Presbycusis

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SUMMARY

Presbycusis is a progressive sensorineural hearing loss varying with age and affecting first the higher frequencies. The physical and social handicap is not fully appreciated by most people with normal hearing. Difficulties in diagnosis exist because of co-existing sensorineural hearing loss in older people. Audiometry provides an excellent means of analyzing the auditory system and is generally accurate in localizing a site of dysfunction. Many people with presbycusis are helped by hearing aids but all of them are helped by good enunciation. There are many factors considered in the etiology but so far there is no convincing means of preventing presbycusis.

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PRESBYCUSIS, 'the hearing of the old man,' has been recognized since the late 19th century.[1] The higher frequencies are first affected and it has always been considered a sensorineural problem – in fact, the most common one in the U.S.A. It has become even more prevalent with our increasing life span. There is no such thing as a normal loss for a particular age, but one can determine the average deviation from the normal for each age and decade. Surveys based on thousands of subjects reveal an increasing hearing loss, progressively involving lower frequencies with each decade over 30 years.[3] The spatial arrangement of the auditory neural elements and the easily applied means for testing them make it possible to measure any slow functional decline over a long period of time and with an accuracy unattainable in any other body system.

Although not all older people are hard of hearing, losses can vary from zero to total deafness. Presbycusis usually progresses very slowly but occasionally increases quickly with physiological stress, for example after a severe illness or a general anesthetic.

Puretone impairment may be moderate with severe speech discrimination loss. Gaeth,[5] in 1948, labelled this "phonemic regression". The dysfunction involves the retrocochlear auditory system. Because of the decreased integrative capacity of the aged, puretones may be heard but words not understood.

Schuknecht[6] has shown that lesions of the neural auditory pathways have a greater effect on speech discrimination than on puretone thresholds. Animal experiments have shown that bilateral oblation of the auditory cortices does not alter puretone thresholds and that as many as 75 percent of the spiral ganglion cells can degenerate in one area of the cochlea without affecting the puretone thresholds for frequencies located in that area.

With the loss of acuity for hearing high frequencies, the aged person frequently fails to hear the consonants, thus the confusion between car and far, ham and lamb, etc. The natural tendency of the speaker in these situations is merely to repeat at a higher intensity when in fact, speaking slowly and articulating carefully is significantly more effective. Naturally, this type of situation is alleviated significantly by lip reading. Whether formally trained or not, the hard of hearing derive tremendous assistance from the visual cues provided when looking directly at the speaker. Patients frequently complain about family members and friends who speak too quickly, who mumble, and who speak while 'going away'.

The difficulty in hearing varies greatly with the situation. Jokinen[7] states that discrimination scores are lower in those over 60 and that in noise there is a distinct problem with discrimination.

The psychological problems associated with presbycusis are of equal concern. The understanding of speech involves not only hearing the sounds but many complex integrative and interpretative processes in the higher auditory system. Restraints such as knowledge of the topic, linguistic and grammatical knowledge etc., are present. Even with normal functioning of the end-organ, the processes may be slowed. Slowness is frequently equated with mental inadequacy and an older person at times remains silent or aloof to avoid the label. The person then withdraws further, entering the conversation occasionally to 'hear what he wants to hear'.

Incidence

The 1959-62 U.S. National Health Survey reported on more than 6,000 people aged 18-79. It showed that progressive hearing loss for men was greater than for women. A similar study in Great Britain in 1959 also showed a progressive loss for all frequencies, more severe in higher frequencies, and more severe for men.

Rosen,[8] in 1961, tested an isolated Sudanese tribe who lived in a relatively stress free and noise free environment. His results were very different from those of previous urban studies: he found far less hearing impairment at corresponding ages and the hearing levels of male and female were about equal.

Of the population with no habitual exposure to noise over 80 dB, 40 percent nevertheless begin to experience a handicap by age 65. With no

history of noise exposure 25 percent of the population nevertheless has a hearing handicap at age 60.[9] The presbycusis patterns of Western Europe and the United States are remarkably uniform.

