ORIGINAL ARTICLE

OTOACUSTIC EMISSION MEASUREMENTS IN COMPARISON TO AUDIOMETRY FOR THE FOLLOW-UP OF HEARING IN HEMODIALYSED PATIENTS

Evis Bendo[1], Nirian Bendo[2]

[1]ENT Department, University Hospital Center "Mother Teresa", Tirana, Albania

[2]Neurosurgery Department, Trauma Hospital, Tirana, Albania

Corresponding E-mail: drbendo@gmail.com

ABSTRACT

Introduction. Patients undergoing hemodialysis frequently exhibit some degree of sensorineural hearing loss (SNHL). The underlying mechanisms are not fully understood, and it remains uncertain whether this impairment results from the hemodialysis procedure itself or from chronic renal failure (CRF).

Methods. A total of 61 patients (122 ears) were examined: 39 subjects undergoing hemodialysis treatment for more than one year, 12 subjects initiating hemodialysis, and 10 healthy controls. Hearing assessment was performed using pure tone audiometry (PTA) and distortion product otoacoustic emissions (DPOAE). DPOAE was applied only in participants with normal middle ear conditions and hearing thresholds better than 30 dB HL, using a 65/55 dB SPL (L1/L2) setting. Additional clinical parameters, including blood pressure, body weight, and blood chemistry, were also recorded.

Results. Both PTA and DPOAE results demonstrated poorer hearing thresholds in patients with chronic renal failure compared to controls, particularly at high frequencies. However, there was no significant difference in hearing outcomes between patients undergoing long-term hemodialysis and those who had recently initiated treatment.

Conclusion. Sensorineural hearing loss in patients with chronic renal failure appears to be associated with the underlying renal disease itself rather than the hemodialysis treatment procedure. Careful monitoring of hearing in CRF patients is recommended as part of their long-term management.

Keywords. Sensorineural hearing loss; Chronic renal failure; Hemodialysis; Pure tone audiometry; Distortion product otoacoustic emissions.

OTOEMISIONET AKUSTIKE KUNDREJT AUDIOMETRISË PËR MONITORIMIN E DËGJIMIT TEK PACIENTET NËN HEMODIALIZË

ABSTRAKT

Hyrje. Pacientët me insuficiencë renale kronike që i nënshtrohen hemodializës shpesh paraqesin çrregullime të ndryshme sistemike, përfshirë edhe ulje të dëgjimit. Studimet sugjerojnë se ndryshimet metabolike, çrregullimet elektrolitike dhe faktorë të tjerë të lidhur

me sëmundjen renale mund të ndikojnë në funksionin koklear. Qëllimi i këtij studimi ishte të vlerësojë funksionin e dëgjimit tek pacientët me insuficiencë renale kronike dhe të analizojë ndikimin e hemodializës në dëgjim.
Metodologjia. Në studim u përfshinë 61 pacientë (122 veshë). Prej tyre, 39 ishin pacientë që i nënshtroheshin dializës për më shumë se 1 vit, 12 ishin pacientë që sapo kishin filluar dializën, ndërsa 10 pacientë shërbyen si grup kontrolli. Vlerësimi i dëgjimit u krye me audiometri tonale të pastër dhe me otoemisione akustike të tipit Distortion Product (DPOAE), vetëm tek pacientët me funksion normal të veshit të mesëm. Për testimin DPOAE u përdorën nivele stimuluese 65/55 dB SPL (L1/L2). Gjithashtu u analizuan parametra të tjerë klinikë dhe laboratorikë, përfshirë tensionin arterial, analizat biokimike, nivelin e elektroliteve dhe urinën komplet.
Rezultate. Rezultatet e audiometrisë dhe testimeve DPOAE treguan një dëgjim më të dobët tek pacientët me insuficiencë renale kronike krahasuar me grupin e kontrollit. Ulja e dëgjimit ishte më e theksuar në frekuencat e larta.
Megjithatë, nuk u evidencua një ndikim i drejtpërdrejtë i hemodializës në përkeqësimin e dëgjimit, pasi nuk u vërejtën ndryshime domethënëse midis pacientëve që sapo kishin filluar dializën dhe atyre me kohëzgjatje më të gjatë trajtimi.
Përfundime. Ulja e dëgjimit tek pacientët me insuficiencë renale kronike është kryesisht e tipit neurosensorial dhe më e theksuar në frekuencat e larta. Hemodializa nuk rezultoi të ketë ndikim të drejtpërdrejtë në dëgjim. Prandaj, çrregullimet e dëgjimit duket se janë pasojë e vetë sëmundjes renale kronike dhe jo e trajtimit me hemodializë.
Fjale kyç: ulje neurosensoriale degjimi, insuficence renale kronike, audiometri e toneve te pastra, otoemisione akustike.

