The Essential Guide to Hearing Loss

Part 1: Understanding Hearing and Hearing Loss

Section 1: Sound and speech
The nature of sound and how speech is produced.

Section 2: How we hear
How the outer, middle, and inner ear work together, enabling us to hear an incredible array of sounds.

Section 3: Types and causes of hearing loss
The differences between conductive and sensorineural ("nerve") hearing loss and common causes of hearing impairment.

Section 4: Informal tests and checklists
Observational checklists for very young children and self-tests for older children and adults help you decide whether to take the next step.

Section 5: Hearing tests for infants and young children
How the audiologist tests for hearing loss in patients too young to respond the usual way.

Section 6: Hearing tests for older children and adults
How the audiologist determines the nature, cause, and degree of hearing loss.

Section 7: Decibels and the *perception* of loudness
What it *really* means if we increase the sound by a certain number of decibels.

Section 8: Ranges of hearing loss
Definitions of mild, moderate, severe, and profound hearing loss.

1. Sound and Speech

Our ear is specially designed to receive, amplify, and transmit speech sounds to the brain. How does it do this?

Well, for starters, the outer ear, with all its curves and grooves, is like a specialized antenna. In the world around us, we see all types of antennas. These antennas are designed to pick up certain types of electromagnetic waves, (radio, TV, microwave, etc.). Like antennas, our ears are designed to pick up waves of a different type - sound waves. Let's see how these sound waves are made in the first place.

The Nature of Sound

Sound waves are nothing more than vibrations of air molecules. The vibrating air molecules are set in motion by vibrating objects. We have no trouble visualizing how a plucked guitar string can vibrate rapidly back and forth for several seconds. Every time it moves to and fro it compresses air molecules, thus pushing out waves of sound like ripples in a pond. (Hence the term, "sound waves.") Strings that vibrate at a higher rate send out more waves per second and this results in higher-pitched sounds. But what about speech?

Producing Speech -- Our Unique Vocal Tract

The vocal cords are two leathery sheets, with a gap in the middle, that stretch across the top of the trachea (the windpipe). A number of muscles control the tension of the vocal cords. When we talk, the muscles contract, stretching the vocal cords and creating more tension, while narrowing or closing the gap. This leaves a very thin opening. As we talk we exhale air and it is this stream of air, passing through the narrow passage, that causes the taut vocal cords to vibrate and produce sound. It is like blowing air through the reed of a clarinet.

Children have shorter vocal cords than adults. As a result, they vibrate more rapidly and produce higher-pitched sounds. The quantity of air passing through determines the loudness.

The sounds produced by the vocal cords are shaped into an incredible array of utterances and words by our tongue, teeth, mouth and lips. In addition, our sounds are made richer and more complex as they pass around and through our vocal tract: the larynx, throat, sinus cavities, and mouth. The size, shape, and flexibility of these structures vary from individual to individual and give us our unique "voice personality."

2. How We Hear

The Outer Ear -- Catching the Sounds
The outer ear catches the waves of sound and funnels them down the ear canal (about an inch long) and flush up against the ear drum. The ear drum (tympanic membrane) is the boundary between the outer ear and the middle ear.

Now it gets interesting. The sound waves or vibrations impinging on the eardrum can be pretty faint. It is the job of the middle ear to pick up these unique patterns of vibrations, amplify them, and pass them on to the inner ear. There the physical vibrations will be converted into electrical signals and passed on to the brain. If the sound patterns aren't amplified, the brain will have little to work with. So, how do the organs of the middle ear do this?

The Middle Ear -- Powering Up
The work is done by a trio of very tiny bones: the malleus picks up the vibrations from the eardrum, passes them to the incus which then passes them to the stapes. The stapes terminates in a tiny footplate that fits precisely into the contact point or window of the inner ear. The sound is strengthened in two ways. First, since the sound energy is collected from the relatively large surface area of the eardrum, and then funneled down and focused onto a much smaller surface area -- the window of the inner ear, 1/80th its size -- it has a magnifying effect. Secondly, these same bones also act as levers, further amplifying the sound waves. So these vibratory messages, traveling through the middle ear, arrive in a strengthened state at the tiny window of the inner ear.