Etiology and Pathology

Crowe,[10] in 1934, examined histologically a number of ears which had shown high tone loss. In some he found atrophy of the organ of Corti and in others atrophy of the cochlear nerve to the basal turn, the focus point of high frequencies.

In 1937 Saxen[11] described atrophy of the spiral ganglion and degeneration of the epithelial elements of the cochlea, presumably related to arteriosclerosis. In one case he found no pathology and considered it a CNS degeneration.

Schuknecht,[6] in 1955, studied histopathology of ears in cats and humans with high tone loss. He described epithelial atrophy (sensory presbycusis) and neural atrophy (*neural* presbycusis). The latter is progressive degeneration of spiral ganglion cells, starting at the basal end, as well as neurons of the higher auditory pathway. He considered it the auditory manifestation of CNS aging and showed that there was a decrease in the neuron population. A disproportionately severe impairment of speech discrimination was found along with high tone loss.

The same author, in 1964, suggested four varieties of presbycusis:

1. *Sensory Presbycusis.* There is atrophy of the organ of Corti and auditory nerve at the basal cochlea. The loss starts in middle life and progresses slowly. The high tone loss is abrupt and speech frequencies (500-2000 cps) are fairly good.
2. *Neural Presbycusis.* There is loss of neurons in the cochlea and higher auditory pathway. The atrophy starts earlier in life and continues throughout, the rate varying with genetic factors. The hearing loss becomes evident later in life when the neuronal population falls, at which time discrimination is disproportionately low (phonemic regression). Cats preserve normal auditory threshold even though they have lost over 80 percent of lower basal coil spiral ganglion cells.
3. *Metabolic Presbycusis.* There is strial atrophy in the organ of Corti, interfering with energy production and thereby producing a flat audiogram.
4. *Mechanical Presbycusis.* A disorder in the mechanics of the cochlear duct with loss of elasticity in the basilar membrane, producing a progressive hearing loss for higher tones.

Simpson[12] et al. describe atrophy of neural tissue secondary to vascular insufficiency from sclerosis or thrombosis. However, Mawson[13] states that there is no parallel between arteriosclerotic changes in vessels of the ear and degeneration of the membranous labyrinth and cochlear nerve.

Rosen[8] found much better hearing in the Mabaans, an African tribe, who have the benefit of a noise free environment, but these people also do not suffer from hypertension, coronary artery disease, duodenal ulcer, allergies or asthma, and they have little arteriosclerosis. He is not certain whether the better hearing is related to the quiet environment, the absence of arteriosclerosis or the relative absence of stress.

Rosen[26] studied the effect of diet on hearing loss in Finland. Two psychiatric hospitals where the patient population did not change rapidly were used. The 'control' hospital continued with its usual highly saturated fat diet while the 'experimental' hospital began a diet with less saturated fat. At follow up, cholesterol levels had dropped, coronary artery disease was less, and after five years the hearing levels were better in the 'experimental' hospital patients than in the 'control' patients who were ten years younger. He concluded that the difference in hearing between the two hospitals paralleled the difference in incidence of coronary heart disease.

Is day-to-day noise a factor in presbycusis? Newby[3] says that populations protected from noise have neglible hearing loss due to age. Glorig[14] uses the term sociocusis. Nixon,[15] in 1962, studied men working in a quiet environment. He concluded that with advancing age, the middle ear loses efficiency as a transducing system due to aging in the conductive tissue. Belal[2] says that there is no proof of a pathological aging process in the conductive elements while Glorig[14] mentions a progressive high tone conductive loss in some older individuals.

Kirikae,[16] in 1969, described degeneration in the major nuclei of the auditory pathway. Hansen and Reske-Nielson,[17] in 1965, described the pathohistology of 12 patients with documented hearing loss. They found changes in the auditory pathways in the cortex to explain some of the losses and concluded that functioning ganglion cells decrease with advancing age.