INTRODUCTION

There are many anatomical, physiological, pharmacological, and pathological similarities between the nephrons and the stria vascularis of the cochlea, and hearing loss has been reported in patients with renal failure (1,2).

The gross anatomy of the kidney and cochlea differ greatly, although there are many similarities at the ultrastructural level. Both contain epithelial structures in close contact with their vascular supply. The basement membrane lies closely opposed to the capillary endothelium in both Bowman's capsule and the proximal renal tubule of the kidney, and around the capillaries of the stria vascularis. They may also share common antigenicity (3,4). These similarities may account for the parallel effects of medications (i.e., the nephrotoxic and ototoxic effects of aminoglycosides) and immunological factors on the two organs.

Inner ear and kidney development are influenced by similar genetic factors in hereditary conditions such as Alport's syndrome and branchio-oto-renal syndrome.

Recording OAEs implies a functioning cochlea and a healthy middle ear mechanism. Distortion product otoacoustic emissions (DPOAE) are produced when the ear is stimulated with a combination of pure tones that are close in frequency (the primary tones). DPOAEs

reflect non-linear processes of hair cell motion and are generated by the active cochlear mechanisms responsible for enhancing basilar membrane vibration, the 'cochlear amplifier.'

The incidence of sensorineural hearing loss (SNHL) among patients with chronic renal failure (CRF) is considerably higher than in the general population. Bazzi et al. (5) found an incidence of 77%, including patients with mild and very mild hearing loss. Ozturan and Lam (6) reported moderate to severe hearing loss in 46% of tested patients. The consensus in audiometric findings among CRF patients indicates high-frequency hearing loss (7,8), often with a notch at 6 kHz (6).

The presence of hearing loss and estimation of type and degree constitute common methods used to investigate the effects of renal disease on the auditory system. In addition to audiometry and tympanometry, otoacoustic emissions (OAEs), particularly distortion product otoacoustic emissions (DPOAEs), are used to evaluate cochlear function.

MATERIALS AND METHODS

A total of 61 participants (122 ears) were included in the study. Among them, 39 patients had been undergoing hemodialysis for more than one year, 12 patients were newly initiated on hemodialysis, and 10 age-matched healthy individuals served as controls. Inclusion criteria for patients were aged between 15 and 50 years, documented hearing impairment following the onset of renal failure, no history of significant noise exposure, no history of diabetes mellitus, and no previous renal transplantation. Healthy volunteers met the following criteria: age 15-50 years, normal renal function tests, and no history of noise exposure, diabetes, or renal transplantation. Renal failure was diagnosed based on elevated blood urea and serum creatinine levels in association with oliguria. Written informed consent was obtained from all participants. Audiological assessment included tympanometry and pure-tone audiometry. Distortion Product Otoacoustic Emissions (DPOAE) testing was performed only in subjects with normal middle ear function and hearing thresholds better than 30 dB HL. DPOAE measurements were conducted using primary tones set at L1/L2 levels of 65/55 dB SPL. Additional clinical parameters, including blood pressure, body weight, and blood chemistry values, were also recorded and analyzed.

OBSERVATIONS

In the CRF patients' group, among the patients newly initiated on hemodialysis, there were 5 out of 12 patients with SNHL, especially in high frequencies, and in the group with the patients undergoing hemodialysis for more than one year, there were 24 patients out of 39 with SNHL. All 29 patients of CRF with SNHL had a moderately severe to severe degree of hearing loss. As the number of hemodialysis patients increases, the chances of developing SNHL and the degree also increase. There is a high incidence of SNHL even in patients with long-standing CRF. As the duration of CRF progresses, patients become more prone to develop hearing loss.

