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# The Analysis of Presbycusis Type and Lesion Location Based on Audiogram Description, Speech Audiometry, and Otoaccoustic Emission

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## Abstract

**AIM:** This study aims to determine the type of presbycusis and the location of the lesion based on audiogram images, speech audiometry, and otoacoustic emission (OAE).

**METHODS:** This study was an observational study of 36 presbycusis patients (72 ear samples). Pure tone audiometry, speech audiometry, and OAE were examined to determine the most types of presbycusis and the location of the lesion. A cross-sectional descriptive research method was conducted to analyze the dynamics of the correlation between risk factors and effects using approaching, observing or collecting data at once (point time approach). Each research subject was observed only once, and measurements were performed toward the character status or subject variables during the examination.

**RESULTS:** The results showed that presbycusis was primarily obtained in the 60–69 years age group (69.4%). And the most types of presbycusis based on the audiogram were metabolic presbycusis (36.1%). The average hearing range based on the audiogram was at a frequency of 26–40 dB or the degree of mild deafness. Most types of deafness were sensorineural hearing loss. In speech audiometry, most NPT and NDT were mild and normal deafness as much as 44.4% in NPT and 56.9% in NDT. Based on the OAE, 72 samples showed the results of the referrals. In addition, regarding the results of the audiogram, speech audiometry and OAE, the location of the lesions of all samples was in the cochlea (100%).

**CONCLUSION:** The most common type of presbycusis based on audiogram images is metabolic presbycusis with a mild hearing loss.

## Introduction

The large number of elderly people in Indonesia in the future has a positive and negative impact. Positive impact if the elderly population is in a healthy, active, and productive state. On the other hand, the large number of elderly people becomes a burden if the elderly has health problems that result in increased health-care costs, decreased income/income, increased disability, the absence of social support and an environment that is not friendly to the elderly population [1].

The process of hearing is very necessary for the elderly because it can improve the quality of life and can be useful for safety and health. Hearing is one of the most important senses for elders. The ability to hear enables the elderly to pick up on sounds, even when they are asleep so that they remain alert, to listen to sounds in the dark and to detect sounds coming from behind. In addition, the incidence of various disabilities related to increasing age is known to be very high in the elderly group. Therefore, they rely heavily on special senses such as hearing to compensate for other age-related disabilities. Elders also need to rely on good hearing to be able to communicate efficiently [2].

Presbycusis, or age-related hearing loss, is the loss of hearing that gradually occurs in most people as they grow older. According to the World Health Organization, approximately one-third of people over 65 years of age are affected by disabling hearing loss [3].

In 1893, the term “presbycusis” was first used and introduced by Zwaardemaker. Presbycusis means hearing loss in the elderly caused by the aging process (from the Greek presbus “aged” and akousis “hearing”) due to age-related changes in hair cells of the cochlea [2]. The aging process occurs in all organs of the body including in the outer, middle, and inner ear structures. In the outer side of ear, there is a change in the reduced elasticity of the ear tissue and the ear canal. Furthermore, degeneration of flexibility occurs from the basilar membrane, neurons in the auditory pathway are reduced, changes to the central auditory system and brainstem occur, and the speed of processing at the hearing center in the brain [4], [5]. Hearing loss affects about one third of adults over the age of 60. Presbycusis is considered a progressive form of sensory neural hearing loss (SNHL), which

deals with age-related involutional changes of different parts of the auditory system and is presented in the form of a pure tone audiogram that is symmetrical with hearing loss occurring at high frequencies [6]. The typical changes in presbycusis begin with hearing loss occurring at high frequencies and decreased hearing range. Many factors contribute to presbycusis include changes in the morphology of the stria vascularis, loss of hair cell in the cochlea, degeneration of the inner ear pathways, genetic factors, smoking, anatomic changes, metabolic disorders, and exposure to loud noises [7].

