Assessment of Hearing

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The assessment of hearing in infants and children is usually performed by an audiologist to achieve three main objectives: the *identification* of infants and children "at risk" for hearing impairment; the *assessment* of the nature and degree of such impairment; and the *management* of impaired children. This article focuses mainly on assessment and management, but a comment on identification is necessary since this area relies on the active participation of the primary care physician.

Identification of Hearing Impairment

The primary care physician often is the first to make contact with children who present with conditions that place them at risk for hearing loss, and can play a vital role in identifying children who require further testing to rule out hearing loss. A family history of childhood deafness, elevated bilirubin levels (greater than 20 mg per 100 mL of serum), maternal intrauterine infections (such as rubella, cytomegalovirus, herpes, and toxoplasmosis), craniofacial anomalies, low birth weight (less than 1500 gm), or neonatal asphyxia represent justifiable reasons for ruling out hearing loss. Approximately 1 in 1000 newborn babies has a hearing impairment, but the incidence is 30 to 40 times greater in newborn infants presenting with risk conditions.

Parental suspicion of hearing loss in a child should not be taken lightly; it may be the earliest indication of significant impairment in the child; in a child who has one or several risk conditions, it mandates referral for in-depth audiologic assessment. Hearing assessment must not be postponed because the child appears to be "too young" to test. There are adequate behavioral and nonbehavioral techniques to rule out hearing loss in any child, regardless of age.

Behavioral Assessment Techniques

The assessment of hearing with behavioral techniques involves the observation of the child's behavioral response to a given auditory stimulus. The nature of this behavioral response is age-dependent. Newborn and young infants respond typically with nonvolitional behavior, but older infants and children can respond with more volition. Consequently, the response repertoire of the child will dictate the most appropriate assessment technique.

Behavioral Observation Audiometry

For the purposes of this discussion an infant is defined as a child whose functional age is less than 24 months. The most appropriate assessment technique for infants is behavioral observation audiometry (BOA). As the name implies, BOA is a procedure whereby the examiner presents a stimulus sound and observes the associated response. Slightly modified versions of BOA that incorporate classic conditioning principles have been used successfully in 6 to 24 months old infants. BOA assesses the responses that are inherent to the infant: the

MORO, aural palpebral, arousal, and cessation reflexes. These reflexes are strongest in the infant who is less than five months of age.

The Moro reflex is a generalized motor response sometimes called the "startle reflex". In infants with normal hearing the startle reflex can be observed in response to rather intense (80 to 85 dB) stimulus sound. The aural palpebral or "eye blink" reflex may consist of either a rapid squint or blink in response to intense sound. In infants with normal hearing it requires a 105 to 115 dB stimulus. The arousal and cessation reflexes are somewhat self-explanatory; the sleeping infant is aroused and the restless infant is quieted by the presentation of an intense sound stimulus. Careful consideration should be given to the baby's baseline activity prior to stimulus presentation because the initial value of this activity can preclude a response from an infant who truly has normal hearing.

At approaximately five months of age, the infant will begin to reflexively seek the source of sound (the "orientation" reflex or the "localization" response). This response begins as a rudimentary head turn in the horizontal plane and matures to a full eye and head turn in all planes by nine months of age. The localization response can extend the use of BOA to the assessment of older infants; moreover, this response is the basis for the conditioning modifications of BOA mentioned earlier. Conditioning modifications of BOA are best suited for assessing 12 to 24 month old infants, but successful results have been reported in the assessment of 5 month old infants.

The most familiar example of BOA is the cursory hearing screening that the primary care physician may use in the office setting. Many physicians have favorite noisemakers or other sound-producing devices (such as a hand clap) to use in such situations, and this form of BOA can influence the physician's decision to refer the child for further testing. An apparently normal response to noise-makers has reduced validity when accompanied by persistent parental suspicion of hearing loss. Noisemakers cannot detect hearing loss limited to the middle to higher frequencies, and if the baby has residual hearing he may respond to the device in an apparently normal fashion. A referral for further testing is justified whenever parental suspicion persists.

