Audiological Evaluation of Nephrotic Syndrome in Children Attending Qena University Hospitals

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Abstract

Background: Nephrotic syndrome is a chronic disease characterized by alterations of permeability in the glomeruli. Some developmental pathways are shared by the kidney and the ear. Both of them involve physiological mechanisms necessary for normal function.

Objectives: to assess the occurrence of hearing loss in children with nephrotic syndrome and determine risk factors leading to hearing impairment for early diagnosis and intervention.

Patients and methods: This cross-sectional study was carried out on 100 children with positive clinical symptoms of nephrotic syndrome attending Audio-vestibular Unit at Qena University Hospital. Basic audiological evaluation was done including Acoustic immittance testing, pure tone and speech audiometry as well as otoacoustic emission.

Results: 18% of cases had hearing loss (15% sensorineural, 2% conductive and 1% mixed). By using transient evoked otoacoustic emission, One hundred thirty-three ears (66 right and 67 left) recorded a Pass and thirty-one ears (16 right and 15 left) recorded a Partial Pass in patients with normal hearing. However, Twenty-eight ears (14 right and 14 left) had a Partial Pass while two ears (1 right and 1 left) had a Fail in patients suffering from sensorineural hearing loss.

Conclusion: Hearing loss is associated with nephrotic syndrome as 18% of nephrotic syndrome patients had hearing loss with speech discrimination scores of 90 (± 3) in right ear and 89 (± 3) in left ear.

Keywords: Nephrotic Syndrome; Hearing Loss; Audiometry; Otoacoustic Emission.

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Introduction

Hearing loss may affect all age groups including children. According to estimates, there are 4 to 60 cases of neonatal hearing loss for every 1000 new-borns. Childhood hearing loss is frequently detected when a parent reports that their child is unresponsive to voice, exhibits speech or language delays, or performs poorly in school. The healthcare provider should conduct additional research if a caregiver expresses concern about hearing loss **(Božanić Urbančič et al., 2020)**.

Hearing is a critical constituent affecting speech and language development in children, as most of them make remarkable advances in learning language during the first 4 years of life. Because of the importance of language to human interactions, it is not unusual to find that language difficulties contribute to problems in different parts of children's lives. Furthermore, studies indicate a significant correlation between language impairments and problems related to reading and writing proficiency in addition to the evolution of memory skills and cognitive functions **(Arora et al., 2020)**.

Nephrotic syndrome is a prevalent long-term condition that involves changes in the permeability of the glomerular capillary wall, causing it to lose its capacity to prevent the excessive loss of protein in the urine. The yearly occurrence of nephrotic syndrome in children is estimated to be between 2 and 7 cases per 100,000 children, whereas the number of existing cases at any one time is estimated to be between 12 and 16 cases per 100,000 children. Epidemiological research indicates a greater occurrence of nephrotic syndrome in children **(Esezobor et al., 2020).**

Nearly all instances (95 percent) are classified as primary or idiopathic. Some underlying disorders, such as Henoch-Schönlein purpura, amyloidosis, systemic lupus erythematosus, parvovirus B19, hepatitis B and C, and human immunodeficiency virus, may only be detected in a small percentage of patients **(Esezobor et al., 2020).**

It has been suggested that a relapse rate of 76-90%. Since nephrotic syndrome is common among children, it is crucial to study its effect on hearing abilities because of the importance of hearing in speech and language development in children. Early detection of hearing loss in cases with nephrotic syndrome is required. Prevention and control of risk factors help good management. This study was conducted to identify the impact of nephrotic syndrome on hearing in children **(Farsy et al., 2021)**.

This work aimed to estimate the incidence of hearing loss in children with nephrotic syndrome, to determine risk factors leading to hearing impairment in those children with early diagnosis and intervention.

Patients and methods

This research was conducted on a sample of 100 children, aged 7 to 17 years old, of both genders, who exhibited clinical signs of nephrotic syndrome. The research was conducted with clearance from the Ethical Committee of Qena University Hospitals, located in Qena, Egypt. Relatives of the patients provided an informed written permission. The research had approval from ethical committee with the following number: SVUMEDENT0301232565.