The diagnosis of presbycusis is based on history and physical examination. It is frequently diagnosed when it meets the following criteria: SNHL of the elderly due to hearing organs that occur slowly, a symmetrical increase in hearing range, absence of injury, history of ototoxic drugs usage, history of ear disease and surgery, presence of conductive hearing loss (10dB or less), and generally age-related factors caring for adults aged 65 years and beyond [8]. Patients with presbycusis may have difficulty to listen to and understand what other people are saying. Measuring the ability to hear and understand in people with presbycusis is essential for selecting the appropriate treatment method and interpreting the results. In addition, the test results can be used as a guideline for treatment and to assess the difficulties faced by sufferers with hearing loss and the ability to adapt to the environment [8].

A study conducted by Sogebi *et al*. [4] regarding clinical and audiometric features of presbycusis in Nigeria found that the most presbycusis type was strial type presbycusis where deafness increases with age which affects speech audiometry and occurs at high frequencies [4].

The objective of this study was to analyze the type of presbycusis, and the location of the lesion based on the audiogram image, speech audiometry, and otoacoustic emission (OAE) in the elderly with presbycusis. Thus, it may meet the need for the availability of scientific information regarding the various audiological examination results in the elderly with presbycusis and can be used as the initial data as a basis for further research on audiological analysis of the elderly in Makassar.

## Methods

The study was performed using a cross-sectional descriptive method which was carried out from January to June 2020 at the Dr. Wahidin Sudirohusodo Makassar hospital, South Sulawesi Province located at THT-KL and Panti Sosial Tresna Werdha as well as at public health center (Posyandu Lansia) in Makassar city by performing hearing screening for the elderly aged 60–90 years after diagnosis of presbycusis. Hearing screening was carried out with pure tone Audiometry, Speech Audiometry and Oto Acoustic Emission on the left and right ear. Afterwards analyzed to figure out the general description of pure tone audiometry, speech audiometry and Oto Acoustic Emission in the elderly with presbycusis. After the screening process was completed and the patient agreed to participate in the study by signing an informed consent letter. Request permission from patients who meet the criteria to be used as a research sample by filling out an informed consent sheet and declared to meet the ethical requirements to be implemented from the biomedical research ethics commission on humans Faculty of Medicine Hasanuddin University. After that, the patient will then take a complete history to obtain information about the history of the disease, hearing loss and deafness, history of ototoxic drugs usage, history of ear disease, and acoustic trauma. Then the examination was followed by an examination of the room to assess the soundproof room, examination of the tuning fork test namely the Rinne test, the Swabach test, and the Weber test, followed by Pure Tone Audiometry examination, speech audiometry examination, Tympanometry examination, and OAE examination. Obtained data would be recorded in the research form and tabulated then depicted descriptively in tabular and narrative form.

## Results

During a period of 6 months, from January 2020 to June 2020, a study was conducted for elderly patients, beyond or equal to 60 years who met the study inclusion criteria. This study involved 36 people and 72 ears as research subjects. Based on data obtained in this study, the following result was obtained. Table 1 shows the sample characteristics based on the age and gender. Based on the table, the most gender in this study was woman (66.7%) and aged 60–69 years (69.4%).

**Table 1: Characteristics of samples**

| Variables | Categories | n | % |
|---|---|---|---|
| Age | 60–69 years | 25 | 69.4 |
| | 70–79 years | 7 | 19.4 |
| | > 80 years | 4 | 11.1 |
| Gender | Male | 12 | 33.3 |
| | Female | 24 | 66.7 |
| Total | | 36 | 100 |

Table 2 shows sample distribution based on hearing threshold ranges. And the table shows that the most threshold range in this study was 26–40 dB with 31 samples or equivalent to 43.1% of all samples. Metabolic presbycusis was the most common presbycusis with 26 samples or 36.1% of all samples, followed by neural presbycusis with 24 samples (33.3%), sensory presbycusis with 12 samples (16.7%), and mechanic presbycusis with ten samples (13.9%).