DPOAE raised the percentages of detection of SNHL, indicating that it is a better technique than the conventional pure-tone audiometry for the evaluation of hearing acuity. In the study

of the control group of 10 healthy volunteers (selected from patients of ENT emergency visited for different problems other than ear problems) only 1 case had SNHL, which was moderate and of high frequency range. All the healthy volunteers had serum creatinine, blood urea, serum electrolyte levels within normal limits, and their systolic blood pressure <140 mmHg.

Patients with SNHL over 70 dB had significantly low sodium and higher potassium and chloride values. This shows the role of electrolytes in causing SNHL. Serum creatinine indicates the extent of renal disease, but its levels are raised in all cases of CRF with or without SNHL.

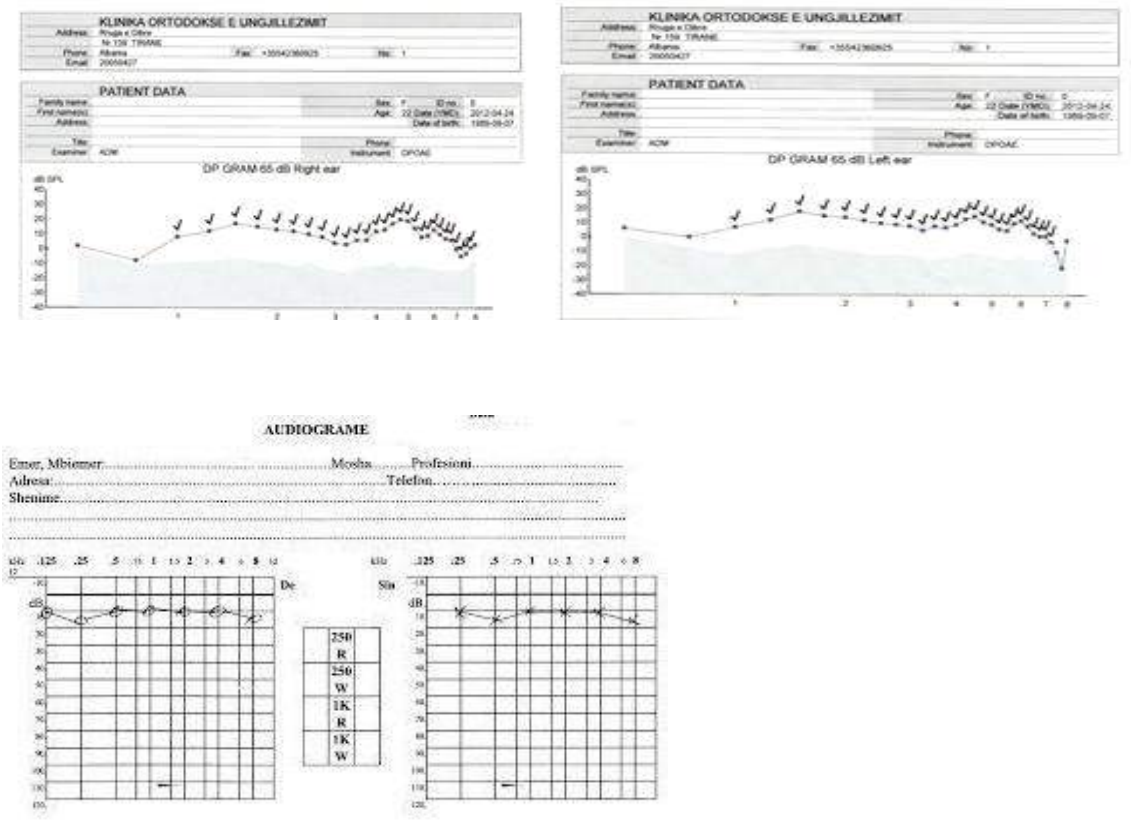
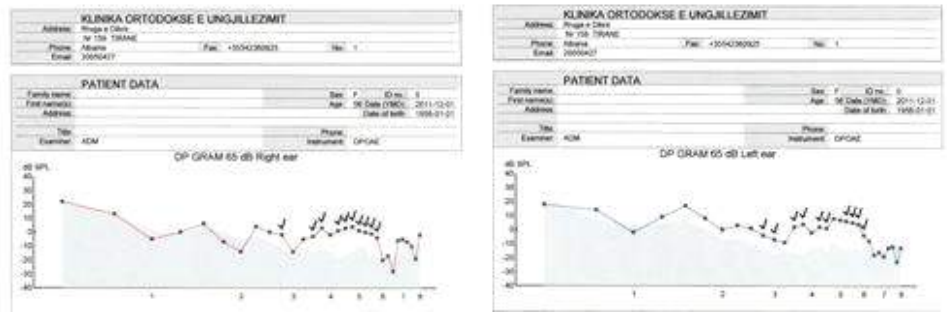