The Inner Ear -- Converting Mechanical Movement to Electrical Impulse
The window of the inner ear is the contact point of the cochlea, a fluid-filled chamber. The vibrations set up rolling waves in the cochlear fluid which stimulate different areas of a free-floating membrane. The membrane, in turn, rubs against specialized cells called hair cells. (They are called hair cells because they are attached to the membrane by very fine hairs.) This friction creates electrical impulses in the hair cells which are then passed to the cochlear nerve and on to the brain.

So, in essence, all sound is produced by vibrating material. Vibrations create waves of air molecules that are captured by the outer ear and funneled down the ear canal where they hit the eardrum. The middle ear picks up and amplifies the mechanical movements of the eardrum and passes them to the fluid-filled cochlear, where waves are created that activate different areas of a free-floating membrane. This membrane, in turn, physically stimulates the hair cells which convert this mechanical energy into electrical energy and pass it onto the brain, via the cochlear nerve.

3. Types and Causes of Hearing Loss

People can suffer from **conductive** hearing loss, **sensorineural** hearing loss, or a combination of the two.

Conductive hearing loss occurs when sound waves are physically prevented from reaching the inner ear. These problems can almost always be corrected through medical or surgical treatment (and sometimes take care of themselves on their own). Common causes of conductive hearing loss include:

- **Perforated Eardrum**. The eardrum is like the head of a drum. If it is punctured, it cannot vibrate in time with the vibrational patterns it receives, and so the sound cannot be picked up on the other side by the tiny bones of the middle ear. In time, this condition usually repairs itself. (But see a doctor anyway.)

- **Ear wax buildup** in the ear canal. This can partially block or muffle the sound waves impacting on the eardrum. Wax can easily be removed by a doctor or nurse.

- **Fluid in the middle ear**. This is very common in children. Known as Otitis Media, it is caused by an infection of the middle ear or by a cold when fluid is backed up into the middle ear. (Fluid normally drains through the eustachian tube to the throat .) In either case, fluid fills the middle ear, preventing the tiny bones from vibrating properly and sending the sound impulses onto the inner ear. The problem can be remedied through antibiotics or by surgically installing a tiny tube in the child's ear so the fluid can drain.

- **Abnormal growth of the bones of the middle ear**. As in the condition above, the bones of the middle ear are unable to move properly and cannot transmit the sound. Severe hearing loss can result. Surgery is usually very effective in this situation.

Sensorineural hearing loss occurs when the sensory cells of the inner ear (the hair cells) or the auditory nerve itself are damaged through aging, exposure to loud noise, drug reaction, head injury, or genetic factors. The most common cause is gradual exposure to excessive noise over a number of years or one or more intense exposures. (That's why ear protectors are so important.) Unfortunately, this damage usually cannot be corrected.

4. Informal tests and questionnaires to see if there *is* a hearing problem

(Note: The material in this section was obtained from the National Institutes of Health, National Institute of Deafness and other Communication Disorders)

Important: If you know you have hearing loss, you should always see a doctor, for the impairment may be caused by a medical condition unrelated to the ear. For example, it may be the result of circulatory problems caused by diabetes, vascular (blood vessel) problems, or a heart condition. If you experience a **sudden** loss of hearing, see a doctor **at once.**

General Observations:

People with hearing loss may experience some or all of the following problems:

- Difficulty hearing conversations, especially where there is background noise
- Hissing, roaring, or ringing in the ears (tinnitus)
- Difficulty hearing the television or radio at a normal volume
- Fatigue and irritation caused by the effort to hear
- Dizziness or problems with balance

Self-Test

Ask yourself the following questions. If you answer "yes" to three or more of these questions, you could have a hearing problem and should see a doctor.

Do I have a problem hearing on the telephone?

Do I have trouble hearing when there is noise in the background?

Is it hard for me to follow a conversation when two or more people talk at once?

Do I have to strain to understand a conversation?

Do many people I talk to seem to mumble (or not speak clearly)?

Do I misunderstand what others are saying and respond inappropriately?

Do I often ask people to repeat themselves?

Do I have trouble understanding the speech of women and children?

Do people complain that I turn the TV volume up too high?

Do I hear a ringing, roaring, or hissing sound a lot?

Do some sounds seem too loud?

Behavioral Checklist for Infants and Children

Important! Infants and young children with hearing problems can have difficulty developing speech and language.

Some babies are born with hearing problems. Other children are born with normal hearing and begin to have hearing problems as they grow older.