Table 3 shows sample distribution based on speech reception threshold (SRT) of speech audiometry, which was used to determine the level of hearing loss of the samples. Based on the table, it is known that the most

**Table 2: Hearing threshold range and type of presbycusis**

| Variables | Categories | n | % |
|---|---|---|---|
| Hearing threshold range of intensity | 0–25 dB | 4 | 5.6 |
| | 26–40 dB | 31 | 43.1 |
| | 41–55 dB | 11 | 15.3 |
| | 56–70 dB | 6 | 8.3 |
| | 71–90 dB | 12 | 16.7 |
| | > 90 dB | 8 | 11.1 |
| Types of presbycusis | Metabolic | 26 | 36.1 |
| | Sensory | 12 | 16.7 |
| | Neural | 24 | 33.3 |
| | Mechanic | 10 | 13.9 |
| **Total** | | 72 | 100 |

common SRT interpretation was the normal and mild hearing loss which each account for 22.2% of all samples.

**Table 3: Characteristics of sample distribution based on speech reception threshold**

| Speech Reception Threshold | | |
|---|---|---|
| Interpretation of SRT | n | % |
| Normal | 16 | 22.2 |
| Very mild hearing loss | 13 | 18.1 |
| Mild Hearing loss | 16 | 22.2 |
| Moderate Hearing loss | 8 | 11.1 |
| Moderate Severe Hearing loss | 15 | 20.8 |
| Severe Hearing loss | 4 | 5.6 |
| Total | 72 | 100.0 |

Table 4 shows sample distribution based on the maximum hearing ability to discriminate each sound unit in words spoken, which was used to determine speech discrimination score (SDS) in speech audiometry. SDS is used to determine degree of hearing loss of the samples. Based on the table, it is known that there were 19 samples with normal SDS interpretation which accounts for 26.4% of all samples.

**Table 4: Characteristics of sample distribution based on speech discrimination score**

| Speech discrimination score | | |
|---|---|---|
| Interpretation of SDS | n | % |
| Normal | 19 | 26.4 |
| Mild hearing loss | 22 | 30.6 |
| Moderate hearing loss | 12 | 16.7 |
| Severe hearing loss | 9 | 12.5 |
| Very severe hearing loss | 10 | 13.9 |
| Total | 72 | 100.0 |

Table 5 shows sample distribution based on OAE test results, which were used to assess cochlear function using a DPOAE tool. All 72 samples used in this study were in the refer category. This study also found that lesions of all 72 samples were located on the cochlea.

**Table 5: Characteristics of sample distribution based on otoacoustic emission**

| Otoacoustic Emission | | |
|---|---|---|
| OAE | n | % |
| Refer | 72 | 100.0 |
| Total | 72 | 100.0 |

## Discussion

Presbycusis is an aging-related hearing loss caused by changes in the hair cells of the cochlea and hearing center. Aging process occurs in all organs, including in the structures of the outer, middle, and inner ears. In the outer ear, the elasticity of the ear tissue and the ear canal will reduce. In addition, the changes can also occur in the form of flexibility degradation of the basilar membrane, reduced neurons in the auditory pathway, changes in the brain stem and auditory center system, as well as decreased processing speed of the hearing center in the brain [4], [5].

The distribution of the degree of hearing loss is used as a parameter to indicate the degree of hearing loss of the samples, which was obtained using pure-tone audiometry (PTA) tests with an average hearing threshold based on ISO. The purpose of the examination is to determine the lowest intensity level in dB of any frequency that can still be heard in a person's ear, in other words the threshold of one's hearing to sound [9].

The results show that most of the samples (24 samples, 36.1% of all samples) had mild SNHL, which is the type of hearing loss with the highest number of occurrences among the samples. This is consistent with a large body of studies about presbycusis around the world, and especially in Indonesia. One of those is a study by Sogebi *et al*. in 2013 in Afrika, which states that the PTA test showed the characteristics of audiogram, namely decreased bilateral SNHL at high frequency [4].