The exclusion criteria included individuals who did not show a response in pure tone audiometry (PTA).

Equipment

1-Sound treated room I.A.C. model 1602.
2- Audiometer: Madsen Itera II.
3- Immittancemeter: Madsen Zodiac 901.
4- Interacoustics Titan TEOAE440.

Every patient underwent a thorough process that included obtaining their medical history, doing a clinical examination, performing laboratory tests [such as complete blood count (CBC), urine analysis, serum albumin, serum cholesterol, and triglyceride levels], and evaluating their hearing ability.

Audiological evaluation

Tympanometry: Type (A), Type (As), Type (Ad), Type (B), Type (C).

Pure tone and speech audiometry were conducted to determine hearing threshold as well as type and degree of hearing

Otoacoustic emission (OAE)

Trans evoked otoacoustic emission (TEOAE440): The Interacoustics Titan, equipped with the TEOAE440 module, provides a compact and dependable equipment for conducting TEOAE screening. It also has 226 Hz tympanometry, allowing for efficient assessment of the middle ear. When used along with the TEOAE440 module, the Interacoustics Titan guarantees accurate stimulus intensity by using real-ear detection techniques. Additionally, it may be adjusted to disregard data taken in noisy surroundings.

Method of hearing assessment by PTA (Shabayek et al., 2022 ; Faisal Amin et al., 2022):

Hearing thresholds are determined depending on age, and PTA include both air and bone conduction. Speech Reception Threshold (S.R.T.) refers to the use of bisyllabic words with children, whereas "speech discrimination" refers to the use of Arabic phonetically balanced kindergarten (PBKG) terms. The Madsen Itera II audiometer was used to conduct PTA. Every child had an otoscopic evaluation. After checking for discharge and wax, patients whose ears had wax removed had their hearing checked for potential loss. Before every hearing test, the audiometer was biologically calibrated. Each kid was given a full explanation before the hearing exam began, and the test was conducted in a quiet, unoccupied room inside the Audio-vestibular unit. The traditional 5-up-10-down technique, which utilizes the Hughson-Westlake methodology as modified by Carhart-Jerger, was used to assess both air conduction and bone conduction (BC). We assessed the intensity in decibels and the hearing thresholds at 250, 500, 1000, 2000, 4000, and 8000 Hz. A pure tone audiogram was created from each set of test data and used for both quantitative and qualitative analysis. Types of hearing loss, such as conductive, mixed, or sensorineural (SNHL), were shown by qualitative data. When the bone conduction loss (BC) was less than 20 dB and the air-to-bone gap difference was 15 dB or more, conductive hearing loss was identified. A diagnosis of SNHL was made when the BC level exceeded 25 dB and the air-to-bone gap difference was at least 15 dB. When both the BC level and the air-to-bone gap were above 25 dB and 15 dB, respectively, it was determined that the patient had mixed hearing loss. To quantify the degree of deafness, we looked at the air conduction threshold and classified it as mild (26-40 dB), moderate (41-55 dB), moderately severe (56-70 dB), severe (71-91 dB), or profound (> 91 dB). The average pure tone threshold level was determined by averaging the following frequencies: 500, 1000, 2000, 4000 Hz.

The primary outcome was to estimate risk factors for hearing loss in children with nephrotic syndrome. The secondary outcome was attempted to implement hearing screening for children with nephrotic syndrome.

Statistical analysis

Software developed by IBM and published in Chicago, Illinois, USA, known as SPSS v26, was used for the statistical analysis. The three groups were compared using quantitative variables, which were expressed as means and standard deviations (SD), using an ANOVA (F) test with a Tukey post hoc test. The Chi-square test was used to examine qualitative variables, which were provided as percentages and frequencies. It was deemed statistically significant if the two-tailed P value was less than 0.05.