Diagnosis

Presbycusis is diagnosed frequently on the basis of exclusion, e.g. a 70 year old man with a high frequency nerve loss has presbycusis, while a 40 year old with a similar loss has a sensorineural loss of unknown etiology. Traditionally, presbycusis is a high frequency sensorineural hearing loss in an older person when there is no other apparent cause. The following audiometric tests can be done by the audiologist or otologist:

Puretone: The patient's threshold is defined as the lowest level at which he can detect the presence of the test tone at least 50 percent of the time.

Speech Reception Threshold (SRT): This is the level at which the patient can repeat simple words or can understand simple running speech. The most common SRT test is done with two syllable words such as airplane, footstool, doorway, etc. The level at which the person can repeat 50 percent of the words correctly is the SRT.

Tolerance Level: This is the level at which speech becomes uncomfortably loud. It represents the maximum amplification a patient can accept with a hearing aid. An abnormal cochlear function with associated recruitment, as is frequently present in presbycusis, may create a very formidable challenge in fitting a hearing aid.

Recruitment: A phenomenon of an abnormal cochlea in which a rapid increase of the sensation of loudness occurs once the patient's threshold of hearing has been crossed.

Discrimination: This refers to the patient's ability to discriminate among similar sounds or among words that contain similar sounds. In testing, phonetically balanced words are presented at a threshold at least 40 decibels above the patient's previously determined SRT. Each list contains 50 monosyllabic words, chosen scientifically in order that each list will contain samples of speech sounds in the same proportion as they occur in the English speech.

Discrimination depends on the integrity of the retrocochlear auditory pathways. A patient may hear puretones adequately but have incapacitating difficulty understanding speech because of retrocochlear dysfunction.

Audiometric Findings of Concern

Not all hearing loss of middle and older age can be labelled as presbycusis and certain presenting signs and symptoms suggest further investigation:

1. Asymmetry in puretone and speech levels, between the two ears. It is not uncommon to find the sensory loss more pronounced in one ear, but a flagrant difference should alert the physician to the possibility of retrocochlear pathology such as an eighth nerve tumor.
2. Discrimination scores decreased to incapacitating levels. Not only is this a problem in rehabilitation but it arouses concern about higher centres where there might be central pathology. Even with advanced high frequency loss, a patient is frequently able to understand to a moderate degree.
3. Unilateral tinnitus. A classical bilateral high frequency sensorineural hearing loss of presbycusis may be present with unilateral tinnitus. However, a unilateral tinnitus warrants a full audiometric assessment. Figure 1 shows the audiogram of a 47 year old man who has had unilateral tinnitus for 15 years. All advanced audiometrics point to a retrocochlear pathology. X-rays show a dilated internal auditory meatus. Nystagmus is present, the patient is now having brief attacks of dizziness, the left corneal reflex is decreased and there seems little doubt that he has a left eighth nerve tumor. He refuses surgery and has not kept follow-up appointments with the neurosurgeon.

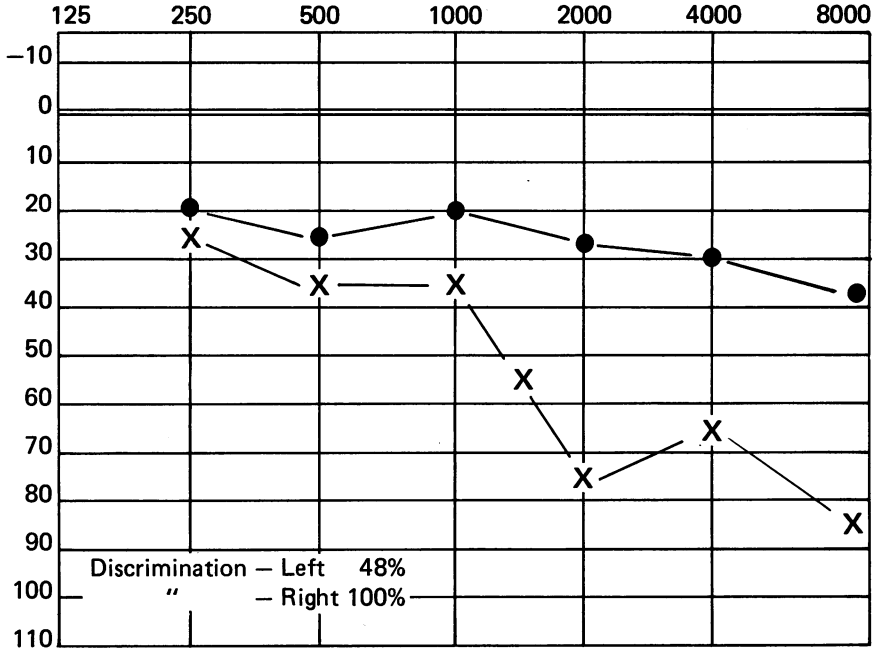
Figure 2 shows the audiogram of a 58 year old man who had a proven left eighth nerve tumor. Left tinnitus began suddenly four years previously. Note the discrimination of only 12 percent vs. 98 percent in the non-involved ear.

