Screening and Management of Adult Hearing Loss in Primary Care

Scientific Review

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Context Hearing loss is the third most prevalent chronic condition in older adults and has important effects on their physical and mental health. Despite these effects, most older patients are not assessed or treated for hearing loss.

Objective To review the evidence on screening and management of hearing loss of older adults in the primary care setting.

Data Sources and Study Selection We performed a search from 1985 to 2001 using MEDLINE, HealthSTAR, EMBASE, Ageline, and the National Guideline Clearinghouse for articles and practice guidelines about screening and management of hearing loss in older adults, as well as reviewed references in these articles and those suggested by experts in hearing impairment.

Data Extraction We reviewed articles for the most clinically important information, emphasizing randomized clinical trials, where available, and identified 1595 articles.

Data Synthesis Screening tests that reliably detect hearing loss are use of an audioscope, a hand-held combination otoscope and audiometer, and a self-administered questionnaire, the Hearing Handicap Inventory for the Elderly-Screening version. The value of routine screening for improving patient outcomes has not been evaluated in a randomized clinical trial. Screening is endorsed by most professional organizations, including the US Preventive Services Task Force. While most hearing loss in older adults is sensorineural and due to presbycusis, cerumen impaction and chronic otitis media may be present in up to 30% of elderly patients with hearing loss and can be treated by the primary care clinician. In randomized trials, hearing aids have been demonstrated to improve outcomes for patients with sensorineural hearing loss. Nonadherence to use of hearing aids is high. Prompt recognition of potentially reversible causes of hearing loss, such as sudden sensorineural hearing loss, is important to maximize the possibility of functional recovery.

Conclusion While untested in a clinical trial, older adults can be screened for hearing loss using simple methods, and effective treatments exist and are available for many forms of hearing loss.

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EPIDEMIOLOGY OF HEARING LOSS

Hearing loss is the third most prevalent chronic condition in older Americans, after hypertension and arthritis[1]; between 25% and 40% of the population aged 65 years or older is hearing impaired.[1-4] The prevalence rises with age, ranging from 40% to 66% in patients older than 75 years[5-7] and more than 80% in patients older than 85 years.[3] Alternative definitions of hearing loss would raise estimates of prevalence even higher.[8] In addition, the impact of hearing loss on society will increase not only because the population is aging, but also because the prevalence of age-adjusted hearing loss has increased significantly since the 1960s.[9,10]

The diminished ability to hear and to communicate is frustrating in and of itself, but the strong association of hearing loss with depression and functional decline adds further to the burden on individuals who are hearing impaired.[11-16] Hearing loss in older patients strongly correlates with depression. For example, in a study of 253 patients aged 70 years or older, a strong statistical association was reported between the threshold of a low-frequency pure tone greater than 35 dB and depression.[17] In addition, a cross-sectional study of 1191 community-dwelling older persons aged 70 to 75 years found that hearing impairment was significantly associated with depression as assessed by the Beck De-

See also p 1986 and Patient Page.

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pression Inventory (odds ratio, 1.76; 95% confidence interval [CI], 1.15-2.71).[14] These associations have been found to be independent of age and socioeconomic status.[12] Furthermore, Mulrow et al[16] have reported the impact of hearing loss on social isolation, poor self-esteem, and functional disability. Other authors also have reported a strong relationship between hearing loss and dementia.[18,19]

Despite the prevalence and burden of hearing loss, hearing impairment is underdiagnosed in older persons. Only 9% of internists offer hearing testing to patients aged 65 years or older.[20] Hearing loss also is undertreated: only 25% of patients with aidable hearing loss receive hearing aids.[3,21] The underdetection and undertreatment of hearing loss are discouraging, because strong evidence supports that the treatment of hearing loss improves quality of life.[22-25]

Given the prevalence and disease burden of undetected hearing impairment in older persons and the availability of effective treatments, it is important for primary care physicians to screen, recognize, treat, and appropriately refer patients with hearing impairment. This article reviews the literature relevant to the care of older adults with hearing loss in the primary care setting and provides insight into the treatment of hearing loss by hearing specialists.

METHODS

We conducted literature searches from 1985 to 2001 in the databases MEDLINE, HealthSTAR, EMBASE, and Ageline, using search terms *hearing*, *hearing loss*, *hearing aids*, *hearing impairment*, *screening*, and other relevant terms. Articles chosen for review were those with the most clinically important information, emphasizing randomized clinical trials, when available. We identified 1595 articles. Additional articles from our personal files and those suggested by experts in hearing impairment were added. A further search was conducted for clinical practice guidelines for hearing impairment in the literature and using the National Guideline Clearinghouse Web site search (http://www.guidelines.gov). Details of the search terms, databases used, and citations retrieved are available from the authors.