The level of background noise and the frequency and intensity of the auditory stimulus are controlled in the audiology center. Testing takes place in a sound-treated test booth with the child positioned on the parent's lap between two loudspeakers. The audiologist presents various auditory stimuli (voice, noise bands, frequency modulated pure tones or warble tones, and sometimes music and recorded environmental sounds) from an adjoining control room and observes the child's responses through a connecting window.

The intensity level of the auditory stimulus necessary to elicit an observable response will vary with the developmental level of the child. Wilber has compiled normative data from several studies on expected intensity level of auditory response in infants. The intensity level required to just elicit a response, regardless of stimulus type, decreases with increasing age. Responsivity is consistently better to the more meaningful speech stimulus than to the less familiar warble tones or noise bands.

Conditioned Responses

Reflexive responses begin to diminish in strength between 2 and 4 months of age, and the child becomes more responsive to softer and more meaningful sound such as the human voice. At 4 to 5 months of age the "localization" response begins to emerge, initially consisting of rudimentary attempts to locate the sound source, and, by 6 to 9 months of age, consisting of a full head and eye turn to the source of sound.

The localization response makes it considerably easier to evaluate infants who should have this capability with BOA. Moreover, certain conditioning techniques have been devised to strengthen this response in order to assess the baby's hearing. These techniques also involve the presentation of a stimulus sound and the observation of the associated behavioral response, but the response is strengthened or conditioned by using a reinforcer.

In 1961, Suzuki and Ogiba suggested the use of a blinking light located near the loudspeaker to reward the "orientation" or localization response in young infants. This technique is commonly referred to as conditioning orientation reflex audiometry (CORA).

Visual reinforcement audiometry (VRA) is a refinement of CORA that uses an interesting visual stimulus (such as an animated toy) to reward the child's localization response. Localization behavior is established during the conditioning phase of VRA, then the intensity level of the test stimulus is decreased until the child no longer responds. Some researchers have reported successful threshold estimation with VRA for babies as young as 5 months of age.

Tangible reinforcement operant conditioning audiometry (TROCA) is another conditioning procedure that uses a tangible reinforcer (such as raisins or other edibles) to reward thechild for pressing a bar in response to an auditory stimulus. A special apparatus is used to dispense the reward when the bar is pressed. Visual reinforcer operant conditioning audiometry (VROCA) is a variant of the TROCA procedure which uses a visual reinforcer instead of a tangible reinforcer to reward the bar-press response.

Although operant conditioning techniques have been found to be most successful in 13 to 20 months old infants, they have also been used successfully in infants less than 12 months of age and have been shown to have particular value in the assessment of severely retarded children.

Play Audiometry

Once the child attains a developmental level of 2.5 years he is capable of voluntary responses to sound. Conventional audiometric techniques can be used, but they must be modified to be more interesting to the young child. The situation is structured to make listening a game, and the child actually responds by "playing" the game. For this reason the technique is often called "play" audiometry. This method can be used to assess hearing levels for both speech and pure tone stimuli (air and bone conduction). A game used frequently is to have the child drop a block into a box each time the tone is heard. With a short practice session, the child can be taught to respond appropriately as stimulus frequency and intensity are varied.

Hearing levels for speech stimuli can be obtained by using a picture or object identification task in which the child is requested to pick up or point to the item named by the examiner. Several picture identification tests (such as the Word Intelligibility by Picture Identification (WIPI) test) have been standardized for assessing speech discrimination ability in the young child or the child with limited speech and language skills.

Conventional Audiometry

The child 5 years and older can learn to perform for audiologic testing in a conventional manner. Conventional testing is conducted in a sound-treated test room with stimuli presented monaurally through earphones. Routine procedures include pure tone testing, speech reception threshold, and speech discrimination testing.

Pure tone testing is designed to assess the child's hearing threshold for the pure tone frequencies most important for understanding speech (250 to 8000 Hz in octave steps). The pure tone signals are presented through earphones (air conduction), then through a bone vibrator positioned on the mastoid (bone conduction). The patient is instructed to respond by raising a hand or pressing a button each time the tone is heard.