Results

A total number of 100 patients (85 males and 15 females) were included in this study. Their age ranged from 7 to 17 years. All patients are presented with nephrotic syndrome (**Table .1 & Fig.1).**

Table 1. Clinical data of patients (n=100)

Characteristic	Summary statistics
Age **Mean (SD)**	10.27 (3.065)
Sex **Males** **Females**	85 15
Residence **Qena**	100

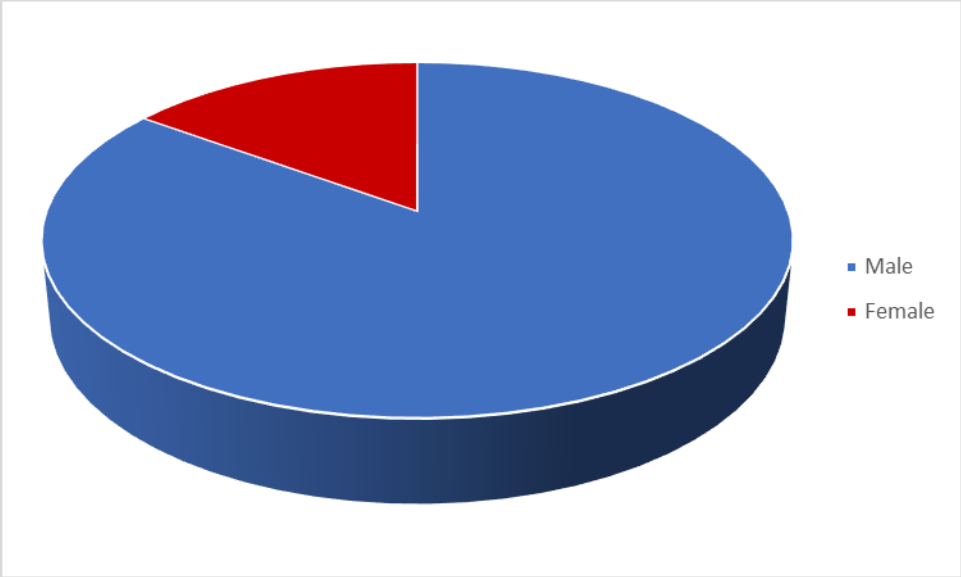

Fig.1.Sex distribution of studied population

There was 12 patients (12%) complaining of hearing loss while 2 patients (2%) had speech disorder (dyslalia). 86 patients (86%) didn't have complaints (**Table.2, Fig.2)**

Table (2): Distribution of complaints among patients as reported by caregivers.

Complaints	N=100
No complaints	86(86.0%)
Hearing loss	12(12.0%)
Speech disorder (dyslalia)	2(2.0%)

Data are presented as frequency (%).