PHYSIOLOGY OF HEARING LOSS

The healthy ear is an exquisitely sensitive organ. It processes sound frequencies ranging from 20 Hz to 20 kHz. It detects sounds as soft as 0.0002 dynes/cm^2 (0 dB) and can tolerate stimuli up to a million times more intense (200 dynes/cm^2 or 120 dB) for limited periods of exposure. The ear is particularly sensitive to signals between 500 and 4000 Hz, which includes the frequencies most important for speech processing.

Anatomy of the Ear

The ear is composed of the external ear, the middle ear, and the inner ear (FIGURE 1). The external ear consists of the pinna (auricle) and the external auditory canal, and it is immediately accessible to physical examination. Its function is thought to be largely protective, although its physical configuration may provide moderate (5-15 dB) passive augmentation of sounds at the upper range of speech processing frequencies.

The middle ear is bounded laterally by the tympanic membrane (eardrum) and medially by the osseous labyrinth, which is the bone-encased structure that houses the end organs of hearing (cochlea) and balance (semicircular canals). The healthy middle ear is an air-filled cleft that contains the 3 ossicles (malleus, incus, and stapes) that transduce vibrations from the tympanic membrane to the oval window of the fluid-filled cochlea. The substantially larger area of the tympanic membrane, compared with that of the oval window, and the relatively minor mechanical gain from the ossicular configuration combine to amplify sound pressures by 20 to 30 dB (approximately the difference between a whispered voice and normal conversational speech).

The inner ear includes the cochlea, the vestibular apparatus, and the vestibulocochlear (acoustic) nerve (cranial nerve VIII). The fluid channels within the cochlea are stimulated by the vibrating stapes footplate through the membranous oval window at the base of the cochlea. These fluid-filled channels (scala vestibuli, tympani, and media) are lined by hair cells, which are organized tonotopically (by sound frequency) in a coiled, spiral shape. The base of the cochlea responds to high-frequency sounds, and the apex responds to low-frequency sounds. Inner hair cells are innervated by a rich array of afferent nerve fibers (10-20 fibers per hair cell) that synapse with auditory division of the vestibulocochlear nerve at the spiral ganglion. Further discussion of cochlear and brain stem physiology is beyond the scope of this review article.

Forms of Hearing Loss

The 2 major forms of hearing loss are conductive and sensorineural disorders. Conductive hearing losses usually involve abnormalities of the middle and external ear, and generally have a mechanical cause (eg, perforated eardrum, fluid in the middle ear, disarticulations of the ossicular chain, cerumen accumulation). As a result, treatment is often surgical (eg, repair of the perforated eardrum, drainage of fluid-filled middle ear, reconstruction of the ossicular chain, removal of cerumen). However, more than 90% of hearing loss is sensorineural (nerve deafness), which typically results from permanent damage to the hair cells of the cochlea.

Sensorineural loss related to aging, or presbycusis, is the most common cause of hearing loss in the United States. This type of hearing loss is typically gradual, bilateral, and characterized by high-frequency hearing loss. Patients with presbycusis typically have difficulty filtering background noise, which makes listening especially challenging in common social settings. Because no known treatment is available for damaged hair cells, presbycusis is typically treated with amplification devices, such as hearing aids. Note that profound deafness can be treated with cochlear implantation, which bypasses the hair cells to stimulate the vestibulocochlear nerve directly.

SCREENING FOR HEARING

Criteria for a Screening Program

The value of routine screening for undiagnosed hearing impairment has not been studied in clinical trials. In the absence of direct clinical trial data, screening programs can be advocated if evidence is available to support each of the 3 commonly accepted criteria for a community screening program.[26,27] These criteria are that (1) the burden of disease must be significant enough to justify the effort of screening, (2) an effective treatment must be available for the detected condition, and (3) an accurate, practical, and convenient screening test must exist. Mulrow and Lichenstein[28] have argued that these conditions are satisfied for screening hearing impairment. The US Preventive Service Task Force, the Canadian Task Force on Preventive Health Care (formerly called the Canadian Task Force on the Periodic Health Examination), and other groups have concurred and recommend screening older adults for hearing impairment (TABLE 1).[27,29,30]