Speech reception threshold testing is designed to assess the child's threshold for simple speech material such as familiar two syllable words with equal stress on each syllable (spondaic words). The child is instructed to repeat the words heard.

In addition to threshold level tests, a suprathreshold speech discrimination test is administered to determine the competency of the child's understanding for conversational level speech. Standardized lists of monosyllabic words serve as stimulus items, and the child is instructed to repeat the words heard. For younger children, pediatric word lists have been devised (for example, the PBK series).

Regardless of the developmental age of a child, some information can be obtained concerning auditory function using behavioral audiometric techniques. Modification of conventional audiometric methods provides the means to evaluate children who are very young or difficult to test. In view of the various techniques available, audiologic assessment should never be deferred because a child is too young or too difficult to test.

Nonbehavioral Assessment Techniques

The results of behavioral assessment techniques are unreliable in certain infants and children because they require the overt response of the child. Nonbehavioral techniques rely instead on the respoonses of the autonomic nerves system or on the electric responses of the child's auditory nervous system.

Autonomic Responses

The tests that measure autonomic responses to sound include respiration and cardiac audiometry. Respiration audiometry relies on measurable changes in the pattern and rate of respiration associated with an acoustic stimulus. The test involves the comparison of post stimulus respiration rate to the individual's base rate. Two popular methods of detecting respiratory changes are: the use of a temperature-sensitive thermistor placed within 1 cm of the subject's nostril which monitors the amount and duration of change in air pressure via a change in temperature; and monitoring changes in the diameter of the rib cage on inspiration and expiration by a special device strapped to the thorax which is so sensitive that the slightest respiratory movement is registered. Recent studies have shown that respiratory audiometry can estimate hearing sensitivity for both air and bone conducted stimuli. The technique appears to work best on infants less than 12 months of age. However, the influence of various procedural and subject related variables is not clearly defined and awaits further investigation.

Cardiac audiometry involves the monitoring of changes in heart rate in response to auditory stimulation. The method requires a source of auditory stimulation (stimulus generator), EKG electrodes, and a recording system that identifies each heart beat and measures the interval between successive beats. A simple electrocardiogram can identify each beat but more involved instrumentation, such as a strip chart recorder that displays the distribution of heart beats over time or a cartiotocometer, is required to measure the interval between beats.

Several variables influence the success of cardiac audiometry. For example, the change in heart rate is significantly dependent on the age and the state of arousal of the subject. Schulman found that normal term babies show an acceleration in heart rate following the onset of an acoustic stimulus when awake but a deceleration in rate when asleep. Premature babies, however, show only an acceleration in heart rate until about 35 weeks' gestational age, when the response pattern begins to look more like that of a term baby. At a developmental age of 3 months, the cardiac response is more characteristic ofthe decelerative adult pattern. In addition, respiration can influence the heart rate by causing a spontaneous variation in heart beat; with inspiration the heart beat rises and with expiration the heart beat falls.

Although cardiac audiometry may provide a valid index of hearing in adults and older children, its applicability to the neonatal population remains uncertain. Gerber, Mulac, and Swain found that the parameters of the cardiac response to sound vary considerably between and within infant subjects. The maturational influences or the response remains uncertain, and the optimal acoustic stimulus has yet to be defined.

Auditory Electric Responses

Auditory electric response audiometry monitors stimulus-related changes in the electrical activity of the auditory pathway from the cochlea to the auditory cortex. These auditory "evoked potentials" (AEPs) comprise component responses that occur at different times following the stimulus onset; early components correspond to cochlea and eighth cranial nerve activitiy (electrocochleography), and later components reflect successively higher levels in the auditory tract.

With the exception of electrocochleography (which requires a needle electrode passed through the tympanic membrane), AEPs can be recorded from the scalp with noninvasive electrodes. The activity recorded in this fashion is filtered, amplified, then analyzed by a special purpose computer.

In our experience, the response component best suited for infants and children is called the auditory brain stem response (ABR). It consists of five to seven positive waves that correspond approximately to major sections of the auditory pathway. The ABR occurs in the first 10 msec following the onset of a brief acoustic stimulus such as a click.