You can help your child's doctor to decide if your child's hearing needs to be tested. Hearing problems can be temporary or permanent. Hearing problems can happen because of ear infections, injuries, or diseases.

Read the hearing checklist. Find your child's age. Indicate "yes" or "no" for every item. After you complete the checklist, show it to your child's doctor. Ask the doctor questions. Talk about the items checked "no". If you think your child has trouble hearing, tell the doctor right away.

Birth to 3 Months

Reacts to loud sounds?

Is soothed by your voice?

Turns head to you when you speak?

Is awakened by loud voices and sounds?

Smiles when spoken to?

Seems to know your voice and quiets down if crying?

3 to 6 Months

Looks upward or turns to a new sound?

Responds to "no" and changes in tone of voice?

Imitates his/her own voice?

Enjoys rattles and other toys that make sounds?

Begins to repeat sounds (such ooh, aah, and ba-ba)?

Becomes scared by a loud voice?

6 to 10 Months

Responds to his/her own name, telephone ringing, someone's voice, even when it isn't loud?

Knows words for common things (cup, shoe) and sayings ("bye-bye")?

Makes babbling sounds, even when alone?

Starts to respond to requests such as "come here."?

Looks at things or pictures when someone talks about them?

10 to 15 Months

Plays with own voice, enjoying the sound and feel of it?

Points to or looks at familiar objects or people when asked to do so?

Imitates simple words and sounds?

Uses a few single words meaningfully?

Enjoys games like peek-a-boo and pat-a-cake?

15 to 18 Months

Follows simple directions, such as "give me the ball."?

Uses words he/she has learned often.

Uses 2-3 word sentences to talk about and ask for things?

Knows 10 to 20 words?

18 to 24 Months

Understands simple "yes-no" questions (Are you hungry?)?

Understands simple phrases (in the cup, on the table)?

Enjoys being read to?

Points to pictures when asked?

24 to 36 Months

Understands "not now" and "no more."?

Chooses things by size (big, little)?

Follows simple directions such as "get your shoes" and "drink your milk."?

Understands many action words (run, jump)?

Talk to your doctor if you think your child has a hearing problem.

Let him know of the following information and observations:

1. Whether **others in the family**, including brothers or sisters, have a **hearing problem**.
2. Whether the **child's mother** had **medical problems** in pregnancy or delivery (serious illness or injury, drugs or medications).
3. If the baby was born early **(premature)**. Weight at birth: _____
4. If the baby had **physical problems at birth.**
5. If the **child rubs or pulls an ear(s)** often.
6. If the child had **scarlet fever**.
7. If the child had **meningitis.**
8. The number of **ear infections** in the past year: _____
9. **How often** the child had **colds, allergies, and ear infections** (once a month or more often).

5. Hearing Tests: infants and children

Infants:

Two hearing tests are often used to screen babies. In both tests, no activity is required.

- **Otoacoustic emissions (OAE) tests** can show whether parts of the ear respond properly to sound. During this test, a sponge earphone is placed into the ear canal. The ear is stimulated with sound, and the "echo" is measured. The echo is found in everyone who hears normally. If there is no echo, it could indicate a hearing loss.
- **Auditory brain stem response (ABR) tests** check how the brain stem and the brain respond to sound. During this test, your child wears earphones, and electrodes are placed on the head and ears. A mild sedative may be given to help keep your child calm during the test. The nurse or doctor sends sounds through the earphones and measures the electrical activity in your child's brain.

Older Infants and Toddlers:

Two screening tests recommended by the American Speech Language Hearing Association are:

- **Visual reinforcement audiometry (VRA)** is highly recommended. Whenever the child looks toward a sound source, she is rewarded. (Six months to two years of age)
- **Conditioned play audiometry (CPA).** The child performs a task (puts a block on the table, touches a toy, etc.) every time a sound is heard. (Two to three years of age)

Pre-schoolers:

- **Conditioned play audiometry (CPA)**. (See above.)
- **Tympanometry** tests the responsiveness of the eardrum. (Next section.)
- **Additional testing** of acoustical reflex (a tiny ear muscle) and **air volume test of ear canal.**

School Age Children:

- **Conditioned play audiometry (CPA)** and tests for adults. (Next section.)

Note: For more on screening tests, including important risk factors, visit the American Speech-Language-Hearing Association at**:** www.ASHA.org.