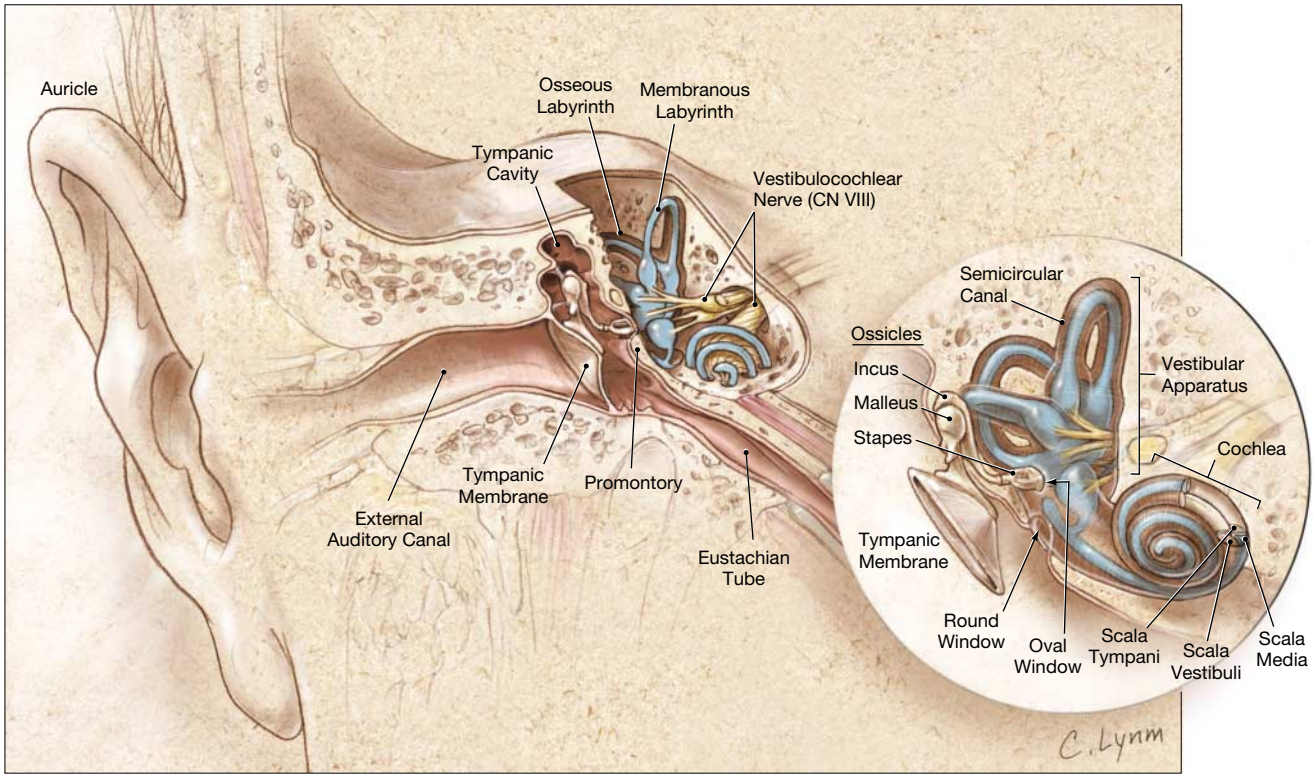
Although screening tests exist and effective treatment is available, it has not been established that routine screening leads to improved long-term outcomes. The first clinical trial to study long-term outcomes after routine screening for hearing impairment in older adults is now under way by the Screening for Auditory Impairment-Which Hearing Aid Test trial, conducted by the Health Service Research and Development Service of the Veterans Health Administration.[31]

In addition, routine screening may be helpful because it is difficult to diagnose hearing loss in the primary care setting. The onset of presbycusis is insidious and patients themselves are frequently unaware of their hearing loss. Physicians may overlook presbycusis in a quiet examination room, since the symptoms of early presbycusis are more apparent in settings with background noise. In addition, the diagnosis of hearing loss must be confirmed with formal audiometric testing, which is the diagnostic criterion standard.

Screening Tests

Many simple tests for hearing loss have been used as a routine part of the physical examination, but they are difficult to implement in systematic screening programs because they cannot be standardized. For example, the Whispered Voice Test is performed by examiners who whisper words from behind the patient at varying distances.[32,33] The degree of hearing loss is reflected by the furthest distance from which patients may still reliably reproduce what is whispered. Attempts to standardize the test have been

Figure 1. Anatomy of the External, Middle, and Inner Ear (Coronal View)



The external ear consists of the pinna (auricle) and the external auditory canal. The middle ear is bounded laterally by the tympanic membrane and medially by the osseous labyrinth. It includes the 3 ossicles (malleus, incus, and stapes). The inner ear is bounded by the osseous labyrinth and includes the vestibular apparatus, the fluid-filled channels of the cochlea (scala vestibuli, tympani, and media), and the vestibulocochlear nerve (cranial nerve [CN] VIII).

Table 1. Summary of Recommendations From Professional Organizations for Screening for Hearing Loss

Professional Organization	Population	Frequency of Screening	Question Patient About Hearing	Otoscopic Examination and Audiometric Testing	Audioscope Testing	Other Tests
US Preventive Services Task Force[29] (http://www.ahcpr.gov/clinic/uspstfix.htm)	Older adults	Periodically (frequency left to clinician's discretion)	Recommended	Recommended for patients with evidence of impaired hearing	Discussed, but no recommendation for or against	None
Canadian Task Force on Preventive Health Care[30] (http://www.ctfphc.org)	Elderly adults	During periodic health examination	Recommended	Not discussed	Recommended	Whispered-voice test Single question about self-reported hearing loss
American Academy of Family Physicians (http://www.aafp.org/exam.xml)	Adults >60 years of age	During periodic health examination	Recommended	Not discussed	Not discussed	None
American Speech-Language-Hearing Association (http://www.asha.org/hearing/testing)	Adults >50 years of age	Every 3 years	Recommended	Recommended	Not discussed	None