4. Sudden hearing loss. One does not usually immediately consider eighth nerve tumor here, but Higgs[25] reported four cases of sudden hearing loss as the presenting symptom in a series of 44 acoustic tumors.

Figure 3 is the audiogram of a lady who had a sudden hearing loss with a 'howling' tinnitus. She later had a left eighth nerve tumor removed. Bilateral involvement has been described in a surprisingly high percentage of sudden hearing losses,[18] but I personally feel that bilateral sudden sensorineural loss is rare.

Advanced audiometric testing such as tone decay, recruitment, Bekesy, acoustic reflexes, short increment sensitivity index, etc., provide the otologist with excellent information for deciding whether a problem is end-organ or retrocochlear. No one test is absolute, thus the necessity for the battery of tests.[19]

Fig. 1. Puretone audiogram of a 47 year old man with unilateral tinnitus.



Associated Pathology

Noise Induced Hearing Loss (NIHL)

It is impossible to separate NIHL quantitatively from presbycusis by audiometric tests. Most authors consider the effects additive and independent.[20] Schmidt[21] and others, however, consider the interrelationship to be more complex, citing the varying susceptibility to noise damage with age and with duration of exposure.

In the early stages of NIHL there is a notch at 4000 cps, but in the more advanced stages it becomes a sloping profile which cannot be distinguished from presbycusis.[11] The inner ear changes in NIHL are very similar to the changes found in the sensory type of presbycusis as described by Schuknecht.[6] Medicolegally, the courts turn to the otologist for guidance, fully aware that we are estimating the age correction.

Compensation policies in the U.S.A. show a lack of uniformity. In some states there is no correction for age, while in others there is a correction of 0.5 dB per year over 40 years. In Ontario and in most of the provinces, the Workmen's Compensation Board makes an age correction of half a decibel per year for each year over age 60. A 30 percent disability is applied for 'total deafness', which they define as a loss of 80 dB or more on averaging the losses at 500, 100, 2000 and 3000 cps. This ruling has been in effect since 1973.

Of course, non-compensible hearing loss is not considered in this formula; for example, in a mixed loss, the nerve levels alone are considered. Each ear is evaluated separately. At the present time, the Workmen's Compensation Board considers a steady noise level of 90 dB hazardous.

Lebo[22] says that age corrections for NIHL can be made and although there may be inequalities for some, there is no alternative. He then presents a very complicated formula for establishing the percentage of hearing loss.

