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RESEARCH ARTICLE

Comparison of sensorineural hearing loss characteristics in different hemodialysis vascular accesses

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Abstract

Background and Aim: Sensorineural hearing loss (SNHL) is one of the complications in hemodialysis patients. Vascular access (VA) represents a lifeline for these patients affecting their life quality and clinical outcomes. Arteriovenous fistula is the gold standard of VAs with minor complications and better hemodialysis adequacy. There is no study investigating hearing differences in hemodialysis VAs. Hence, this study aimed to compare SNHL characteristics amongst hemodialysis VAs.

Methods: This cross-sectional study conducted on 64 patients aged 18−60 years received regular hemodialysis in 2019. Demographic data and comorbid conditions were recorded based on patients' case records and electronic databases. After a physical examination, otoscopy, tympanometry, and conventional audiometry, patients were divided into fistula (n = 26), permanent catheter (n = 36), and temporary catheter (n = 2) groups according to vascular access type.

Results: Prevalence rate of SNHL was 63.89%, 50% and 50% in the permanent catheter, fistula and temporary catheter groups, respectively. Most patients had mild sloping-SNHL in the permanent catheter and fistula groups as against moderate degree in the other group. There was no significant difference in hearing thresholds, degree and audiogram shape among VA groups. No significant relation was found between age, sex, hemodialysis duration and disease duration with hearing loss in all groups ($p > 0.05$).

Conclusion: More patients had SNHL in permanent catheter group. Vascular access types, longer duration of hemodialysis and disease duration do not seem to be associated with SNHL. However, further investigation is needed to clarify the relationship.

Keywords: Sensorineural hearing loss; vascular access; chronic renal failure; hemodialysis

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Introduction

The global prevalence of end-stage renal disease (ESRD) has been rising in recent years [1-3]. According to previous studies, the number of

patients with ESRD has progressively increased by about 6% annually in developed and developing countries. A similar rising trend has also been reported in Iran [4]. Long-term hemodialysis has been proposed as the most common alternative option of kidney transplantation due to the high cost of medical care and the high failure rate of transplantation. Nowadays, more than 87% of ESRD patients undergo hemodialysis to prevent uremia and other complications. Some researchers found that vascular access (VA) also affects morbidity and mortality of hemodialysis patients [5,6]. VA is considered a lifeline for hemodialysis patients, with significant effects on complications and overall health. There are different types of VAs for hemodialysis, including arteriovenous fistulas, prosthetic arteriovenous grafts, and central venous catheters.

Arteriovenous fistulas have been recommended as the first VA option for most hemodialysis patients, showing better dialysis adequacy, minimal complications (infection, blood clots) and lower cost of care [7]. Nowadays, intravenous catheters are widely used because of growing age of patients and late-referral phenomenon, poor forearm vascular district to provide immediate dialysis access. VA complications include infection, thrombosis, stenosis, neuropathy and even limb ischemia [8]. In the United States, thrombosis is the most prevalent cause of hospitalization in these patients. Permanent catheters are associated with greater blood flow and fewer infections, compared to temporary ones [9]. Generally, any parameter, which makes arterial blood thinner than systemic blood, may lead to a decrease in hemodialysis adequacy and impair the function of other organs, including the inner ear [10,11]. However, controversy exists regarding the impact of hemodialysis and its duration on hearing. Some researchers have found that hemodialysis has no effects on the hearing function for at least the first five years after treatment. Others have reported the adverse effects of hemodialysis on the inner ear function, with symptoms of hearing loss, tinnitus, and even vertigo [11]. Electrolyte or osmotic disturbances, immunological and hormonal reactions, and elevation in uremic toxin levels can result in hair cells atrophy, edema in the auditory-vestibular organs and nerve damage in the inner ear [5,11,12]. Few studies have shown that hemodialysis is an effective method to improve SNHL at low frequencies [1,13].

SNHL is more prevalent in ESRD patients compared to the general population [14]. Hemodialysis may affect hearing at all frequencies. High-frequency impairment has been known as the most common pattern of hearing loss due to the affected sites from the cochlea to central auditory regions [15-18]. Numerous risk factors and etiopathogenetic mechanisms have been proposed in the development or progression of hearing loss, such as duration of disease, use of ototoxic drugs, age, and comorbidities (e.g. diabetes and hypertension) and hemodialysis itself [15,19,20].