made (eg, by whispering only after full expiration), but there is no reliable way to control the loudness of the whispers, and robust descriptions of interobserver variability and test-retest reliability are lacking.[31,34] Screening with a vibrating tuning fork or the sounds of an examiner's fingers rubbing also has been proposed.[32,35] Judgments about hearing loss generally rely on measuring the threshold distance beyond which the sounds cannot be heard. Alternatively, the hearing thresholds of the patient and the examiner can be compared by placing the vibrating tuning fork on each person's mastoid process (Schwabach test). Again, although reasonable test accuracy has been reported in small series,[32,35] the intrinsically subjective nature of these tests (What is the degree of the examiner's hearing loss? How hard should the tuning fork be struck?[34]) is a serious limitation.[28]

Box 1. Questions From Hearing Handicap Inventory for the Elderly-Screening Version (HHIE-S)*

1. Does a hearing problem cause you to feel embarrassed when meeting new people?
2. Does a hearing problem cause you to feel frustrated when talking to members of your family?
3. Do you have difficulty hearing when someone speaks in a whisper?
4. Do you feel handicapped by a hearing problem?
5. Does a hearing problem cause you difficulty when visiting friends, relatives, or neighbors?
6. Does a hearing problem cause you to attend religious services less often than you would like?
7. Does a hearing problem cause you to have arguments with family members?
8. Does a hearing problem cause you difficulty when listening to TV or radio?
9. Do you feel that any difficulty with your hearing limits or hampers your personal or social life?
10. Does a hearing problem cause you difficulty when in a restaurant with relatives or friends?

*The HHIE-S scores are yes, 4 points; sometimes, 2 points; or no, 0 points, to each question about a particular handicap. Scores range from 0 (no handicap) to 40 (maximum handicap). Adapted with permission.[36,37]

In contrast, 2 inexpensive and simpler approaches to screening—a self-administered questionnaire and a simple physiologic test—have demonstrated excellent accuracy in detecting hearing loss and have gained widespread interest.

Hearing Handicap Inventory for the Elderly-Screening. The self-administered instrument is the Hearing Handicap Inventory for the Elderly-Screening version (HHIE-S),[36,37] a 10-item, 5-minute questionnaire that measures the degree of social and emotional handicap from hearing loss (BOX 1).

The patient responds yes (4 points), sometimes (2 points), or no (0 points) to each question about a particular handicap. Scores range from 0 (no handicap) to 40 (maximum handicap). A total score of 0 to 8 indicates a 13% probability of hearing impairment, a score of 10 to 24 indicates a 50% probability of a hearing impairment, and a score of 26 to 40 indicates an 84% probability of a hearing impairment.[38]

Several cross-sectional studies [7,36,38-41] have investigated the performance of the HHIE-S. Each study has a slightly different patient population and definition of hearing loss, but substantial evidence shows that patients with abnormal HHIE-S scores have high rates of hear-

Table 2. Summary of Hearing Handicap Inventory for the Elderly-Screening Version (HHIE-S) Studies

Study	No. of Patients	Age, y	Prevalence of Hearing Loss, %	Criteria for Actual Hearing Loss: Failure to Hear a 40-dB Tone at	HHIE-S Cutoff Scores	Sensitivity	Specificity
Ciurlia-Guy et al[7]	104	≥60	69	1 or 2 kHz in either ear	NA	Correlation coefficient, $r = 0.33$ ($P<.003$)	
Ventry and Weinstein[36]	100	≥65	51	1 or 2 kHz in both ears or 1 and 2 kHz in one ear	≥10	0.80*	0.69*
					≥24	0.33*	0.98*
Lichtenstein et al[38]	178	>65	30	1 or 2 kHz in both ears or 1 and 2 kHz in one ear	≥10	0.72	0.77
					≥26	0.24*	0.98*
McBride et al[40]	185	>60	NA	1 or 2 kHz in both ears or 1 and 2 kHz in one ear	≥10	0.63	0.75
					≥26	0.42	0.88
Mulrow et al[41]	238	≥65	58	2 kHz in both ears with Audioscope	≥10	0.75*	0.67*

Abbreviation: NA, not available.
*Calculated from receiver operating characteristics curves or likelihood ratios.