Figure 1. Normal values in both DPOAE and Audiometry



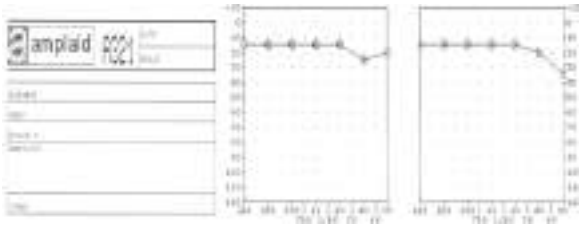


Figure 2. Detection of hearing loss in DPOAE but not in Audiometry.

DISCUSSION

Distortion product otoacoustic emissions (DPOAEs) are sounds emitted in response to two simultaneous tones of different frequencies. A setting of 65/55 dB SPL (L1/L2) is typically used. DPOAEs reflect nonlinear processes of outer hair cell motion and are generated by the active cochlear mechanisms responsible for enhancing basilar membrane vibration ("cochlear amplifier").

Since the cochlea and kidney may share antigenicity (3,4) and employ similar mechanisms of active transport of fluids and electrolytes, mediated by the stria vascularis and glomerulus, respectively (6,9), this may explain the similar influence of genetic factors and medications on both organs.

The etiological factors linked to hearing loss in renal failure include the use of ototoxic medications, electrolyte disturbances (10), hypertension (11,12), and hemodialysis treatment itself (5,13,14). Brookes (15) suggested that vitamin D deficiency might be a contributing factor to hearing loss in renal failure. Albertazzi et al. (16) documented alterations in the peripheral and central nervous system in uremic patients, demonstrating the existence of "uremic neuropathy."

Renal failure is linked to hearing loss irrespective of treatment modality; however, it remains difficult to separate the effects of disease duration, hemodialysis treatment, medication ototoxicity, age, noise exposure, and their possible interactions.

As treatments become more efficient and patients' life spans increase, there is a better chance of observing co-existing conditions, as well as the added factors of geriatric concerns.

Treatment evolution may have modified the contribution of several factors in causing hearing loss. For example, hyponatremia was common in earlier decades (10), but is less frequent with modern hemodialysis techniques.

From these observations, the positive factor that may be a cause of hearing loss in CRF patients was the long duration of the renal failure. The hearing loss in these patients is not of genetic origin; it happens even after exclusion of known risk factors such as noise exposure, ototoxic drugs, head injuries, old age, etc. The presence of additional factors accelerates the cause of hearing loss. The presence of electrolyte imbalance, hypertension, proteinuria, and hemodialysis is one of the factors that seem to have a cumulative effect on the deterioration of hearing in patients who were suffering from CRF.

CONCLUSION

Patients with long-standing chronic renal failure are at increased risk of developing bilateral, symmetrical high-frequency sensorineural hearing loss. The severity of hearing loss may be influenced by the duration of chronic renal failure and cumulative metabolic disturbances. Electrolyte imbalance and uncontrolled hypertension further contribute to the development and severity of SNHL, whereas elevated serum creatinine and blood urea levels alone are not reliable predictors of hearing loss.

As survival in CRF patients improves, hearing impairment is becoming increasingly prevalent and clinically relevant in this population. DPOAE testing demonstrated higher sensitivity in detecting SNHL compared to conventional pure-tone audiometry, supporting its value as a useful tool for early auditory assessment in patients with chronic renal failure.

Conflict of interests. The author declares no conflict of interest.

Author contribution. All authors contributed to the preparation of the manuscript and approved the final version.

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