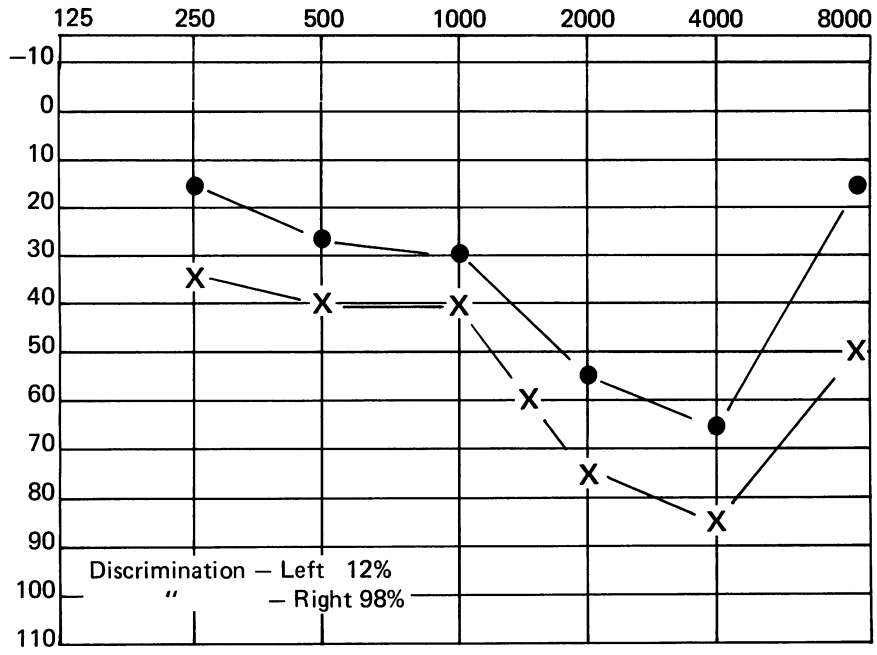
Chronic Renal Failure

Paparella[23] found a significant hearing loss in 49 of 290 transplant and dialysis patients. The loss varied with the number of hemodialyses and transplants. He postulated that electrolyte, osmotic, biochemical, vascular and/or immunological changes occurred in the inner ear. It has been reported that ethacrynic acid has an ototoxic effect and may have combined effects with other aminoglycosides such as kanamycin or streptomycin, especially with impaired renal function.

Acromegaly

Menzel[24] describes a 72 year old patient with bilateral hearing loss. The audiometric tests all suggested a retro-

Fig. 2. Puretone audiogram of a 58 year old man with an eighth nerve tumor.



cochlear pathology and X-rays of internal auditory meati showed narrowing. Pressure on the eighth nerve by abnormal bone presumably resulted in this picture. I personally have two cases of acromegaly with bilateral sensorineural hearing loss, greater than that to be expected from aging alone. These patients, however, do not show the retrocochlear pathology.

Ototoxicity

A great number of drugs have a proven ototoxic effect: aspirin, dihydrostreptomycin, neomycin, kanamycin, garamycin, ethacrynic acid, etc. The sensorineural hearing loss labelled as presbycusis may, in part, be due to ototoxic drugs in the past. In the case of aspirin, the hearing level usually returns to normal when the high aspirin intake is discontinued.

Assistance

To facilitate the hearing and understanding of the person with presbycusis, the speaker should enunciate clearly, speak more slowly and allow the listener to see the lip movement.

A hearing aid may amplify the sound sufficiently to reach the patient's threshold but it does not eliminate the problem of mumbling and it does not satisfactorily help those with extremely poor discrimination. Technical advancement has produced aids which are partially successful in increasing the intensity for high frequencies, without a parallel increase in the lower frequencies. This refinement has increased significantly the effectiveness of amplification for presbycusis because most of the loss is usually in the higher tones. Nevertheless, an abnormal cochlea which is usually hypersensitive at certain levels of intensity may simply not accommodate the amplification of an aid. Tremendous perseverance may be necessary for a few months before the patient finally adjusts to his aid. Failure to adjust explains the great number of dresser-drawer aids.

