The Cause and Examination of Hearing Loss

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Abstract: Information obtained through auditory sense has become increasingly important in the information-oriented society where information technology revolution is being advocated. It is important for increasing quality of life of man as well. Hearing loss is considerably involved with the density of communication. The severity and cause of hearing loss are variable; differences between reversible and irreversible conditions and between congenital and acquired types have much influence on the treatment policy. The influence of systemic diseases is hidden within the background of a certain type of hearing loss. This type of hearing loss and another type of hearing loss due to the influence of socially environmental factors (e.g., social noise, stress, etc.) can be prevented to some extent by the spread of knowledge. Various kinds of early audiometry are essential. Precise data on examination leads to the prevention of reversible hearing loss from becoming irreversible and to appropriate treatment and rehabilitation. With regard to the matters necessary as fundamental knowledge for the comprehension of the actual entity of hearing loss, the cause and methods of examination of hearing loss are mainly outlined.

Key words: Conductive hearing loss; Sensory-neural hearing loss; Puretone audiometry; Speech audiometry; Auditory evoked response

Introduction

Hearing loss is manifested by disorders developing at either site of the organ of hearing, which originates from the external ear to the auditory center, or the auditory pathway. In general, hearing loss cases are classified roughly into “conduction hearing loss” and “sensorineural hearing loss”.

Sounds enter the external auditory meatus as air vibration to vibrate the tympanic membrane and to induce vibration of three chains of the auditory ossicles inside the tympanic membrane, i.e., in tympanic cavity. The membrane of a small window (oval window) in the boundary between the tympanic cavity and
the internal ear is also vibrated. Vibration of the small membrane surface is transmitted to the endolymphatic fluid filling the cochlea of internal ear, and stimulates hairy cells of the Corti’s organ in part of the cochlea.

The process of movement of the membrane, auditory ossicles, and the endolymphatic fluid by air vibration is called conduction mechanism, and hearing loss due to a disorder at the site is called “conduction hearing loss”.

Then, movement of the endolymphatic fluid stimulates hairy cells to be caught in the peripheral minute structures, and electrophysiological biophenomena occur. The biophenomena ascend the central auditory tract from the cochlear nerve, and reach the primary auditory cortex of the temporal lobe. Hearing loss due to a disorder at the site ranging from the hairy cell level of the cochlea to the central auditory pathway is called “sensorineural hearing loss”. Hearing loss due to a disorder of both the conductive system and the sensorineural system is called mixed hearing loss.

Main Causes of Hearing loss

1. Etiological classification
   (1) Hearing loss cases due to inflammatory diseases
   The cases include acute otitis media, chronic otitis media, exudative otitis media, internal otitis, etc. The tympanic cavity and the nasopharynx are connected with each other through the auditory tube. When upper respiratory inflammation is manifested by cold, etc., the tubal function is impaired to cause hearing loss. Infection of mothers with rubella because of viral infection, epidemic parotitis, auricular shingles, and so on also cause sensorineural hearing loss.
   (2) Hearing loss cases due to systemic diseases and medications
   The majority of living habitats-induced diseases may be related to disorders in the inner ear because of circulatory disorders and the feature to be easily infectious. They include diabetes mellitus, renal diseases, arteriosclerosis, hypertension, etc. Some of the drugs administered for a long term for the treatment of these living habitats-induced diseases are associated with hearing impairment. (drug induced)
   (3) Hereditary deafness
   The cases will be discussed in other sections.
   (4) Hearing loss cases accompanying trauma and tumors
   Typical examples of such cases are temporal bone fractures due to traffic accidents, temporal bone tumor, and acoustic nerve tumor.
   (5) Psychogenic hearing loss cases
   Hearing loss is observed in the absence of abnormality in the auditory tract. This type of hearing loss frequently develops in children and occurs due to various psychogenic factors including various problems at school and home, friendships, etc.
   (6) Hearing loss cases of unknown cause
   Sudden deafness is included in the cases; it suddenly shows lateral severe hearing loss.