Based on the data in Table 1, it can be concluded that presbycusis occurs mostly at the age of 60–69 years. At this age, outer hair cells and organ of corti degenerate which cause the decreased hearing function. This is in accordance with a study conducted by Zhang *et al.* (2013) [2] and a study conducted by Fatmawati *et al*. (2016) [10], which states that most presbycusis occurs at the age of 65 or more.

Table 3, in which the samples are categorized based on frequencies of hearing threshold ranges, shows that the category with the highest number of samples is 26–40 dB with 31 samples or 43.1% of all samples. This result is different from the study conducted at RSUP DR. Hasan Sadikin Bandung from January 2012 to December 2014 by Fatmawati *et al*. (2016) [10], which states that 54 samples (12.6%) affected by presbycusis had a normal hearing threshold of 0-25 dB.

In this study, the highest type of presbycusis, which is shown in Table 4, is metabolic types with 26 samples or 36.1% of all samples.

A study conducted by Nuryadi *et al*. (2017) [11] in 2013–2014 states that the prevalence of metabolic or stria presbycusis was quite high, that is 34.6%, followed by neural (30.7%), mechanic (22.8%), and sensory (11.9%). They suspect that there was a vascular involvement between age factor and hearing loss in histopathological studies of aging mice because stria vascularis has a lot of vascularization.

There are various causes of metabolic presbycusis. A study conducted in Makassar in 2014 found that the most common risk factor of hearing loss in the elderly was hypertension with 37 samples (52.1%) [12].

The second most common type is neural presbycusis with 24 samples (33.3%). A study found

that neural presbycusis was the most common presbycusis [12]. According to Schuknecht and Gacek, neural presbycusis is characterized by progressive loss of nerve cells along the cochlea, especially in the basal region. Primary nerve degeneration must exceed 90% to affect the hearing threshold on a PTA test. Nerve loss has the greatest effect on the ability to discriminate words, but a loss of nerve cells exceeding 50% is corresponding to normal or mild SDS as shown in this study.

As for the location of lesion, we found all 72 samples located on the cochlea. Fioretti *et al.* [7] stated that the disfunction of outer hair cells will lead to hearing loss originated from the cochlea. This indicates that there has been a disruption in the function of the cochlea, which involves the outer hair cells. The outer hair cells in the basal area are longer so to be able to pass on stimulation to nerve fibers requires more energy. With reduced function of outer hair cells, the work of the cochlea will be reduced dramatically by 50–70 dB in the basal cochlea [13].

Recruitment phenomenon can be used to differentiate between cochlear and retro cochlear deafness. Automatic brainstem response (ABR) is very useful in establishing a differential diagnosis for the type of hearing loss whose lesion location is originated from retro cochlea, vestibular schwannoma, and neurovascular disorders. ABR can be used in conjunction with MRI and angio-MRI.

Considering the speech audiometry, based on the SRT and SDS results obtained in this study, both have the highest occurrence in mild hearing loss as described above. This suggests that although most of the samples examined had NPT and NDT that were still relatively good but with age, the ability to discriminate or recognize what was said decreased. It is said by Cech Donna and Martin that 75% of people over the age of 70 will show hearing loss with NPT and NDT like this [14].

However, considering the type of presbycusis, based on the results of the speech audiometry, it is found that the most common type of presbycusis is metabolic presbycusis. All samples in this study have lesions located in the cochlea and show refer results, most of which have metabolic presbycusis.

### *Limitations*

a. Examination cannot be done within a day because the examination period for 1 patient takes a long time, elderly patients often feel bored and tired
b. Some risk factors that can cause hearing loss and deafness are not studied and no serologic blood examination is done to rule out these risk factors
c. The number of samples is not enough; auditory brainstem response (ABR) examination which is an objective examination in distinguishing cochlear and retroocular deafness is not carried out.

## Conclusions

Most common type of presbycusis based on audiogram image is metabolic presbycusis with a hearing threshold of 26–40 dB or mild hearing loss. The most common type of hearing loss based on the audiogram is SNHL. The most common SRT and SDS are mild and normal hearing loss, which account for 44.4% on SRT and 56.9% on SDS.

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