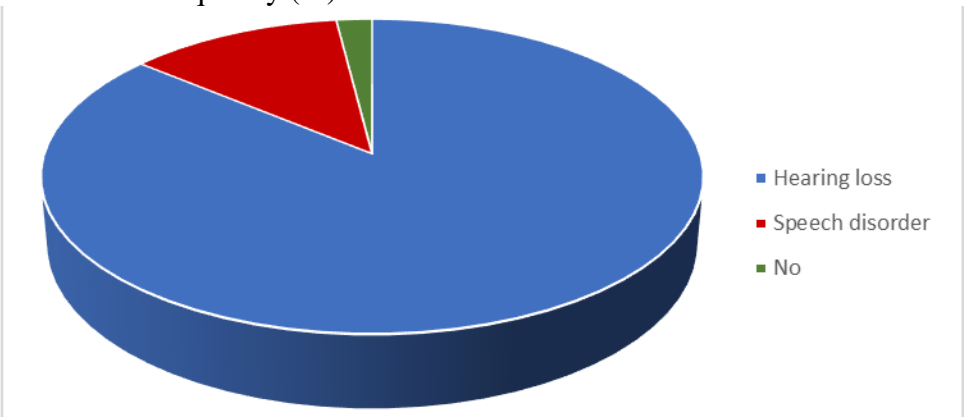

Fig.2. Distribution of complaints among patients

Our study revealed that 18 patients (18%) had hearing loss (15% sensorinural hearing loss, 2% conductive hearing loss, 1% mixed hearing loss) while 82 patients (82%) had normal hearing. Among patients who didn't have audio-vestibular complaints, 78 patients had normal hearing, 1 patient had conductive hearing loss and 7 patients had sensorineural hearing loss. There was 2 patients with normal hearing, 1 patient with conductive hearing loss, 1 patient with mixed hearing loss and 8 patients with sensorinearal hearing loss among children whose parents complain of inconsistent response to soft sounds (hearing loss complaint). 2 patients who presented to clinic with speech disorder had normal hearing after audiological evaluation **(Table .3, Fig.3).**

Table (3): Distribution of types of hearing loss versus complaints of the patients

	Normal	Conductive hearing loss	Mixed hearing loss	SNHL
No audiovestibular complaints	78	1	_	7
Hearing loss	2	1	1	8
Speech disorder	2	_	_	_
P-value	**0.01***			

* Significant p value <0.05. SNHL: Sensorineural hearing loss.

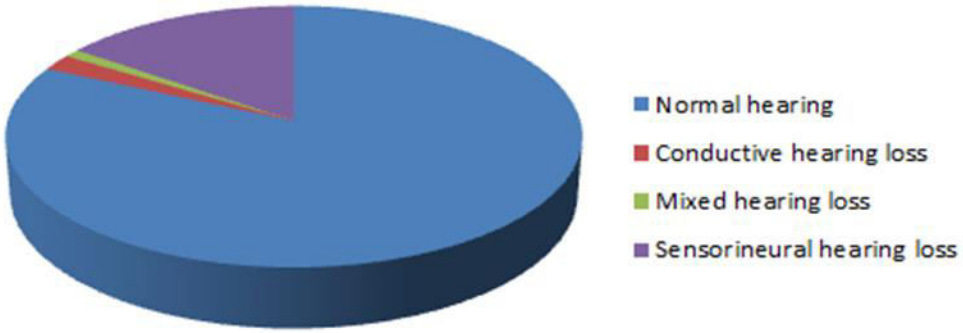

Fig.3. Distribution of types of hearing loss among patients

Results of Pure tone and speech audiometry

• At 250 Hz, pure tone audiometry (PTA) with mean value (± SD) of 19.90 (± 8.41) dB HL in Rt ear and with mean value (± SD) of 15.80 (± 9.02) dB Hl in Lt ear.

• At 500 Hz, PTA with mean value (± SD) of 16.65 (± 7.35) dB HL in Rt ear and with mean value (± SD) of 16.45 (± 7.12) dB HL in Lt ear.

• At 1000 Hz, PTA with mean value (± SD) of 17.95 (± 6.93) dB HL in rt ear and with mean value (± SD) of 17.50 (± 6.65) dB HL in Lt ear.

• At 2000 Hz, PTA with mean value (± SD) of 19.85 (± 6.54) dB HL in Rt ear and with mean value (± SD) of 20.20 (± 6.40) dB HL in Lt ear.

• At 4000 Hz, PTA with mean value (± SD) of 20.75 (± 6.26) dB HL in Rt ear and with mean value (± SD) of 21.40 (± 5.96) dB HL in Lt ear.

• At 8000Hz, PTA with mean value (± SD) of 24.90 (± 5.24) dB HL in Rt ear and with mean value (± SD) of 26.05 (± 4.54) dB HL in Lt ear.

• Speech discrimination scores with mean value (± SD) of 90 (± 3) % in Rt ear and with mean value (± SD) of 89 (± 3) % in Lt ear (**Table .4, Fig.4 & 5).**

Table 4. Results of PTA thresholds in dB and speech discrimination scores (DS%) among patients.

