Devices for the Hearing Impaired

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Hearing loss can result in significant communicative and social dysfunction. Various methods of sound amplification are available for the hearing impaired. Hearing aids are becoming more technologically sophisticated, more cosmetically appealing and more commonly used. The choice of hearing aid must be individualized and depends on several factors, including the type of hearing loss, the cost of the device, the patient's work environment, motivation and vanity, and the degree of difficulty in using the hearing aid. Devices are also available to help hearing-impaired persons in specific situations where hearing aids may not be necessary. The cochlear implant is a relatively new device for use in the profoundly hearing impaired.

Of the approximately 20 million Americans with impaired hearing, more than 2 million are profoundly deaf. The prevalence of hearing impairment increases with age, reaching 48 percent for persons 85 and older. Hearing loss is the second most common cause of disability in this country. Loss of hearing can cause devastating limitations in communication ability, socio-economic status, cognitive function, overall function and reading skills.

Accurate and early diagnosis of hearing loss is imperative for appropriate treatment; however, this is not often achieved. On average, congenital hearing loss is not diagnosed until the age of two and one-half years. As a result, language skills and psychologic development are often delayed in children who have congenitally impaired hearing. With the recent emphasis on screening of all newborns at high risk for hearing loss, problems with hearing may be detected earlier and appropriate interventions may be implemented expeditiously, thereby improving the development of communication skills in these children. At the University of Michigan Medical Center, for example, screening of high-risk newborns has reduced the average age at diagnosis to under six months, making earlier intervention possible.

As in infants, prompt detection of hearing impairment in the elderly may improve patient outcome. In particular, accurate and early recognition may reduce the frequency with which the behavior associated with hearing loss is incorrectly attributed to dementia.

Most experts define hearing loss as at least a 25-dB loss in one or more frequencies. Rough estimates of the degree of hearing loss can be made on the basis of the history and physical examination. Accurate diagnosis, however, requires a comprehensive audiologic evaluation, which can also determine whether the hearing loss is sensorineural or conductive.

Sensorineural hearing loss is the result of abnormal function of the cochlea, the eighth cranial nerve or the part of the central nervous system involved in auditory function. Conductive hearing loss is the result of mechanical impediment to the transmission of sound through the external or middle ear. Differentiating between the two types of hearing loss is important, since

conductive hearing loss is often medically or surgically curable, whereas sensorineural hearing loss is usually not amenable to treatment.

All patients clinically diagnosed as hearing impaired should be appropriately evaluated, and a specific management plan should be formulated for them. Treatment of sensorineural hearing loss involves assessing the degree to which hearing loss affects communication, informing the patient about available assistive devices and maximizing residual hearing by determining the best means of sound amplification. Information about community resources and support networks for hearing-impaired persons is also beneficial.

Hearing Aids

A hearing aid is an electronic device that amplifies and shapes sound waves entering the external auditory canal. Tremendous advances have been made in the design and effectiveness of hearing aids since bulky body-worn devices were developed 40 to 50 years ago. In the 1950s, hearing aids were used mainly for mild to moderate conductive hearing loss and were rarely used for sensorineural hearing loss. However, because of marked improvement in technology, hearing aids are now being used more frequently in milder cases of conductive hearing loss and in persons with high-frequency sensorineural loss.

Currently, the average age for initial use of a hearing aid is between 55 and 70 years. This high average is skewed, however, because of the large number of elderly hearing-impaired persons. In fact, hearing aids are appropriately used at any age when a significant sensorineural hearing loss exists.

In 1977, the US Food and Drug Administration issued regulations setting standards to be followed by all who manufacture, sell or repair hearing aids. The regulations require that hearing aid candidates receive a medical evaluation within six months prior to the purchase of a hearing aid. Adults may waive this evaluation after receiving informed consent notification that such evaluation would be in their best interest; however, persons under 18 years of age must be evaluated by an audiologist.

In addition, the FDA regulations state that hearing aid users should obtain medical consultation if any of the following are present: visible congenital or traumatic deformity of the ear; active drainage from the ear; sudden or rapidly progressive hearing loss (unilateral or bilateral); acute or chronic dizziness; an air-bone gap of 15 dB or greater at 500, 1.000 and 2.000 Hz; evidence of excessive cerumen or foreign body in the ear canal, and pain or discomfort in the ear. In addition to federal regulations, most states also require a license or registration for those who sell hearing aids.

It is imperative that the audiologic assessment include a speech recognition score. This test measures the ability to distinguish between individual monosyllabic words above the speech reception threshold and provides an estimate of the potential effectiveness of hearing aids. The test can be performed with a noise background to reproduce real-life situations. Patients with low

recognition scores may not understand speech clearly even if sounds are amplified well above the sensitivity threshold. In such situations, hearing aids may not be effective. However, the speech recognition score should not be the sole reason for making the decision to use or not use hearing aids.