2. Morbid conditions (according to sites of disorders)
   The causes of and inducements to main cases of hearing loss were enumerated above. Typical morbid conditions developing hearing loss are described below according to disturbed sites.
   (1) Conductive hearing loss
   1) Foreign bodies in the external auditory canal and ceruminal plug embolism: Mild to moderate conductive hearing loss develops.
   2) Congenital atresia auris: Moderate to severe hearing loss develops.
   3) Damage to (perforation of) the tympanic membrane: It includes direct injuries by the use of an earpick and indirect injuries due to a slap, a bomb blast, etc. There are a variety of hearing loss cases due to the damage, which range from mild conductive hearing loss to severe sensorineural hearing loss.
4) Diseases of the tympanic cavity: Acute otitis media and chronic otitis media (including cholesteatoma) develop various cases of hearing loss. The initial stage of chronic otitis media shows conductive hearing loss, which gradually shows features of sensorineural hearing loss via mixed hearing loss in some cases. A considerably large number of the cases become severe. Exudative otitis media manifested by retention of the exudate in the middle ear cavity also shows hearing loss. Mild to moderate hearing loss is commonly observed.

As described above, conductive hearing loss develops when the auditory tube connecting the middle ear cavity with the nasopharynx becomes stenotic. It frequently accompanies a sense of aural fullness. The chain of auditory ossicles in the middle ear cavity may also be transected by a blow to the head and the direct external force. Moderate to severe hearing loss is observed.

In recent years, otosclerosis has become considerably common in Japan. In the morbid condition, the stapes, one of chains of the auditory ossicles, shows fusion with the peripheral bone tissues to restrict the mobility. The incidence of the morbid condition is believed to be high in Caucasoids and low in colored races, but changes in dietary life may be related to the incidence. It frequently occurs in young women, and generally, hearing loss gradually progresses in them. Much attention should also be paid to the morbid condition, because hearing loss may worsen in association with pregnancy and labor.

(2) Sensorineural hearing loss

A. Cochlear hearing loss

The majority of sensorineural hearing loss cases are included in the type.

1) Senile hearing loss: It is manifested by physiological phenomena of aging; at first, it becomes difficult to hear high-tone sounds of 8,000 and 4,000 Hz; “articulation of words” starts to decline; and the frequency of the so-called “asking back” increases. The physiological phenomena of aging start at the former half of the 50s. Many people are aware of the phenomena at the latter half of the 60s.

2) Noise induced deafness: There are two types of the condition; i.e., noise induced deafness due to acute acoustic trauma and the gradually developing type, chronic noise induced deafness. These cases are caused by exposure to big sounds, a sound of an explosion, big sounds at live spots, and persistent noise at occupation. The morbid condition is called headphone hearing loss as well; it develops by listening to music characterized by a strong beat with headphones for a long time, and the people must be guided to pay attention to the method how to use headphones. The condition, in which hearing of only 4,000 Hz declines, is called “C5 dip” that is characteristic as the initial symptom of noise induced deafness.

3) Sudden deafness: Sudden deafness that shows suddenly severe sensorineural hearing loss is also believed to be cochlear disfunction. Tinnitus may be associated with sudden deafness, and vertigo occasionally occurs simultaneously with or before/after the occurrence of hearing loss. Unlike Ménière disease that will be described later, the vertigo is not repeated. The condition may be cochlear disfunction, but the cause has not been adequately elucidated. There are various theories discussing the cause; e.g., viral infection theory, blood circulation disorder theory, immunological disorder theory, allergy theory, etc.

4) Viral infection: Infections with herpes virus, Paramyxoviridae, rubellavirus, adenovirus, influenza virus, and so on induce cochlear hearing loss. Many cases of viral infection develop via blood circulation. Typical examples of viral infections are auricular shingles, epidemic parotitis, affection of mothers with rubella, and others.
5) Drug-induced hearing loss: The cases of hearing loss induced by administration of drugs with toxicity to the acoustic organs are also cochlear. The drugs that are problematic include aminoglycoside antibiotics, some loop diuretics, some antitumor agents, drugs belonging to nitrogen mustard, cisplatin as a platinum compound, and others. It has long been known that quinines, arsenic compounds, and salicylate compounds are also associated with the occurrence of the condition.

6) Ménière disease: Paroxysmal rotary vertigo, transient hearing loss, and tinnitus are associated with the disease. As it is repeated, the disease shows hearing loss, which becomes increasingly severe and irreversible.