Frequency		Mean ± SD
250 Hz	**Rt ear**	15.90 ± 8.41
	Lt ear	15.80 ± 9.02
500 Hz	**Rt ear**	16.65 ± 7.35
	Lt ear	16.45 ± 7.12
1000 Hz	**Rt ear**	17.95 ± 6.93
	Lt ear	17.50 ± 6.65
2000 Hz	**Rt ear**	19.85 ± 6.54
	Lt ear	20.20 ± 6.40
4000 Hz	**Rt ear**	20.75 ± 6.26
	Lt ear	21.40 ± 5.96
8000 Hz	**Rt ear**	24.90 ± 5.24
	Lt ear	26.05 ±4.54
DS%	**Rt ear**	90 ± 3
	Lt ear	89 ± 3

Data are presented as mean ±SD. Rt: right, Lt: left. PTA: pure tone audiometry.

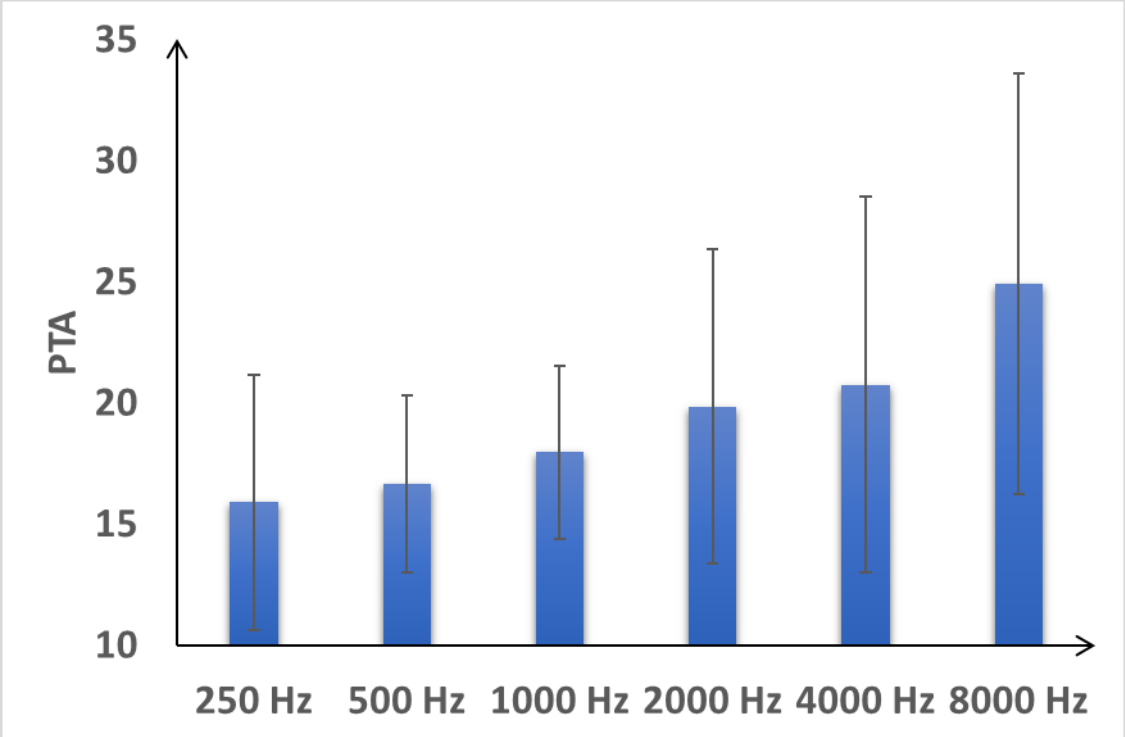

Fig.4. Pure tone audiometry results in right ear among patients

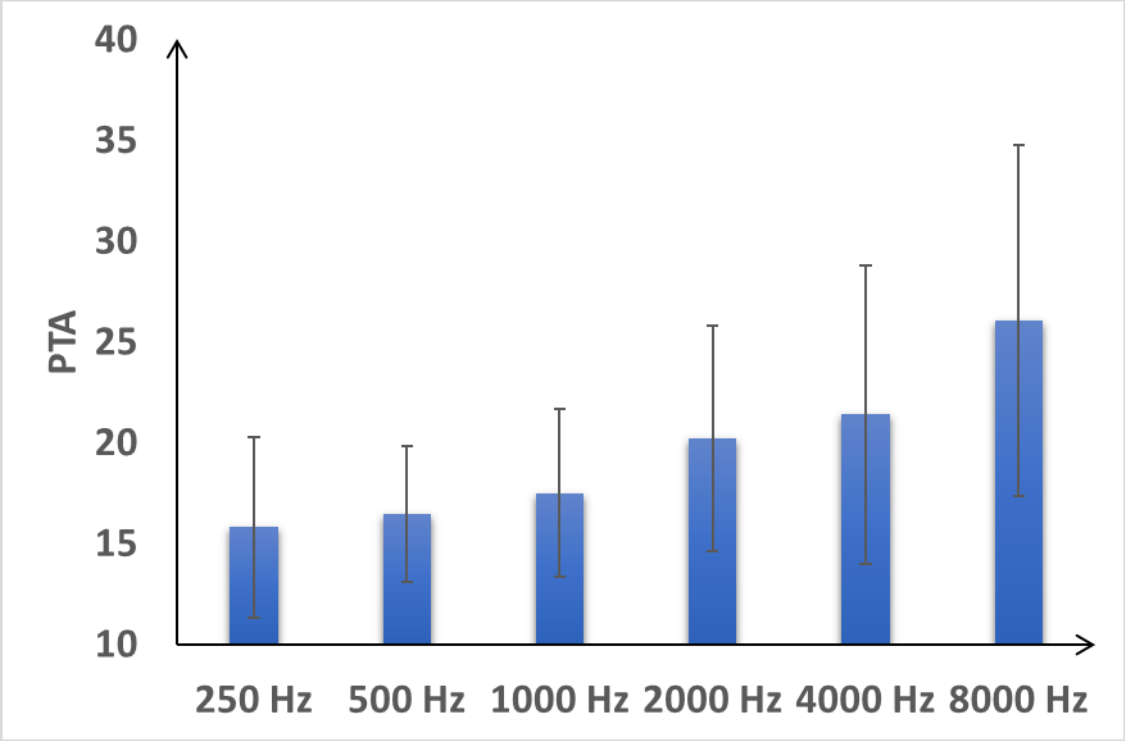

Fig.5. Pure tone audiometry in left ear among patients

Results of transient evoked otoacoustic emission (TEOAE)

One hundred thirty-three ears (66 right and 67 left) recorded a Pass and thirty-one ears (16 right and 15 left) recorded a Partial Pass in TEOAE in patients with normal hearing. However, Twenty-eight ears (14 right and 14 left) had a Partial Pass while two ears (1 right and 1 left) had a Fail in patients suffering from sensorineural hearing loss (**Table.5, Fig.6).**

Table 5. Results of TEOAE

Right ear	Pass	Partial Pass	Fail
Normal	66	16	-
SNHL	**-**	14	1
Left ear			
Normal	67	15	-
SNHL	-	14	1
P-value:	**0.0001***		

* Significant p value <0.05. TEOAE: transient evoked otoacoustic emission, SNHL: Sensorineural hearing loss.