To the best of our knowledge, the impact of hemodialysis VAs type on hearing function has not been fully elucidated. Some researchers found that oxidative stress is very common in chronic kidney disease and is further exacerbated by hemodialysis procedures. VA is likely to play a critical role in the development of dysfunctions in different organs, such as the ears [3]. Effects of hemodialysis VAs on hearing has not been investigated. Therefore, due to the paucity of information on this subject and contradicting reports regarding the effect of hemodialysis on hearing, this study aimed to explore and compare the prevalence and features of SNHL in different types of hemodialysis VA by using data from a single hemodialysis Unit.

Methods

Study population

This cross-sectional study was performed on 70 patients with chronic ESRD, who were undergoing regular hemodialysis (three times per week for four hours per session) for different durations attending Hami Center in Arak, Markazi Province, Iran, in 2019. Diagnosis of ESRD was based on history, physical examination and laboratory tests. The census method was performed for sampling. The inclusion criteria were patients aged 18−60 years already under management of

a nephrologist receiving at least one session of hemodialysis. Patients with a syndromic etiology of chronic renal disease, previous history of head trauma or ear surgery, local otological disease, conductive hearing loss confirmed through assessment of middle ear functioning, or childhood-onset hearing loss, exposure to intense noise and consumption of ototoxic drugs were excluded. All patients underwent hemodialysis, using a Bellco hemodialysis machine (Formula Plus, Italy).

Clinical evaluation

After collecting written informed consent forms from all participants, the demographic characteristics (age, gender), medical history, comorbidities, duration of disease, hemodialysis duration and type of VAs were recorded from patient case records and electronic database. Disease duration was calculated from time of physician diagnosis.

All subjects underwent physical examination by a specialist to ensure that the vascular access site was proper. Then, the patients were subjected to otoscopy. Patients with normal otosopy underwent tympanometry with impedance audiometer (Interacoustics AT235, Denmark) to exclude conductive hearing loss.

Patients with tympanogram Type A underwent pure tone audiometry (PTA). The pure tone audiometry was conducted by an experienced audiologist, using an Itera II clinical audiometer (Madsen, GN, Denmark) in an anechoic chamber. Hearing acuity was assessed across the frequencies of 250−8000 Hz with TDH-39 headphones and bone vibrator B71 in 250−4000 Hz. The average for the 4-frequency (i.e. 500, 1000, 2000 and 4000 Hz) was recorded for each ear separately [15]. An average hearing threshold ≤ 20 dB was defined as normal, according to the Gelfand's criteria [21].

Of the total 70 patients undergoing hemodialysis, two cases died, and four cases were excluded according to the exclusion criteria. The final sample size was measured to be 64 patients of both sexes. Then, we grouped whole hemodialysis patients into three groups as arteriovenous fistula, permanent catheter, and temporary catheter based on the type of VA. Audiogram was interpreted for degree of loss, configuration and frequency distribution of SNHL to compare features between the three groups.

Ethical Considerations

This study was approved by the Ethics Committee of Arak University of Medical Sciences (Code No: IR.ARAKMU.REC.1397.37). The study participants were informed about the study purpose and answered the questionnaire anonymously.

Statistical analysis

Statistical analysis was performed using SPSS Version 23. Normality of the numerical data was verified using Kolmogrov-Smirnov test. Chi-square or Fisher's exact test were used to find the significance of differences in categorical parameters. T-test, one-way ANOVA and Post hoc Tukey was used to determine the significance of differences for continuous variables. Moreover, Pearson correlation coefficient was measured to determine the correlation of hemodialysis duration with SNHL. $P < 0.05$ was considered statistically significant.

Results

The demographic and clinical data for the patients undergoing hemodialysis are outlined in Table 1. Sixty four patients were involved in this study including 42 males (65.6%) and 22 females (34.4%). The mean age ± SD of studied population was 55.14 ± 9.22 (range: 18−60); 53.75 ± 10.07 years in the fistula group; 51.44 ± 8.13 years in the permanent catheter and 60 ± 0.00 years in the temporary catheters group. Table 1 shows the number of patients in both age groups (< 60 years and = 60 years).