B. Retrocochlear deafness

Of sensorineural hearing loss cases, those whose causes are located in the area ranging from the inner ear to the center, i.e., the central auditory tract originating from the cochlear nerve to the acoustic center, are called retrocochlear deafness. Typical examples of the cases include tumorous lesions such as acoustic nerve tumor, cerebellopontine angle tumor, etc., cerebrovascular accidents, head injury, demyelinating disease, hereditary diseases, and others. Various disorders in the center directly and indirectly influence the central auditory tract to manifest hearing loss.

Tests for Hearing Loss

There are at least 20 types of tests; they are typical tests regarding the identification of the severity, type, and responsible site of hearing loss.

The complaints of hearing loss are roughly divided into two groups: one group consisted mainly of complaints, “hardly heard” and “poorly heard”, and the other group consisted of a complaint, “it’s not hardly heard, but impossible to catch the contents of the talk”.

In other words, the former group has problems with decrease in the hearing level, and the latter group has those with decrease in the speech discrimination.

Four of the typical tests for these cases of hearing loss are roughly described below.

1. Standard pure tone audiometry

The levels, at which pure tone sounds ranging from low-tone sounds (125Hz) to high-tone sounds (8,000Hz) can be heard, i.e., “hearing levels”, are determined by the test. “Air conduction hearing” and “bone conduction hearing” are determined by the test. In the air conduction audiometry, a receiver is attached to the auricle. In the bone conduction audiometry, a vibrator is attached to the site of the mastoid process in the rear of the ear. In conductive hearing loss, air conduction hearing decreases but bone conduction hearing is normal; that is, difference between air conduction hearing and bone conduction hearing appears. The difference is called an Air-Bone gap. On the other hand, both air conduction and bone conduction hearing decrease in sensorineural hearing loss. That is,
no Air-Bone gap appears (Figs. 1 and 2). Examinations of “recruitment phenomena” and “a temporal increase in threshold” are also conducted with pure tone sounds. Recruitment phenomena are observed in the elderly; for instance, it indicates the condition, in which small sounds are hardly heard but big sounds are so noisy that they are hardly heard. Such a condition is tested on the examination of recruitment phenomena. In other words, the range of the sounds heard regarding loudness is determined. Normal people can hear both small sounds and considerably big sounds, while the range of the sounds heard decreases in cochlear hearing loss cases represented by senile hearing loss. This case is positive for recruitment phenomena, and the positivity is one of the criteria for the methods of diagnosing cochlear hearing loss.

When we are listening to sounds of a constant tone, it becomes impossible to hear them, because we get used to hearing them. When the tone is increased, the sounds are heard, but it becomes gradually impossible to hear them. Thus, the degree of inaudibility for the sounds, which are heard in the beginning, because of practice or fatigue, is determined on the examination of “a temporal threshold shift”. In retrocochlear deafness, the patients feel fatigue soon on hearing. This phenomenon is called a temporal threshold shift.

Cochlear cases of sensorineural hearing loss are differentiated from the retrocochlear cases by examinations of recruitment phenomena and a temporal threshold shift.

2. Speech audiometry

In this test, examinees are subjected to hear words and speech sounds and examined for the degree at which they can hear the contents of a talk precisely (speech discrimination). The decrease in “articulation of words”, i.e., the condition in which “the sounds are audible, but the contents cannot be comprehended”, is examined by the test. In general, speech discrimination decreases when the site of disorder is located in the center; e.g., when a disorder is present in the auditory cortex, articulation of speech sounds shows the extreme decline, despite the fact that pure tone audiometry does not reveal so severe hearing loss.

3. Objective audiometry

In this test, electrophysiological evoked responses to sound stimuli involving the area ranging from the inner ear to the center are recorded non-invasively from the site on the
The development of medical electronics allowed the recording of microscopic electric phenomena in the brain with a simple instrument. Responses to sound stimuli, which have various characteristics, are obtained from each site of the auditory tract. A typical example of the responses is auditory brainstem response (ABR) (Fig. 3). With these tests, objective data can be obtained without declaration of intention of examinees to have heard by themselves. Therefore, the test has a wide range of application; i.e., it is applied to tests in neonates to infants, the case in which feigning illness is suspected, and the case in which psychogenic hearing loss is suspected.

4. Other tests
There are tympanometry as a test for function of the middle ear and otoacoustic emission as a new test for function of the inner ear, which has recently been developed. The accuracy of these tests for determining the severity of hearing loss and diagnosing the site is increasingly being improved.