Research Article

Acceptable Noise Level in Unilateral Ménière's Disease

Elahe Nasiri[1], Hamid Jalilvand[1*], Nasrin Yazdani[2], Alireza Akbarzadeh Baghban[3,4]

[1.] *Department of Audiology, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[2.] *Otorhinolaryngology Research Center, Tehran University of Medical Sciences, Tehran, Iran*
[3.] *Proteomics Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[4.] *Department of Biostatistics, School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

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Citation: Nasiri E, Jalilvand H, Yazdani N, Akbarzadeh Baghban A. Acceptable Noise Level in Unilateral Ménière's Disease. Aud Vestib Res. 2022;31(1):11-6.

https://doi.org/10.18502/avr.v31i1.8129

Highlights

- The study investigated noise tolerance in both ears of people with unilateral MD
- The ANL in the affected ear was higher than in the contralateral ear
- We showed that sample size affects ANL results in MD patients

Article info:
Received: 19 May 2021
Revised: 13 Jun 2021
Accepted: 27 Jun 2021

*** Corresponding Author:**
Department of Audiology, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
hamidjalilvand4@gmail.com

ABSTRACT

Background and Aim: Noise tolerance and performance in noisy environments are influential factors of hearing aid use in people with hearing loss. One of the causes of hearing loss is Meniere's disease (MD), which affects speech perception in noise. Acceptable noise level (ANL) is a test that measures the maximum tolerated background noise level (BNL) while listening to the running speech. Since the effect of MD on ANL needs further study, the present study aims to examine the ANL test results in people with unilateral MD, and compare the results between the two ears.

Methods: This cross sectional study conducted on 33 individuals with unilateral MD (21 females and 12 males) aged 32–60 years who had the disease for at least one year, who participated in this study. Their most comfortable level (MCL), BNL, and ANL in both ears were then evaluated.

Results: The mean MCL and BNL were significantly different between the two ears, where they were higher in the affected ear than in the contralateral ear. There was also a significant difference in the ANL results between the two ears. In the affected ear, a statistically significant relationship was reported between the ANL and the average hearing thresholds at frequencies of 250, 500, and 1000 Hz.

Conclusion: MD affects the ANL in the affected ear and causes a deterioration in its level and speech perception in noise.

Keywords: Meniere's disease; acceptable noise level; perception in noise; speech intelligibility

Introduction

Hearing loss is one of the most important and influential problems in people that can affect their performance and speech perception in noise. One type of hearing loss is sensorineural hearing loss (SNHL) which is caused by damage to the inner ear or auditory nerve. This type of hearing loss is associated with many problems, one of which is Meniere's disease (MD) first introduced in 1861 by Prosper Meniere [1], which affects the inner ear and is associated with cochlear impairment and increased endolymphatic pressure. The prevalence of MD increases at the age of 40–60 years [2, 3]. The exact cause of this disease has not been found yet, but it is probably due to disruption of the endolymph production or endolymph absorption following microvascular disorder of the stria vascularis, obstruction, stenosis or incomplete growth of the endolymphatic sac, or other factors [4-6]. The onset of this disease is associated with a set of symptoms such as vertigo, SNHL, tinnitus, and a sensation of aural fullness in the ear [7-9]. In the early stages of the disease, changes in fluid volume or elastic changes in the cochlear membrane increase the threshold at low frequencies, leading to rising configuration of audiogram. Over time with the disease progression, other frequencies are involved and a flat curve is observed [10]. The incidence of MD is often unilateral, but over time may also affect the contralateral ear. In House et al.'s study, the average time interval for the disease to convert from unilateral to bilateral was 7.6 years, with 48% occurring within five years after initial diagnosis [11]. In other studies, after an average of five years from the initial diagnosis, symptoms were observed in the contralateral ear and led to impairment in noise perception [11-14]. One of the tests that examine a person's performance in noise is the acceptable noise level (ANL) test developed by Nabelek in 1991 [15]. This test measures the maximum tolerated background noise level (BNL) while listening to the running speech, and the results remain constant for at least 3 months [16]. This test also predicts the success of using a hearing aid with 85% accuracy. The ANL does not depend on age [17-19], gender [19-21], middle ear condition [22, 23], and cochlear responses [23, 24], but is related to speech presentation level [19, 25-28], audiogram configuration [29], and degree of hearing loss [30]. Olsen et al. examined the ANL in people with unilateral MD [31]. Although the mean of most comfortable level (MCL) and BNL were higher in the affected ear, they found no difference in the mean ANL results between the two ears [31]. Considering the use of not enough samples by Olsen et al. (n=11) [31], and due to the fact that the ANL is influenced by some variables mentioned above, the question is whether the lack of difference in ANL between the two ears is due to employing small number of patients and the lack of control over the above-mentioned variables. In this regard, the present study aimed to investigate the ANL on a higher number of patients with unilateral MD.