Nonauditory factors are sometimes more important than audiologic results in the decision to use hearing aids. Such factors include the patient's overall communication difficulty, tolerance of amplification, motivation and listening demands. One study showed that 21 percent of elderly persons who met at least one of four accepted criteria for significant hearing loss experienced little communicative or global dysfunction as a result of their hearing impairment. Children who lose their hearing before they have learned language often suffer severe limitations in oral communication and usually benefit from amplification. Regardless of the age of the patient, a hearing aid rehabilitation and training program significantly increases the benefit of the aid. Unfortunately, such programs are underutilized.

Physicians are often the motivating force when patients (especially older persons) obtain a hearing aid. Patients may obtain the hearing aid from one of three sources: a physician (usually an otolaryngologist), an audiologist or a hearing aid dealer. Physician dispensing of hearing aids is a relatively recent development. Otolaryngologists often work with an audiologist colleague to provide this service. An audiologist is a nonphysician hearing specialist trained in the identification, diagnosis, measurement and rehabilitation of hearing impairment. A qualified audiologist has a master's or doctoral degree in audiology, plus a Certificate of Clinical Competence from the American Speech and Hearing Association.

Hearing aid dealers have long been the traditional dispensers of hearing aids. Although dealers may have little academic education in treating hearing impairment, they often have considerable practical experience in fitting hearing aids. Even if patients elect to purchase hearing aids from a dealer, they should first be evaluated by an audiologist and/or a physician to determine the type of hearing loss and the need for amplification, and to rule out a medically or surgically treatable cause of the hearing impairment.

The number of hearing aid users is increasing dramatically, because the US population is aging. Concurrent with the increased number of hearing aids dispensed is a change in the type of aids preferred. Today, the most popular hearing aid is the in-the-ear type, with the behind-the-ear device being second in popularity. Body and eyeglass hearing aids are now used rarely.

The placement and type of hearing aid depend on several factors. patient preference is important. In-the-ear aids are considered cosmetically superior by most patients. However, because of the small size of these aids, patients must have good vision and manual dexterity to insert and adjust them; this can be a problem for some older patients. In addition, in-the-ear aids may not deliver sufficient amplification for some patients with severe or profound hearing loss.

Hearing aids may be used in one (monaural) or both (binaural) ears. Studies have shown that patients who have tried both prefer binaural aids; they improve sound quality, speech

recognition in noise and sound localization. Persons with asymmetric pure-tone loss, however, may not benefit from binaural amplification. Cost is also an important consideration.

Types of Aids

In technical terms, hearing aids can be divided into three types: traditional analog aids, hybrid aids and digital aids, which are a recent development. All hearing aids amplify sound, but although aids usually improve sound detection, they do not necessarily improve speech comprehension, especially in noisy situations or with telephone use. Moreover, unlike eyeglasses worn to correct refractive visual deficits, hearing aids do not perfectly compensate for hearing loss, and amplified sounds may appear somewhat unnatural.

Analog hearing aids are the original electronic amplification devices. They work by converting sound to a continuous electronic signal that is modified by electronic components. The term "analog" refers to the fact that the electric waveforms within the circuits are analogous in appearance to the acoustic pressure wave forms in the environment.

Hybrid hearing aids are similar to analog aids, except that digital chips are used to control or alter the operation of analog components in the signal-processing stage. Hybrid aids are more adaptable than analog aids.

Digital hearing aids use a totally different approach. With these devices, the electronic signal is changed to a discrete series of signals coded by binary numbers. As a result, the wave forms can be changed in multiple ways by merely changing the software. This type of aid does not have the loss of precision or the limitations imposed by the capacitors and resistors found in analog hearing aids.

Digital aids offer improved signal-processing sophistication and increased flexibility of use. Theoretically, digital aids can be programmed for each individual's hearing loss. This specificity should improve discrimination scores, especially in noisy environments, and reduce background noise distraction.

Digital aids have some drawbacks, however, including a markedly higher price (currently $2.000 to $3.000) and an increased power requirement. They are also larger, since the level of miniaturization achieved for other hearing aid types is not yet possible for digital aids. In addition, despite theoretic advantages, digital aids have not shown any significant benefit over traditional aids in real-life situations. So far, more people are still being fitted with analog and hybrid aids than with digital aids.

An appropriate and properly fitted ear mold is an integral part of any hearing aid system. The ear mold is used to modify the sound signal to the ear through variations in bore size, canal length, vent size or ear mold style. These factors can affect the frequencies of sound reaching the eardrum. For example, large vents attenuate low-frequency sounds, which can help persons with high-frequency hearing loss.