The threshold of the ABR is determined by reducing stimulus intensity to a level that just elicits a repeatable response. For a click stimulus, this threshod provides a reasonable approximation of hearing for the frequency range from 1000 to 4000 Hz. Other types of stimuli can be used to estimate hearing in lower frequencies, but the reliability and validity of these estimates remain uncertain.

The ABR is a valuable adjunct to the assessment of hearing in infants and children. Its use is reserved to either establish a baseline response in children who cannot be tested behaviorally or to clarify the interpretation of ambiguous results of behavioral assessment. The test is noninvasive, and the response itself is immune to the effects of varying mental state and/or sleep (either natural or induced). The test takes approximately one hour for a complete evaluation. One critical requirement is that the child must lie very still to avoid obliteration of the response by muscle artifact. This means that most infants and children below six years of age require sedation for the ABR test. This requirement, in addition to the need for experienced personnel to interpret the results, confines the use of the ABR to major medical centers devoted to pediatric assessment.

Assessment of Middle Ear Function

Acoustic Impedance

Middle ear disease may result in an abnormal increase (or decrease) in the resistance a sound encounters at the tympanic membrane. This resistance is a complex interaction of the properties of mass and stiffness of the middle ear system and is more appropriately called "impedance".

A reasonable approximation of this acoustic impedance can be gained by delivering a sound to the ear and measuring the degree to which this sound is reflected back away from the tympanic membrane. If a great deal of the energy is reflected, the impedance at the membrane is high; conversely, if very little energy is reflected, impedance is low. High impedance can correspond to the middle ear abnormalities, such as otitis media with effusion, that are likely to increase impedance. The sound situation may correspond to conditions that abnormally reduce impedance, such as ossicular discontinuity.

Consequently the measurement of acoustic impedance at the plane of the tympanic membrane permits certain inferences to be made about the condition of the middle ear. The instrumentation used for such measurment is shown diagrammatically. A "probe" tip with three small apertures is sealed in the external auditory meatus. Each aperture serves a separate function. The incident sound or "probe" tone is delivered through one, the second leads to a microphone, and the third provides an avenue for varying air pressure in the meatus. The most familiar name for this device is an acoustic impedance "bridge". An approximation of the absolute acoustic impedance for a given ear is obtained by "balancing" the bridge. In other words, a reference level of sound energy built into the bridge is varied until it matches that reflected from the tympanic membrane, and the corresponding impedance value (in ohms or cubic centimeters of equivalent volume) is read from the device.

Tympanometry

Tympanometry is a measure of "relative" acoustic impedance because it monitors the change in impedance associated with the variation of an air pressure load on the tympanic membrane. A positive air pressure (for example, 200 mm H_2O) is applied to the tympanic membrane through the probe tip aperture, then the pressure is released gradually toward atmospheric pressure and reapplied in a negative direction to as much as - 600 mm H_2O. The associated change in impedance can be observed on a meter or displayed on an X-Y plotter or strip chart recorder with the abscissa and ordinate respectively representing air pressure and relative impedance. The trace itself is called the tympanogram.

The tympanogram will peak when the air pressure on both sides of the tympanic membrane is approximately the same. Consequently, the position of the peak on the abscissa represents the air pressure in the middle ear. The height of the peak denotes the relative impedance at the tympanic membrane corresponding to the air pressure in the middle ear; sometimes this is called tympanic membrane compliance. The shape or gradient of the peak reflects the responsiveness of the tympanic membrane; a smoother or rounded peak denotes a more sluggish responsiveness to pressure changes than a sharp, well-defined peak. These three features of the tympanogram - peak position, height, and gradient - contribute useful information in the clinical setting.

The Acoustic Middle Ear Muscle Reflex

The stapedius and tensor tympanic muscles contract reflexibly in both ears, then an intense acoustic stimulus is presented to either ear. This contraction is called the acoustic reflex and it results in an increase in acoustic impedance at the tympanic membrane. Consequently the acoustic reflex can be detected by monitoring impedance just prior to and during adequate acoustic stimulation. The sudden increase in impedance coincident with the stimulus represents the contraction of the middle ear muscles. Reflex tests can be conducted by placing the probe tip in the meatus and stimulating either the same ear or the contralateral ear.

