hyponatremia and suggested the possibility of a common defect in membrane transport of ions.[6]

Early and more recent reports present conflicting findings concerning possible contributions of haemodialysis treatment to hearing loss in renal failure.[2] The exact role of hemodialysis in HL is unclear, but various studies have shown that it is associated with HL. The results of audiological tests indicate no significant adverse effect of a single session of hemodialysis on hearing.[8] In a study by Erkoc et.al, the mean duration of hemodialysis in the patient group with HL was longer than that in the patient group without HL.[1]

Mancini et.al. found no correlation between HL, the duration of nephropathy and hemodialysis, suggesting that there must be another factor that caused HL before treatment was started. They concluded that, as the incidence of hearing loss was identical in the patients receiving conservative treatment and those receiving haemodialysis, there must be an early onset of the impairment, suggesting that the disease is causatively linked to hearing loss, but not the treatment.[10] Similarly, Ozturan et.al. found a notch at 6 kHz among CRF patients not related to haemodialysis indices concluding that the frequency specificity of possible CRF and haemodialysis effects remains inconclusive.[3] Studies by Bazzi et.al.[7] and Pagani et.al.[11] found a permanent high frequency hearing loss in all groups related to the disease and treatment but did not report a correlation between haemodialysis duration and severity of hearing loss.

In our study it was observed that the duration of disease and hemodialysis was longer in the hearing

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loss group and both these were found to be statistically significantly associated with hearing loss. Blood urea and serum creatinine levels were found to be higher in the group of patients in our study suffering from hearing loss; however, this association was not statistically significant. Adler et.al. found a reduction in the Na+/K+–adenosine triphosphatases in the ears of uremic guinea pigs and suggested that inhibition of this enzyme system may be a potential cause of HL as Na^+K^+-activated ATPase in the cochlea is important for maintaining cationic gradients. They also reported an inverse correlation between serum creatinine levels and Na^+K^+-activated ATPase.[10] Albertazzi et.al.documented the presence of alterations in the peripheral and central nervous system of uraemic patients demonstrating the existence of 'uraemic neuropathy'as a possible cause for hearing loss in these patients.[13] Di Paolo et.al. indicated a very high incidence of nerve conduction dysfunction in groups of CRF patients. They found decreased conduction velocity in sensory and motor units, with the sensory units being more affected than the motor.[9] In agreement with these studies, several auditory brainstem response studies in CRF indicated dysfunction of the auditory nerve and pathways. Also, in CRF, apart from the associated hearing loss, these patients might be susceptible to additional noise induced hearing loss.[14]

Conclusion

High frequency hearing loss seen in CRF is related to the duration of the disease, duration of hemodialysis and internal homeostasis through levels of serum electrolytes and nitrogenous end products of metabolism. Its early detection can prevent further progression of hearing loss by reducing exposure to ototoxic agents wherever possible, noise and other rapid changes during haemodialysis.

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