Table 3. Summary of Audioscope Studies

Study	No. of Patients	Age, y	Prevalence of Hearing Loss, %	Failure to Hear 40-dB Tone at		Sensitivity	Specificity
				Audioscope Screening	Actual Hearing Loss With Audiogram Screening		
Ciurlia-Guy et al[7]	104	≥60	69	1 or 2 kHz in either ear	1 or 2 kHz in either ear	0.97	0.69
Lichtenstein et al[38]	178	>65	30	NA	1 or 2 kHz in both ears or 1 and 2 kHz in one ear	0.94	0.72
McBride et al[40]	185	>60	NA	2 kHz in better ear	1 or 2 kHz in both ears or 1 and 2 kHz in one ear	0.96	0.80

Abbreviation: NA, not available.

ing impairment. Cutoff scores of 10 and above provide reasonable sensitivity and specificity, with values for both scores ranging from 0.63 to 0.80 (TABLE 2). It should be emphasized that the HHIE-S screens for functional not physiologic hearing loss. Therefore, when audiometric testing (a physiologic measure) is used as the criterion standard, the sensitivity of the HHIE-S appears low. Higher cutoff scores provide significantly improved specificity and likelihood ratios (data not shown), but poorer sensitivity.

Audioscope. The physiologic test uses an audioscope, a hand-held, combination otoscope and audiometer that delivers a 25- to 40-dB pure tone at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz, the most commonly tested frequencies needed to hear speech. The listed price for the Audioscope (Welch Allyn Medical Products, Skaneateles Falls, NY) is $500 to $600, according to the company's Web site (http://www.welchallyn.com/medical/). The audioscope is held directly in the external auditory (ear) canal with a probe tip sealing the canal. Tones are presented at each frequency, and the listener is asked to indicate whether he or she can hear the tone.[6] Minimal training is required. Patients unable to hear a predetermined series of tones may then be referred for formal evaluation. Audioscope testing is recommended by the Canadian Task Force on Preventive Health Care.[30] In addition to screening for hearing loss, the audioscope also allows for direct inspection of the ear canal to assess external ear abnormalities, such as cerumen, otitis, and foreign bodies.

The audioscope also has been tested against the diagnostic criterion standard of formal audiogram in several reports (TABLE 3).[7,38,40] Each study used the 40-dB threshold for both screening and audiometry, which is the threshold that the Veterans Health Administration uses to adjudicate hearing loss.[42] Despite small differences in methods, all 3 studies[7,38,40] demonstrated excellent sensitivity (≥0.94) and good specificity (0.69-0.80) for hearing loss. Each study concluded that the most efficient screening frequencies would be at 2 kHz,[7,40] or a combination of 1 and 2 kHz.[38] These studies also tested the performance of the HHIE-S, and the study by McBride et al[40] concluded from the performance using receiver-operating curves for both the HHIE-S and the audioscope (using the formal audiometric testing as the criterion standard) that the audioscope performed better. A review of 185 patients aged 60 years or older who were screened consecutively by both the audioscope and the HHIE-S in a primary care clinic reported that patients preferred the audioscope (60%) over the HHIE-S (13%) as a screening tool.[40]

Because the HHIE-S and the audioscope screen different aspects of hearing loss, it is possible that they preferentially identify different types of hearing-impaired patients. The audioscope detects only physiologic loss, so it may identify more patients with hearing loss,[40] but not necessarily those patients who are motivated to seek treat-

ment. On the other hand, because the HHIE-S identifies individuals with handicap from hearing loss, it may be less sensitive to early disease, but more likely to identify motivated individuals. Therefore, it is unclear whether the HHIE-S or the audioscope is likely to be more successful in detecting hearing impairment. Several authors have proposed that a combination of both physiologic and self-report screenings may represent a viable third alternative,[38,40] which is the focus of the ongoing Screening for Auditory Impairment-Which Hearing Aid Test trial.[31]

TREATMENT OF HEARING LOSS IN THE PRIMARY CARE CLINIC

Cerumen Impaction

Several otologic abnormalities can be identified and treated by the primary care physician. Cerumen impaction may result in substantial hearing loss and can be found in up to 30% of elderly patients with hearing loss.[43] If physical inspection of the external auditory canal reveals cerumen impaction, the cerumen may be removed by several techniques. A small cerumen curette, if available, may be used to remove the cerumen if the practitioner is comfortable and familiar with this technique. Alternatively, gentle warm water irrigation may be used to loosen and remove the cerumen if the patient has no history of tympanic membrane perforation or ear surgery. Hydrogen peroxide–containing solutions (sold over-the-counter, such as Debrox or Murine) can be prescribed to loosen firm cerumen impactions if the patient has no history of tympanic membrane perforation or ear surgery. Deep cerumen impactions may be resistant to these maneuvers and the patient can be referred to an otolaryngologist for safe removal of the cerumen under microscopic examination.

Chronic Otitis Media

Chronic otitis media with effusion is a common problem in older adults. This condition, also known as *serous otitis* since the middle ear becomes filled with a serous fluid, may result in discomfort and a conductive hearing loss. We were unable to identify any randomized, placebo-controlled trials that documented the efficacy of antibiotic therapy or other treatments in older adults with this condition. In children, systematic reviews of randomized placebo-controlled trials suggest that antibiotics[44,45] and oral steroids[46,47] both shorten the course of disease, but that decongestants and antihistamines had no significant effect on effusion clearance.[44,48] Serous otitis may persist for weeks or months, and such patients should be referred to an otolaryngologist either for more aggressive treatment (eg, surgical aspiration of fluid) or to rule out an underlying disorder with resultant obstruction of the eustachian tube (eg, nasopharyngeal carcinoma).