In the age < 60 group, hearing loss was more prevalent in the fistula group (66.7%) while more ears were affected by hearing loss in the permanent catheter group (75.5%) in the age = 60 group. No significant relationship was found between access method and hearing of both ears using Chi-square test ($p = 0.52$). The number of males was more than females in the all groups (Table 1). According to the results of Fisher's

Table 1. Demographic and clinical characteristics of patients undergoing hemodialysis

Parameters	Vascular access groups			p
	Fistula group (n=26)	Permanent catheter group (n=36)	Temporary catheter group (n=2)	
Age (years)	53.75 ± 10.07	51.44 ± 8.13	60 ± 0.00	0.131
Age groups (%)				0.599
Age < 60 years	15 (48.40)	16 (51.60)	0 (0.00)	
Age = 60 years	11 (33.30)	20 (60.60)	2 (6.10)	
Mean duration of hemodialysis (years)	5.34 ± 4.80	2.25 ± 1.81	1.7 ± 0.70	0.002*
Mean disease duration	6.80 ± 4.95	2.60 ± 1.77	1.80 ± 0.71	0.0001*
Mean hearing threshold (dB)	32.42 ± 15.51	32.92 ± 13.14	47.18 ± 29.60	0.209
Male-to-female ratio	1.88	1.77	2.00	0.072
Comorbidities				0.240
Hypertension (%)	7 (26.92)	9 (25.00)	1 (50.00)	
Diabetes	11 (42.30)	21 (58.33)	1 (50.00)	
Others	8 (30.77)	6 (16.66)	0 (0.00)	

Data are presented as mean ± SD or n (%).
*significant

exact test, no significant association was found between age (p = 0.38) and gender (p = 0.07) with hearing loss.

Hemodialysis duration and mean ± SD disease duration at the time of audiological evaluation were 3.48 ± 3.66 years and 4.32 ± 3.98 years respectively. Hemodialysis duration (F = 6.72, p = 0.002) and disease duration (F = 11.53, p = 0.0001) were longer in the fistula group than in other groups, their differences were statistically significant using ANOVA test (Table 1) Post hoc Tukey test showed a significant difference only between fistula and permanent catheter groups (p < 0.002). According to Pearson correlation test, there is no significant relationship between hearing of both ears and duration of hemodialysis in each group (p = 0.39).

SNHL was detected in 73.4% cases (63.88% in the permanent catheter group, 50% in the fistula group and 50% in temporary catheter group), 53.1% of whom had bilateral SNHL. The difference was not statistically significant (p = 0.07).

The degree of hearing loss and audiogram shape is presented in Table 2. Majority of patients had mild SNHL in all groups (44.2% in the fistula, 32.35% in the permanent catheter, 50% in the temporary catheter group) predominantly downward sloping audiogram (6−10 dB fall per octave) shape. However, there was no significant difference in the audiogram shape and SNHL degree between the groups, according to the results of Fisher's exact test (p = 0.39).

Table 3 reveals the details of frequencies involved in three groups of study. In both ears, an increase in the auditory thresholds was found with increasing frequency. The mean hearing threshold was observed to be higher in the permanent catheter group compared to other groups, but this difference was non-significant in three groups according to the results of the ANOVA test (p = 0.07).

Subjects with longer duration of hemodialysis (≥ 5 years) showed the highest prevalence of SNHL, but this difference was not significant

Table 2. The hearing characteristics for each ear according to the vascular access type