Methods

In this cross sectional study, participants were 33 people with unilateral MD (21 females and 12 males). Of these, 12 had the disease in the right ear and 21 had it in the left ear. Their mean age (±) was 47±9.69 years (ranged 32–60 years). As shown in Table 1, they were selected based on the 2020 protocol of the American Academy of Otolaryngology-Head and Neck Surgery [7] from among those referred to Amir Alam Hospital in Tehran, Iran whose disease was approved by an ENT physician and at least one year had elapsed since the onset of their symptoms.

The condition of their middle ear was normal in both ears and their hearing thresholds at frequencies of 250–8000 Hz in the contralateral ear were less than 25 dB HL (Figure 1). The speech and noise test materials used in this study were in accordance with the Persian version of the ANL test [32-35]. In this test, the story told by a female speaker was used as a speech signal and the babble noise of 12 speakers was used as background noise. The test contents were entered into the AC40 Interacoustic audiometer (Denmark) via a cell phone (Samsung

Table 1. Diagnostic criteria for Meniere's disease, based on Clinical Practice Guideline for Meniere's disease, 2020 [7]

Definite Meniere's disease
Two or more spontaneous attacks of vertigo, each lasting 20 minutes to 12 hours Audiometrically documented fluctuating low to midfrequency sensorineural hearing loss in the affected ear on at least one occasion before, during, or after one of the episodes of vertigo Fluctuating aural symptoms (hearing loss, tinnitus, or fullness) in the affected ear
Probable Meniere's disease
At least two episodes of vertigo or dizziness lasting 20 minutes to 24 hours Fluctuating aural symptoms (hearing loss, tinnitus, or fullness) in the affected ear other causes excluded by other tests

Galaxy S10) and, then, played via the headphone after calibration. Before the test, instructions for its use were given to the participants orally and in writing. First, the speech signal was played for them at 30 dB HL as recommended by Nabelek et al. [15], leveling up and down by 5 dB to assess if the sound was too high or too low for them. It was then leveled up and down by 1 dB to determine the MCL for each patient. In the next step, the intensity of the running speech remained constant, and the babble noise was played monaurally at 30 dB HL. It was leveled up and down first by 5 dB and then by 1 dB to assess the highest level of background noise at which they were able to tolerate while listening to the running speech. This level was determined as the BNL. Finally, by subtracting the BNL from the MCL, the ANL was obtained. The ANL of the contralateral ear was also measured in the same way. It should be noted that the MCL and BNL were calculated twice for each person and for each ear, and the average of their results was considered as the final MCL and BNL. Collected data were analyzed in SPSS 26 software. Considering the normal distribution of data ($p>0.05$) based on the results of Kolmogorov-Smirnov test, we used paired t-test to compare the mean of each MCL, BNL, and ANL parameters between the two ears, considering a significance level of 0.05. Pearson correlation test was used to evaluate the correlation between the results of the ANL test and the average hearing thresholds, and also the correlation of MCL, BNL, and ANL with the disease duration.