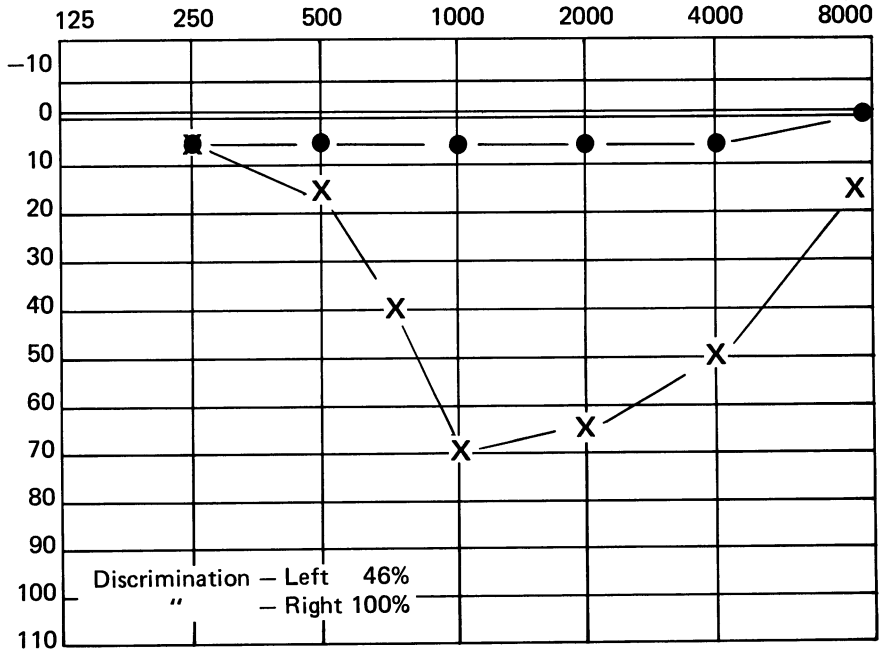
A person with hearing loss usually benefits from an otologic examination and audiometric assessment, including a hearing aid evaluation before the purchase of an aid. The evaluation provides the objective assessment of the aided hearing as determined by SRTs, discrimination, threshold of discomfort, etc. A selection of aids are tested and the most efficient is then recommended. I am continually amazed at the number of people whose aids have not been functioning, who have been wearing aids on the wrong ears or who have paid handsomely for aids which are sometimes not indicated.

Audiometric Assessment by Family Physician

A family physician may wish to do his own puretone testing, but the evaluation of a conductive problem, the determination of nerve levels, speech testing and other advanced audiometry are best done by an otologist or an audiologist. Without the proper use of masking, one may establish false levels when one ear is significantly different from the other.

I am continually surprised by the number of severe unilateral sensorineural losses which have been labelled 'conductive'. Usually this diagnosis is made on the basis of an 'apparent' negative Rinne, when in fact the tuning fork is being heard across the bone to the opposite, non-involved ear. Similarly, false nerve levels can be established with an audiometer if proper masking is not used. One can

Fig. 3. Puretone audiogram of a women with sudden hearing loss and 'howling' tinnitus.



usually recognize this testing problem by the lateralization of the Weber to the better nerve of hearing.

Skillful use of the 512 tuning fork usually allows a rather fast and accurate assessment of these situations. Frequently the tuning fork is a valuable tool in confirming or rejecting audiometric results.

Conclusions

1. The degenerative processes of presbycusis vary greatly from person to person and are probably influenced by factors such as heredity, environment, diet, blood vessels, hormones and metabolism.
2. All studies have shown a progressive sensorineural hearing loss with advancing age, after about age 40, affecting first high frequencies and then the lower tones. The loss of ability to discriminate among sounds may constitute the major problem.
3. Pathohistology has shown atrophy not only in the end-organ but also in the higher centres, up to and involving the cortex.
4. Diagnosis is frequently influenced by concurrent aging in other tissues and is frequently established by exclusion.
5. Unilateral tinnitus or a gross asymmetry of response between the two sides frequently suggests a pathology other than presbycusis and warrants further investigation.
6. Advanced audiometry provides a very sophisticated means of evaluating the auditory system to differentiate between end-organ and more central pathology.
7. Sensorineural hearing loss in later years may be related to a combination of factors and it is impossible to segregate presbycusis audiometrically from other sensorineural hearing loss, e.g. noise induced hearing loss.
8. A person with presbycusis has tremendous difficulty with a speaker who mumbles, speaks quickly, shows poor lip movement or faces away as he speaks.
9. Hearing aids are helpful in many cases but careful selection and an honest effort in adjusting to the aid are necessary. ◉

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