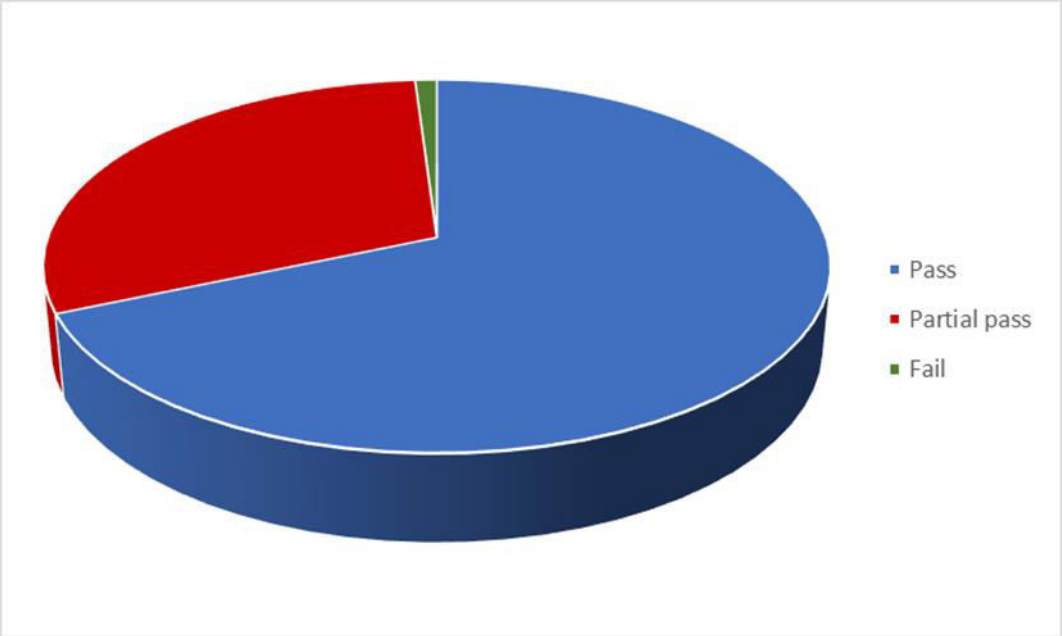

Fig.6. Transient evoked otoacoustic emission of studied patients

Discussion

Nephrotic syndrome (NS) is a prevalent kidney illness in children that is distinguished by the passage of protein from the bloodstream into the urine due to impaired glomeruli. Classically, it is characterized by the presence of proteinuria (≥40 mg/m2/hour or urine protein/creatinine ratio > 200 mg/mL or 3 + protein on urine dipstick), hypoalbuminemia (<25 g/L), and edema **(Verma and Patil, 2024)**.

Our results revealed that 18% of cases had hearing loss (15% sensorineural, 2% conductive and 1% mixed). Some medications used to treat nephrotic syndrome, such as corticosteroids or immunosuppressants, may have side effects that affect cognitive function, including speech and language abilities. Also, complications of nephrotic syndrome, such as infections or electrolyte imbalances, could potentially lead to neurological issues that might affect speech and language **(Park and Shin, 2011)**. Moreover, **(Marei et al., 2019)** found that 23.7% of NS patients showed hearing impairment while 76.3% had normal hearing. The different sample size and duration of disease may explain this difference from our results. But El Mashad et al. **(El Mashad et al., 2017)** found that 40% of children with INS had SNHL. The different age of their patients and including SSNS, steroid dependent/frequently relapsing nephrotic syndrome and SRNS patients in their study may explain this difference from our results.

In the current study, at 250 Hz, pure tone audiometry (PTA) with mean value (± SD) of 15.90 (± 8.41) dB HL in Rt ear and with mean value (± SD) of 15.80 (± 9.02) dB Hl in Lt ear.

Different from our results, **Faisal et al. (2022)** conducted a case controlled study on 40 patients with idiopathic nephrotic syndrome. They found that air conduction frequency at 250 Hz was 22.8 ± 3.4 Hz in steroid sensitive nephrotic syndrome patients.

Furthermore, **El Mashad et al. (2017)** illustrated that PTA was 18 ± 4.6 in SSNS patients, 18.7 ± 5.1 in steroid dependent nephrotic syndrome and 22.7 ± 6.1 in SRNS at 250 Hz.

Regarding our results, at 500 Hz, PTA with mean value (± SD) of 16.65 (± 7.35) dB HL in Rt ear and with mean value (± SD) of 16.45 (± 7.12) dB HL in Lt ear. Higher than our results, **Faisal et al. (2022)** illustrated that air conduction frequency at 500 Hz was 23.5 ± 4 Hz in

steroid sensitive nephrotic syndrome patients.