Despite documentation that hearing aids improve the ability to communicate and perceive sound, many persons who could benefit from hearing aids to not wear them. Cost is a major factor; 59 percent of hearing aids are dispensed to the elderly, many of whom have limited incomes. Medicare does not cover the cost of hearing aids, and Medicaid coverage varies by state. In one study of elderly persons, the foremost reasons for not using hearing aids were high cost, the belief that use of such aids calls attention to the handicap, dealer sales techniques, concern about the nature of the amplified sound, difficulty in manipulating hearing aid controls and lack of knowledge about where to obtain the aids. Another study found that 32 percent of hearing aid users had problems with the devices. Annoying feedback sounds, problems with ear molds, amplified background noise and distorted sounds were the factors most often mentioned in this study.

A good audiologist and hearing aid dispenser can offer invaluable assistance to patients in selecting the appropriate aid and learning how to use it. Several visits are often necessary before a patient can use the aid effectively. Most hearing aid dispensers give patients a 30-day free trial before requiring a financial commitment.

Once a patient has a hearing aid, he or she may periodically present to the family physician with the complaint that the aid does not work. Before referring the patient to someone who repairs hearing aids, the physician should check to be sure the problem is not a dead battery or a cerumen impaction in the external canal or the ear mold. These common problems are easily correctable in the family physician's office.

Assistive Devices

Numerous assistive devices are also available for persons with hearing loss. These include assistive devices for listening, alerting, signaling, telecommunicating and informing. The devices are designed to improve a hearing-impaired person's communicative ability in specific listening situations, particularly when environmental influences such as background noise and distraction may interrupt communication. Persons with hearing loss may benefit from these devices, whether or not they use hearing aids. Physicians should make their patients aware of these devices, since many do not know about them.

Examples of assistive devices are listed in Table 1. Most of these items are inexpensive, and many of them, such as telephone amplifiers, are widely available. It should be noted that telephone amplifiers, in particular, are not all of equal quality. It is important to try various brands before purchasing a telephone amplifier. Assistive signaling devices, such as flashing lights, are widely used by profoundly deaf persons. These devices are quite effective, even as wake-up alarms. Items not available locally can be ordered from specialty stores or catalogs that cater to the hearing impaired.

Additional information about assistive options can be obtained from local groups that serve the hearing impaired or from national groups such as the National Association of the Deaf (814 Thayer Avenue, Silver Spring, MD 20910; telephone 301-587-1788; telecommunication

device for the deaf (TDD): 301-587-1789); the Alexander Graham Bell Association for the Deaf (3417 Volta Place NW, Washington, DC 20007; telephone: 202-337-5220; TDD is the same) or the National Information Center on Deafness (Gallaudet University, 800 Florida Avenue, NE, Washington, DC 20002-3625; telephone: 202-651-5051; TDD: 202-651-5052).

Cochlear Implants

A recent development in the management of profound hearing impairment is the cochlear implant. This device takes advantage of residual neural elements in the spiral ganglion and the auditory nerve in patients whose cochlear hair cells have little or no function. The implant electrically stimulates these neural elements, based on external acoustic input.

Of a variety of implant systems, the most widely used is the one manufactured by the Cochlear Corporation, the Mini-System 22. This system consists of 22 electrodes on a Silastic carrier that is implanted into the scala tympani through the round window (fenestra cochleae) or through a cochleostomy. The receiver is embedded in the surface of the temporal bone and covered by scalp; it receives sound input transcutaneously through electromagnetic transmission from the speech processor coil positioned above it.

The Cochlear Corporation's Mini-System 22 is approved by the FDA for use in children from two to 17 years of age and in postlingually deafened adults (adults whose hearing loss occurred after they learned language). Other hearing-impaired persons (ie, prelingually deaf adults) can sometimes obtain a cochlear implant through an investigational program. Almost 4.000 patients worldwide have received the Cochlear Corporation's device, including about 3.000 (800 of them children) in the USA.

Currently, the cochlear implant is the assistive device of choice for patients with severe or profound sensorineural hearing loss who derive little or no benefit from amplification. There is a significant increase in sentence recognition among patients who received cochlear implants at the University of Michigan Medical Center and demonstrates the remarkable improvement in both auditory detection and perception that patients obtain from cochlear implants.

The preoperative evaluation of candidates for cochlear implants is extensive and includes the following: complete audiologic and hearing aid evaluation, imaging studies of the temporal bone, preoperative electrical stimulation, balance function evaluation and extensive counseling. In children, the evaluation also includes controlled trial periods with hearing aids or other assistive devices.

Postoperatively, a six- to 10-week period of rehabilitation and training is sufficient for postlingually deaf adults. In children, postoperative management involves frequent follow-up testing, programming of the implant and close communication with the child's teachers. Follow-up also includes interaction with speech pathologists experienced in working with hearing-impaired children, psychologists, social workers, educators of the deaf and family members. For all implant recipients, an individualized management and support system is essential.

Research is under way to improve cochlear implants, and new systems are currently undergoing clinical trials. The field is evolving and will no doubt continue to have a significant effect on the management of profound deafness.