6. Hearing Tests: Older Children and Adults

Your audiologist may conduct some or all of the following basic tests:

1. Pure Tone tests.
The **air conduction test** is the most general hearing test as it evaluates the entire mechanism: the outer, middle, and inner ear as well as the hearing nerve. Soft tones are played through headphones to determine the **hearing threshold** (the softest sound one can hear at least 50% of the time) for different pitches.

If there *is* hearing loss, the **bone conduction test** can help determine where the problem lies. A small vibrator is placed on the skull bone directly behind the ear. When sound is transmitted through this device, it bypasses the outer and middle ear and delivers the sound vibrations directly to the inner ear. If the hearing improves during this procedure, then the audiologist knows there is a problem involving the conduction of sound through the outer or middle ear. (It can also be a combination of both conductive hearing loss *and* sensorineural loss.) If the hearing loss is the same after this test, then the problem most likely lies in the inner ear. Once the results of the tone tests are in, the audiologist can prepare an audiogram -- a picture of our hearing.

2. Tympanometry tests the flexibility of the ear drum. The eardrum must be extremely pliable so it can respond to the softest impulses. But sometimes, over time, the eardrum stiffens and it takes a stronger, more forceful sound wave to make it move. The audiologist determines its flexibility by taking some air out of the air canal (painless) and pumping some back in. As he does this, he measures the minute movement of the eardrum.

3. Word tests determine how well one understands normal conversation. There is a difference between being able to hear words and being able to understand them. The **speech reception threshold** test determines the softest level at which an individual can hear words. The **speech recognition** test determines how well the individual can understand words spoken at normal volume. The words include all the common phonemes (basic sounds) of normal conversation.

4. Interview Questions may include:

- Known hearing loss
- Health history including history of ear problems, tinnitus, or vertigo
- Noise exposure history
- Family history of hearing loss

Note: For more information on screening tests, including important risk factors, visit the American Speech-Language-Hearing Association at**:** www.ASHA.org

7. Decibels

Sounds are measured in decibels. Zero (0) decibels is the softest sound a person with normal hearing can hear at least 50% of the time. Here are decibel levels of everyday sounds:

0 Decibels Threshold of hearing
10 Rustle of leaves
20 Water dripping
30 Whisper
40 Quiet radio in room
50 Moderate rainfall
60 Conversation, dishwasher
70 Busy traffic, vacuum cleaner
80 Alarm clock
90 Lawnmower
100 Snowmobile, chainsaw
110 Rock music
120 Jet plane takeoff

The important thing to know about decibels is this: if a sound *increases* by 10 decibels, it *doubles* in loudness as we perceive it. It sounds twice as loud to us. If a sound *decreases* by 10 decibels, it seems as if the sound has been reduced to half the volume.

Perceived Change in Loudness by Decibel Level

This chart shows the *change* in decibel sound level and how it is perceived by the human ear:

+, - 1 dB Not perceptible
+, - 3 dB Threshold of perception
+, - 5 dB Clearly noticeable
+, -10 dB Twice as loud or 1/2 as loud
+, -20 dB Four times as loud or 1/4 as loud
+, -30 dB Eight times as loud or 1/8 as loud

8. Ranges of Hearing Loss

When we speak of hearing loss, we mean threshold hearing points that are higher than normal. If, for example, a person has a 45 dB loss in the 4000 Hz range, it means that for him to be able to hear a sound at that frequency or pitch, the sound must be at least 45 dB in loudness. He cannot hear sounds below that volume at that frequency.

Normal hearing. Loss of **0 - 19 dB (decibels).**

Mild hearing loss. Loss of **20 - 39 dB**.
Symptoms: Unable to hear soft sounds. Cannot hear a whispered conversation in a quiet room. *Can* hear a normal conversation in a quiet room but has difficulty in a noisy environment

Moderate hearing loss. Loss of **40 - 59dB.**
Symptoms: Has considerable difficulty hearing a normal conversation in a quiet room. If there is background noise, he will not be able to understand many of the words, unless he lip reads.

Severe hearing loss. Loss of **60 - 89dB.**
Symptoms: Cannot hear a conversation unless the speaker speaks loudly.

Profound hearing loss. Loss of **90+ dB.** Cannot understand speech even if the person speaks very loudly. Can only hear very loud sounds such as a chainsaw.