	Vascular access type					
	Fistula group		Permanent catheter group		Temporary catheter group	
	N(%)		N(%)		N(%)	
Hearing parameter	**RE**	**LE**	**RE**	**LE**	**RE**	**LE**
Degree of HL						
Normal	13 (50,00)	7 (26.90)	13 (36.10)	13 (36.10)	1 (50.00)	0 (0.00)
Mild	9 (34.60)	14 (53.80)	13 (36.10)	10 (28.60)	0 (0.00)	1 (50.00)
Moderate	3 (11.60)	2 (7.80)	7 (19.50)	10 (27.00)	0 (0.00)	0 (0.00)
Moderate to severe	1 (3.80)	2 (7.70)	3 (8.30)	3 (8.30)	0 (0.00)	1 (50.00)
Severe and higher	0 (0.00)	1 (3.80)	0 (0.00)	0 (0.00)	1 (50.00)	0 (0.00)
Audiogram shape						
Normal	13 (50.00)	7 (26.92)	13 (36.10)	13 (36.10)	1 (50.00)	0 (0.00)
Sloping	6 (23.08)	12 (46.16)	15 (41.68)	20 (55.60)	1 (50.00)	2 (100.00)
Flat	3 (11.54)	3 (11.54)	5 (13.91)	2 (5.60)	0 (0.00)	0 (0.00)
High-tone loss (> 2 KHz)	4 (15.38)	4 (15.38)	3 (8.30)	1 (2.70)	0 (0.00)	0 (0.00)

RE; right ear, LE; left ear, HL; hearing loss

(p = 0.07). There was no significant correlation between the mean hearing thresholds at different frequencies in both ears and hemodialysis duration, according to the results of Pearson correlation test (p = 0.2). In the temporary catheter group, no correlation test was performed due to the small number of subjects.

Prevalence of diabetes was higher (almost 50%) than other comorbidities, with no significant differences amongst groups (p = 0.2) (Table 1). Among diabetes, SNHL had higher rate in the permanent catheter group (76.19% in the RE, 80.95% in the left ear) compared to fistula group (45.5% in the RE and 72.72% in the left ear). In the temporary catheter group hearing loss was seen in the left ear of a patient. In patients with hypertension, SNHL was 42.85% in the right ear, 85.71% in the left ear in the fistula group compared to 55% of both ears in the permanent catheter. SNHL was observed in both ears of patient in the temporary catheter group. No significant relationship has been found between comorbidities with the SNHL in all groups (p = 0.3).

Discussion

This study was conducted to investigate and compare the characteristics of SNHL amongst hemodialysis VA groups. To the best of our knowledge, this is the first study has investigated hearing status among hemodialysis patients in terms of VAs.

SNHL was observed in 73.4% of all patients, while the percentage was higher in the permanent catheter group (63.88%) compared with other groups. These results almost match with findings of Sharma et al. (73.7%) [21] and Singh et al. (70.9%) [22]. In contrast, lower rates of SNHL have been reported in previous study in Iran (46%) [13] and in some other countries [18,23-25]. This may be due to variation in sample sizes, differences in the age, duration of ESRD and

Table 3. The mean and standard deviation of hearing thresholds at 250−8000 Hz according to the vascular access type

		Frequency (Hz)								
Ear	**Groups**	**250**	**500**	**1000**	**1500**	**2000**	**3000**	**4000**	**6000**	**8000**
Right	**Fistula**	21.15 (8.52)	22.50 (9.30)	22.69 (11.50)	23.84 (13.28)	27.88 (15.30)	33.26 (16.78)	39.61 (18.48)	44.61 (21.06)	49.80 (24.14)
	Permanent catheter	21.80 (9.79)	23.33 (10.55)	25.69 (11.34)	28.05 (13.32)	30.69 (16.52)	40.13 (17.13)	47.91 (19.87)	50.13 (20.89)	53.33 (21.24)
	Temporary catheter	27.50 (17.67)	37.50 (21.81)	45.00 (35.35)	47.00 (30.89)	55.00 (40.04)	60.00 (42.20)	65.00 (35.35)	75.00 (21.21)	70.00 (14.14)
	p	0.660	0.173	0.051	0.065	0.104	0.073	0.099	0.125	0.188
Left	**Fistula**	23.26 (16.96)	24.42 (16.63)	28.46 (19.63)	33.07 (21.63)	40.19 (23.68)	46.34 (21.88)	53.65 (22.43)	60.76 (27.15)	63.07 (26.04)
	Permanent catheter	20.83 (10.31)	21.80 (7.76)	25.69 (10.29)	31.80 (14.49)	38.05 (20.11)	43.88 (20.94)	50.27 (22.16)	54.02 (22.48)	57.91 (22.24)
	Temporary catheter	22.50 (10.60)	22.50 (10.60)	35.00 (21.21)	45.00 (28.28)	50.00 (28.28)	57.00 (24.78)	67.00 (24.74)	67.50 (17.67)	70 (14.14)
	p	0.780	0.709	0.586	0.600	0.726	0.650	0.521	0.473	0.595

hemodialysis or hearing assessment methods [16].