Results

The mean disease duration in patients was two years, ranged from 1–8 years. The mean and range of hearing thresholds at frequencies of 250–8000 Hz are presented in Table 2. The mean word recognition score (WRS) was 93.2% in the affected ear (ranged 20–100%) and 99.3% in the contralateral ear (ranged 90–100%). The mean MCL, BNL and ANL for the affected ear were higher than those for the contralateral ear (Table 2). In order to evaluate the mean difference between the two ears, paired t-test was used whose results showed a significant difference in the MCL ($p<0.01$), BNL ($p<0.02$), and ANL ($p<0.01$) between the two ears. Pearson correlation test results showed a relationship between the average hearing threshold at frequencies of 250, 500, and 1000 Hz and the ANL in the affected ear ($p<0.008$, Figure 2). Moreover, there was a significant positive correlation between the ANL and disease duration in the affected ear ($r=0.6$, $p<0.002$).

Discussion

Speech perception, especially in noisy environments, has always been one of the most important and influential factors affecting the life quality, auditory function, and hearing aid use in people with SNHL. The present study investigated noise tolerance in both ears of people with unilateral MD. For this purpose, the Persian version of the ANL test was used. The results showed that the mean MCL, BNL, and ANL were higher (poorer) in the affected ear than in the contralateral ear, and the difference was statistically significant. Due to the nature of MD and its effect on cochlear structures including cochlear membrane and hair cells, the hearing thresholds in the affected ear are influenced after the onset of disease, followed by an increase in the MCL. In this study, the ANL in the affected ear was higher than in the

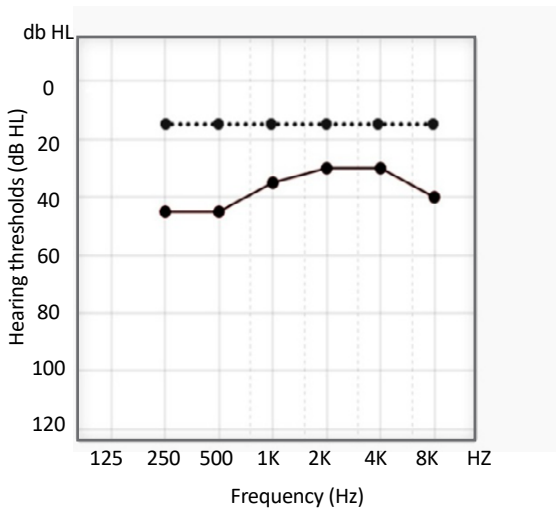

Figure 1. Mean hearing thresholds in the affected and contralateral ears. The continuous line indicates the affected ear and the dashed line represents the contralateral ear

Table 2. Measures of hearing threshold, most comfortable level, background noise level and acceptable noise level in the affected and contralateral ears

Measures	Affected ear (dB HL)				Contralateral ear (dB HL)			
	Mean (SD)	Max	Min	Range	Mean (SD)	Max	Min	Range
0.25 kHz	47.12 (12.12)	75	30	45	14.70 (4.83)	20	5	15
0.5 kHz	43.33 (14.82)	75	20	55	14.85 (5.07)	20	5	15
1 kHz	35.76 (17.50)	70	10	60	13.48 (4.41)	20	5	15
2 kHz	28.79 (14.68)	60	10	50	12.88 (5.15)	20	5	15
4 kHz	31.06 (18.53)	75	5	70	14.09 (6.18)	20	0	20
8 kHz	39.39 (21.82)	90	5	85	16.52 (5.22)	20	0	20
Most comfortable level	62.27 (9.85)	85	45	40	53.33 (6.20)	70	40	30
Background noise level	59.39 (8.23)	77	40	37	54.58 (6.36)	71	43	28
Acceptable noise level	2.58 (3.38)	10	–3	13	–1.27 (1.77)	2	–4	6