Sudden Sensorineural Hearing Loss

Early intervention by the astute primary care physician may halt or reverse 2 forms of sensorineural hearing loss: unilateral sudden sensorineural hearing loss (or sudden deafness) and hearing loss caused by ototoxicity.

Sudden Hearing Loss. The etiology of sudden sensorineural hearing loss is not yet clear. A variety of mechanisms ranging from viral infections to microcirculatory injuries to immune-mediated disorders have been proposed,[49,50] although expert opinion is that viral infection may be the most important contributor.[50-52] However, 2 recent randomized trials failed to show benefit from antiviral agents.[53,54] To date, the only treatment to show efficacy in placebo-controlled trials has been glucocorticoid administration. In an earlier randomized trial, nearly twice as many patients (61% vs 32%) receiving glucocorticoids experienced at least partial recovery of hearing as those receiving placebo.[55] To document the hearing loss, and to rule out masquerading retrocochlear processes such as acoustic neuromas,[56,57] these patients should be referred urgently for specialty care.

Ototoxicity. The ototoxic effects of antibiotics and antineoplastic agents are well documented. The aminoglycosides and platinum compounds are particularly ototoxic, but a variety of other agents have been implicated as well in case reports (BOX 2).[58-63] When known ototoxic agents need to be administered, ultra high-frequency audiometry is available for early detection of ototoxicity in adult populations,[64] but currently no guidelines are available on the use of ultra high-frequency audiometry. Because high-frequency hearing loss usually precedes loss in the normal range, early detection of such loss may lead to modifications in treatment that prevent clinically important hearing loss. A frequently overlooked ototoxic agent is aspirin. Little is known about what level of dosage causes ototoxicity, but it is generally believed that 80 mg of aspirin on a daily basis is safe. Fortunately, in most cases, the resulting tinnitus and hearing loss are temporary and reversible with cessation of aspirin.[65,66]

When disease management lies beyond the scope of the primary care setting, it is important to refer patients to hearing specialists for additional evaluation. Audiometric testing by audiologists is not only the criterion standard for diagnosing hearing loss, but critical for determining whether hearing loss is sensorineural or conductive in origin, which strongly influences choice of therapy. It is important to recognize that certain hearing disorders, such as traumatic injury with vestibular symptoms and/or deafness, and erosive lesions, such as cholesteatoma, require urgent consultation.

Box 2. Partial Listing of Ototoxic Medications

Antibiotics: aminoglycosides, erythromycin, and vancomycin
Antineoplastics: cisplatin, carboplatin, and vincristine sulfate
Loop diuretics: furosemide, ethacrynic acid
Anti-inflammatory: aspirin and quinine

TREATMENT OF HEARING LOSS BY HEARING SPECIALISTS

Referrals for hearing loss are best directed to audiologists, otolaryngologists, or both. Audiologists have expertise in hearing testing, use of assistive listening devices (eg, telephone amplifiers, infrared systems, pocket talkers, and visual/tactile alerts for the doorbell, telephone, and smoke alarm), and the selection and fitting of hearing aids. Otolaryngologists have specialty training in a range of disorders in the head and neck, which include the medical and surgical treatment of otologic problems.

The first step in the clinical workup of hearing loss is formal audiometric testing by an audiologist. The audiometric tests are performed in a sound-protected environment. These tests include a standard test battery consisting of pure-tone audiometry that assesses the patient's threshold of hearing for tones from low frequency (250 Hz) to high frequency (8 kHz); word recognition tests that measure the percentage of monosyllabic words that a patient can repeat (discrimination scores); the speech reception threshold that measures the lowest intensity level at which a patient can repeat 50% of spondaic words (ie, 2-syllable words with equal emphasis on each syllable, such as baseball, cowboy, and pancake); and bone-conduction testing, acoustic reflexes, and tympanometry, which primarily target the presence or absence of specific disorders, such as otosclerosis, acoustic neuromas, or otitis media.