According to the relevant literature, fistula has been considered as the cost-effective choice with fewer complications and low frequency of infection, vessels stenosis and blood clots resulting in better hemodialysis adequacy and health outcome. These advantages have been more prominent compared to central venous catheter. Also, it has been proposed that long-term use of central venous catheters might be a considerable pro-oxidative factor for developing inflammation, and other relevant complications [26].

SNHL was predominantly mild in the fistula and permanent catheter groups. In the temporary catheter group SNHL severity was found to be more due to small sample size (Table 2). It is in agreement with Saeed et al. [15] and Acharya et al. [18] indicated mild hearing loss among patients and contradicts other study that reported moderate to severe range of hearing loss.

Studies have demonstrated that bilateral hearing impairment found in most ESRD patients [20,24] which is higher than findings (almost half) in our study. Among patients with hearing loss, nearly half of cases displayed sloping audiogram pattern followed by high tone loss (Table 2). No significant differences were found in hearing degree and audiogram shape among all groups.

In fact, higher frequencies were more involved in these patients. The worst mean threshold was 70 dB HL at 8000 Hz in the temporary catheter group (Table 3). This finding is similar to Saeed et al. in Iraq [15], Peyvandi and Ahmady Roozbahany in Iran [13] and Govender et al. in South Africa [19]. The reason for this may be explained by increased vulnerability of basal turn of the cochlea to certain diseases and substances that affects high frequencies. However, we found no significant differences between mean hearing thresholds across all frequencies in all three groups.

Our findings demonstrated that VA types are not associated with SNHL incidence and features in hemodialysis patients. It is in agreement with Esmaeelivand et al. findings revealed no differences between VA groups in terms of dialysis adequacy and complications [9]. Absence of relationship between VAs and SNHL in the hemodialysis patients may be due to sample size,

improvements of vascular access techniques and standards or overstating the benefits of fistula and underestimating the harms of practices with catheter users in existing studies.

Duration of hemodialysis and ESRD duration was longer in the fistula group, but no significant association was found between hemodialysis duration with SNHL in contrast to Saeed et al. findings [15]. These findings are in accordance with Nikolopoulos et al. [27], Ozturan and Lam [28] and contradict the findings of other studies, indicating hemodialysis as a potential contributor to increasing prevalence and severity of hearing loss [14,16,18]. Our finding is in consistent with Sam et al. reported no significant correlation between the duration of disease with the hearing thresholds [11].

In the present study, hypertension and diabetes were the commonly associated risk factors observed in hemodialysis patients with hearing loss, with no association between comorbidity and SNHL (Table 1). This contrasts with previous literature suggested abnormal thresholds in initial audiogram and accelerate the risk of SNHL in hemodialysis patients with increased risk of cardiac aging and cardiovascular risk factors such as hypertension and diabetes [29,30].

There were some limitation in our study, first, a basic audiogram was unavailable in our study; therefore, it was not possible to investigate changes in hearing thresholds. Second, the otoacoustic emission test was not performed to confirm the regular function of the inner ear. The decreased amplitude in these patients can predict the likelihood of hearing loss in cases with normal hearing.

Conclusion

Sensorineural hearing loss (SNHL) was observed as a hidden complication in the majority of hemodialysis patients especially in permanent catheter group. This study demonstrates that mild sloping SNHL was most prevalent in all groups. However, the duration of disease, vascular access (VA) type and hemodialysis were not associated with VA type, duration did not show any significant relationship with SNHL. Further studies with larger size are necessary to clarify effect of VAs on SNHL and its risk factors in hemodialysis patients. Also, assessing auditory function in the preventive care protocols at the time of admission for early diagnosis and management of hearing loss are recommended.

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Conflict of interest

The authors state that there was no conflict of interest.

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