contralateral ear, indicating a different effect on the cochlea of individuals based on signal processing in noise. In Olsen et al.'s study, although MCL and BNL were higher in the affected ear than in the contralateral ear, no difference in ANL results was observed between the two ears [31], which may be due to the role of recruitment in affected ear. In contrast, our results showed the statistically significant difference in the ANL results. This discrepancy may be related to the difference in disease duration and sample size. The number of samples in our study was three times more than in Olsen et al.'s study. Studies have reported that, with disease progression, the probability of contralateral ear involvement is 2–73%, depending on the follow-up period and strict adherence to diagnostic criteria [10]. In many studies, most patients showed the signs of contralateral ear involvement and converted to bilateral MD within five years after initial diagnosis [36]. In House et al.'s study, the mean duration of MD conversion was 7.6 years, where 48% occurred within five years after initial diagnosis [11]. Of 610 individuals with unilateral MD in Harrison's study, more than 70% reported the contralateral ear involvement within five years after initial diagnosis [37]. Given that the mean disease duration of patients in the present study was lower (2 years) compared to Olsen et al.'s study (13 years), and the results of ANL were better in the present study, maybe since the patients in our study were in the early stages of the disease and their contralateral ear had not yet been affected. Thus, they were in better conditions than the participants in other studies, indicating the

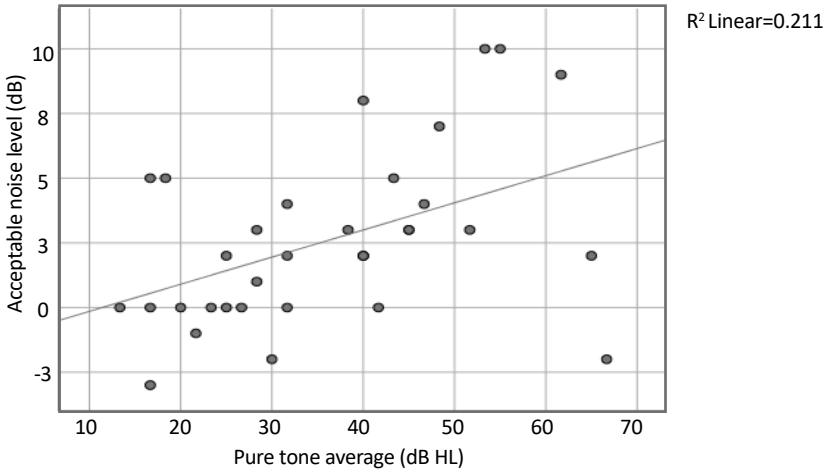

Figure 2. Acceptable noise level as a function of pure tone threshold average (0.5, 1 and 2 kHz) in the affected ear

need for further studies. Moreover, among the patients in our study, 5 were unable to perceive the speech in noise due to severe cochlear damage and hearing loss, which were excluded from the study. Given the relationship of ANL with audiogram configuration and severity of hearing loss, and considering the change in the audiogram pattern over time in MD, and a moderate relationship between disease duration and the ANL in affected ear (r=0.6) in this study, similar studies are recommended on individuals with MD at different stages of disease progression and involvement duration.

Conclusion

Meniere's disease affects the noise tolerance of people such that the most comfortable level and background noise level in the affected ear are higher than in the contralateral ear, leading to higher acceptable noise level (ANL). In the affected ear, ANL is associated with pure tone average; with the increase of hearing threshold, the ANL increases.

Ethical Considerations

Compliance with ethical guidelines

This article was extracted from a research project and obtained its ethical approval from the Research Ethics Committee of Shahid Beheshti University of Medical Sciences (Code: IR.SBMU.RETECH.REC.1399.269).

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' contributions

EN: Study concept and acquisition of data; HJ: Study concept, design, and supervision; NY: Study concept, design, and supervision; AAB: Statistical analysis. All authors discussed the results and contributed to the final manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

Acknowledgements

This study is the result of the research project No. 28301 at Shahid Beheshti University of Medical Sciences. The authors would like to thank the personnel of the ear and hearing section of Amir Alam Hospital in Tehran, Iran for their cooperation.

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