Audiology Services

The majority of hearing loss is sensorineural. In mild-to-severe loss, the most effective treatment is hearing amplification with hearing aids. In a seminal randomized clinical trial of 194 elderly veterans, patients randomly assigned to receive a hearing aid experienced significant improvements in social and emotional function, communication function, and depression after 4 months, compared with patients in the control group.[22] The authors subsequently found that the improvements were sustained 1 year after being fit with a hearing aid.[23] These findings were confirmed by a cross-over trial involving 180 older patients, comparing a hearing aid, an assistive listening device, and in combination.[24] The most significant improvements in emotional and social function were noted with the hearing aid. More recently, in a 4-arm, randomized trial of 60 older veterans comparing 2 types of hearing aids and 2 types of control arms, substantial improvements in quality-of-life measures, communication function, patient preferences, and adherence were noted for patients using hearing aids, with particular preference for a programmable hearing aid with a directional microphone.[25]

However, treatment effectiveness is not guaranteed even if patients receive hearing aids. Nonadherence to use of hearing aids is high. Several authors have conservatively estimated that up to 30% of patients who receive hearing aids do not use their aids.[3,67-69] As patients age, handling the hearing aid can become increasingly difficult.[70] Older patients experience more problems with inserting the earmold into the ear, switching on and off the hearing aid, changing the battery, cleaning the earmold, and changing the volume.[71] These difficulties are among the most common explanations for failure to wear a hearing aid. Among a group of 138 hearing aid users who were older than 90 years, 33% to 79% experienced difficulty with any or all of these tasks.[5] However, age (or any other predetermined variable) has not yet been identified as an accurate predictor of hearing aid use. In a group of 87 elderly male veterans, variables such as subjective functional handicap, age, education, and number of medications had no consistent correlation with hearing aid use.[23]

A number of hearing aid technologies have been a focus of study, including digital sound processing. Despite the promise of this technology, to date, little evidence is available to show that digital hearing aids result in improved hearing, since no trials involving digital technology have used adequate concurrent control groups.[72] Valente et al[73] have suggested that features, such as directional microphones confound existing comparisons between digital and analog hearing aids. Another recent study found that expectations strongly influence outcomes in patients who receive digital aids.[74] The investigators provided digital aids to the entire cohort, but they led half of the patients to believe that they received analog aids. Significantly lower satisfaction rates were observed in these patients. Since digital hearing aids cost substantially more than analog hearing aids, they cannot yet be considered cost-effective. However, advances in digital technology may lower cost and improve effectiveness and thereby improve the cost-effectiveness ratio.

The size and shape of hearing aids may influence satisfaction. In one randomized study, 244 elderly patients were fitted with either behind-the-ear, in-the-ear, or in-the-canal hearing aids.[75] The in-the-ear aid was rated as the easiest to manipulate, but surprisingly, cosmetic judgments were unaffected by the size of the hearing aid.[76] Another study of 40 patients compared patient satisfaction with behind-the-ear vs in-the-canal hearing aids.[77] Patients with in-the-canal hearing aids used their aids more frequently than patients with behind-the-ear aids (45.4 h/wk vs 19.5 h/wk, $P<.005$). In both studies, patients with behind-the-ear aids reported significantly more "undesirable experiences" (operational difficulties, ear discomfort, and negative sound experiences).[76,77]

Audiologists also commonly use assistive listening devices in auditory rehabilitation.[78] We are unaware of randomized controlled trials demonstrating that assistive listening devices have benefit over placebo. However, these devices have face validity and are commonly accepted and prescribed by audiologists. In patients with moderate hearing loss, devices such as infrared systems and telephone amplifiers may supplement the use of hearing aids. For patients with profound hearing loss in whom conventional amplification is unsuccessful, frequency-modulated systems, consisting of a microphone placed near the source of sound, a transmitter,

and a receiver worn by the patient, are commonly used. In addition, visual and/or tactile alerts for the doorbell, telephone, and smoke detector have been used in place of hearing aids.[79,80]

Otolaryngology Treatments

Surgical treatment of common causes of hearing loss are briefly discussed. Less common causes of hearing loss, such as acoustic neuromas, are beyond the scope of this review. Because few controlled trials of surgical treatment of hearing loss in adults have been conducted, our intent is not to provide a formal evidence-based review, but rather to provide the primary care physician with insight into how patients are treated after referral.

For persistent chronic otitis media with effusions, the use of myringotomy (incision in the tympanic membrane) and pressure-equalization tubes are routinely used to aspirate the contents and aerate the middle ear cleft, which immediately restores hearing. It also is important for the otolaryngologist to examine the patient's nasopharynx to rule out both benign (eg, allergic disease) and malignant (eg, nasopharyngeal carcinoma) underlying conditions that might obstruct the eustachian tube and predispose the patient to otitis media.

Small tympanic membrane perforations from recent traumatic events or otitis media frequently heal spontaneously (FIGURE 2). However, large persisting perforations may cause substantial conductive hearing loss and predispose patients to recurrent otitis. Surgical repair of the perforation with fascial grafts (tympanoplasty) has an extremely high success rate. Ossicular chain discontinuities also may result from trauma or long-standing ear infections and are readily treated with ossicular chain reconstructions using transposed ossicles or surgical implants.

A cholesteatoma is a cystic mass of the middle ear or mastoid cavity that contains trapped squamous epithelium (Figure 2). It is not a neoplasm, but the slowly growing mass can destroy surrounding structures, including the ossicles. Patients with chronic ear infections are predisposed to cholesteatoma formation. Examination frequently reveals a superior and posterior tympanic membrane perforation, with the presence of white keratinaceous debris. No medical treatment for cholesteatoma is currently available, although topical antibiotic drops may help to alleviate superinfections. Surgery (mastoidectomy) is required to remove the cholesteatoma.