Moreover, **El Mashad et al. (2017)** illustrated that PTA was 18.3 ± 4.8 in SSNS patients, 18.3 ± 5.5 in steroid dependent nephrotic syndrome and 22 ± 6.9 in SRNS at 500 Hz.

In the present study, at 1000 Hz, PTA with mean value (± SD) of 17.95 (± 6.93) dB HL in Rt ear and with mean value (± SD) of 17.50 (± 6.65) dB HL in Lt ear.

However, **Faisal et al. (2022)** demonstrated that air conduction frequency at 1000 Hz was 22.8 ± 13.4 Hz in steroid resistant nephrotic syndrome patients. The different sample size and different age of patients included may explain this difference from our results.

Lower than our results, **El Mashad et al. (2017)** reported that PTA was 12.3 ± 4.5 in SSNS patients, 14 ± 4.2 in steroid dependent nephrotic syndrome and 17 ± 4.8 in SRNS at 1000 Hz. As all patients had sensorineural hearing loss, this may explain this difference from our results.

Our results revealed that at 2000 Hz, PTA with mean value (± SD) of 19.85 (± 6.54) dB HL in Rt ear and with mean value (± SD) of 20.20 (± 6.40) dB HL in Lt ear.

This came in line with **Faisal et al. (2022)** who reported that air conduction frequency at 2000 Hz was 22 ± 15 Hz in steroid resistant nephrotic syndrome patients.

However, **El Mashad et al. (2017)b** that PTA was 11 ± 3.3 in SSNS patients, 11.3 ± 2.2 in steroid dependent nephrotic syndrome and 11.1 ± 0.8 in SRNS at 2000 Hz.

In the current study, at 4000 Hz, PTA with mean value (± SD) of 20.75 (± 6.26) dB HL in Rt ear and with mean value (± SD) of 21.40 (± 5.96) dB HL in Lt ear.

Supporting our results, **Faisal et al. (2022)** documented that air conduction frequency at 4000 Hz was 21.3 ± 15.4 Hz in steroid resistant nephrotic syndrome patients while was 16 ± 8.8 Hz in steroid sensitive nephrotic syndrome But **El Mashad et al. (2017)** that PTA was 10 ± 1.9 in SSNS patients, 9 ± 2.8 in steroid dependent nephrotic syndrome and 11.7 ± 5.5 in SRNS at 4000 Hz.

In the current study, at 8000Hz, PTA with mean value (± SD) of 24.90 (± 5.24) dB HL in Rt ear and with mean value (± SD) of 26.05 (± 4.54) dB HL in Lt ear.

However, **Faisal et al. (2022)** revealed that air conduction frequency at 8000 Hz was 21.5 ± 16.1 Hz in steroid resistant nephrotic syndrome patients while was 15.5 ± 9.2 Hz in steroid sensitive nephrotic syndrome. In contrast, **El Mashad et al. (2017)** that PTA was 10.3 ± 2.9 in SSNS patients, 11 ± 2.8 in steroid dependent nephrotic syndrome and 11.7 ± 4.8 in SRNS at 8000 Hz.

Speech discrimination scores with mean value (± SD) of 90% (± 3%) in Rt ear and with mean value (± SD) of 89% (± 3%) % in Lt ear. To the best of our knowledge, we are the first who evaluate speech discrimination scores in NS patients. According to our results provided by transient evoked otoacoustic emission, One hundred thirty-three ears (66 right and 67 left) recorded a Pass and twenty-three ears (16 right and 15 left) recorded a Partial Pass in patients with normal hearing. However, Twenty-eight ears (14 right and 14 left) had a Partial Pass while two ears (1 right and 1 left) had a Fail in patients suffering from sensorineural hearing loss.

Limitations of this study including that the sample size was relatively small that may produce insignificant results. The study was in a single center that may result in different findings than elsewhere. We didn't compare patients with healthy individuals as a control group.

Conclusion

Hearing loss is associated with nephrotic syndrome as 18% of nephrotic syndrome patients had hearing loss with speech

discrimination scores of 90% (± 3%) in Rt ear and 89% (± 3%) in the Lt ear.

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