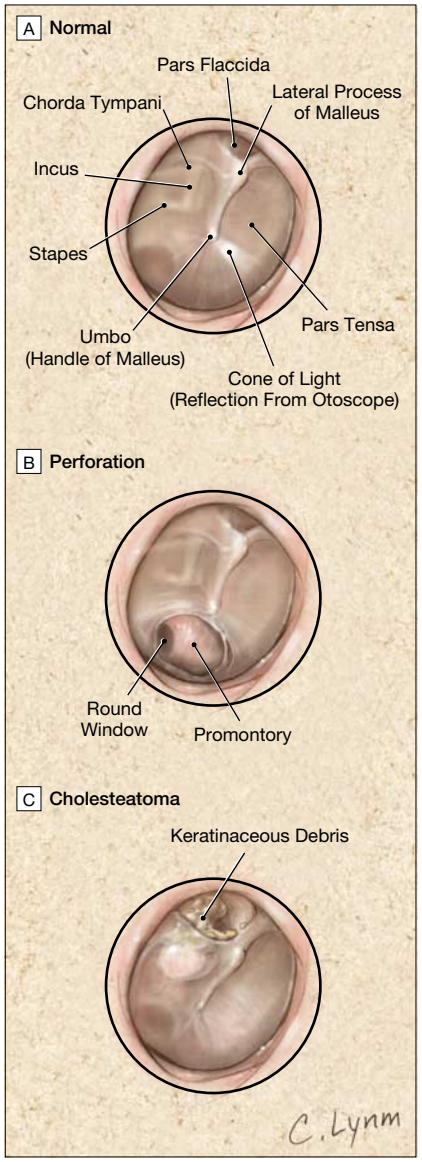
Bony sclerosis of the otic capsule is termed *otosclerosis*. When this common condition involves the stapes footplate, immobility of the stapes prevents sound transduction to the oval window. This typically results in a conductive hearing loss.[81] Otoscopic examination results of a patient with otosclerosis are most often normal. Surgery on the footplate (stapedectomy or stapedotomy) provides excellent aural rehabilitation. Hearing aids may be an alternative if surgery is not appropriate. Elderly patients should be offered both options since several studies have shown no increased surgical risk based on age alone, and they appear to benefit from the surgery as much as younger patients.[82-84]

Profound sensorineural hearing loss (defined as >80 dB of loss in the better ear), or true deafness, is increasingly amenable to treatment with cochlear implantation. Rapid technological advances in implant technology in the past 2 decades has led to successful rehabilitation of these patients who previously had no reasonable alternative forms of treatment. Much of the literature has focused on the effectiveness of treatment in the pediatric population,[85] but recent findings from systematic reviews[86] and prospective cohorts[87,88] suggest that cochlear implantation results in such substantial improvements in quality of life, and patient preference states that implantation is cost-effective in the adult patient as well.

COMMENT

Substantial evidence exists that hearing loss in older persons is underdiag-

Figure 2. Otoscopic Views of the Right Tympanic Membrane



A, The 2 major regions of the tympanic membrane include the pars tensa and flaccida. Landmarks of the tympanic membrane include the handle and lateral process of the malleus. Middle ear structures that may be visible through the tympanic membrane include sometimes the incus and rarely the chorda tympani (branch of the facial nerve, cranial nerve VII) and the stapes. B, Perforations of the tympanic membrane may occur in any location and vary in size. In this depiction, the perforation allows visualization of the round window and the promontory (bony eminence of the basal turn of the cochlea). C, Cholesteatoma formation can result in retraction or perforation of the pars flaccida and, as shown in this depiction, entrapment of dead cells (squamous epithelium, keratin, and other debris) that can progress into a cystic mass.

nosed and undertreated, despite the availability of effective treatment. The primary care physician should vigilantly ask about hearing loss in older patients and recognize common symptoms of hearing impairment, such as communication impairment and social withdrawal. A variety of screening tests are available for use in the primary care setting, most notably the portable audioscope and the HHIE-S questionnaire. The Screening for Auditory Impairment-Which Hearing Aid Test trial will assess whether mass screening leads to better patient outcomes; results are expected in 2005. In the meantime, it seems reasonable to provide hearing screening to older patients using either the audioscope or HHIE-S. Many cases of hearing loss are treatable in the primary care setting, and prompt recognition of sudden hearing loss may prevent further deterioration or permanent deafness. In addition, recognition of hearing loss facilitates referral to appropriate hearing professionals for treatment that may lead to better quality of life.

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Poetry is the breath and finer spirit of all knowledge; it is the impassioned expression which is in the countenance of Science.
—William Wordsworth (1770-1850)