It is likely that middle ear disease will obviate detection of the acoustic reflex. Since the condition has already influenced the acoustic impedance, further increases in impedance secondary to muscle contraction may not be detectable. Moderate conductive and severe sensorineural hearing loss may also result in a failure to detect the acoustic reflex.

Clinical Interpretation of Impedance Data

Tympanometry and, in certain instances, acoustic reflex tests provide an essential adjustment to audiologic assessment of infants and children. The information provided can clarify the clinical picture by excluding or confirming middle ear disease.

Tympanometry is ideally suited for the office situation: the test is non-invasive, rapid, and can be administered by minimally trained personnel. However, the equipment is relatively expensive, and many commercially available versions of the basic impedance bridge have not been validated. This can put the clinician at a disadvantage, especially when interpreting the data obtained.

Table 2 lists several variants of the tympanogram and the pressured middle ear conditions associated with each variant. The varients represent changes in peak position, height, and gradient in various combinations. Consequently, simplified interpretation can be based on these tympanogram features. Jerger and Paradise et al have classified tympanograms into distinct categories to further simplify interpretation.

Table 2. The Relationship between Tympanogram Variations and the Condition of the Tympanic Membrane and/or Middle Ear

Pressure	Mobility	Presumed tympanic membrane / middle ear condition
Normal	Normal	Normal
Normal	Low	Middle ear effusion, and/or thickened tympanic membrane, and/or ossicular fixation
Normal	High	Flaccid tympanic membrane or ossicular discontinuity
Negative	Normal	High negative pressure with or without middle ear effusion
Negative	Low	Middle ear effusion, and/or thickened tympanic membrane, and/or ossicular fixation
Negative	High	flaccid tymanic membrane and high negative pressure (or ossicular discontinuity and high negative pressure)
Positive	Normal	High positive pressure with or without middle ear effusion.

Because otitis media significantly alters the tympanogram, tympanometry is very sensitive to its presence. The majority of ears with otitis media with effusion (OME) present with tympanograms that have a rounded peak of reduced height and are elevated in the negative pressure range. The absence of a peak is another common finding.

The validity of the tympanogram depends on the age of the child. The technique is less valid in infants less than seven months of age, presumably because of the exceesive ear canal distensibility in these babies.

Management

The nature of hearing impairment can be conductive, sensorineural, mixed (conductive and sensorineural), or central. The degree of loss can range from minimal to profound, and the impairment can be unilateral or bilateral. The onset of loss can be prelingual (before speech is acquired) or postlingual. Successful management is a function of all these factors in addition to other handicaps the hearing impaired child may sustain.

Unilateral Hearing Loss

The child with unilateral hearing loss, either conductive or sensorineural, will have difficulty in at least two listening situations: localizing the source of auditory signal, and hearing in the presence of noise. Localization ability can be enhanced by training the child to take advantage of other sensory avenues, especially vision; discrimination between foreground signals and background sounds can be improved by structured practice in listening in the midst of increasingly interfering background sound. Classroom and family adjustments include placement of the child with his good ear toward the primary source of instruction and close to the speaker to that background sounds are at a minimum, and teching the child to "stage-manage" himself so that his good ear is close to the speaker.

If hearing loss in the poorer ear can be improved with amplification, then a hearing aid may enhance binaural hearing. If not, a hearing aid that provides a contralateral routing of signals (CROS) may be helpful. CROS hearing aids have been helpful especially to individuals who have a sudden onset of hearing loss in one ear.

Because parents, and even the unilaterally handicapped child himself, may be concerned that the normal ear will acquire a hearing loss, judicious medical and audiological monitoring is imperative. Excessive exposure to noise (amplified music) and sudden changes in pressure (scuba diving) should be avoided. The detection and treatment of recurring ear infections and the maintenance of good general health are equally important.

Bilateral Hearing Loss

Conductive Loss. A hearing threshold elevation caused by middle ear disease, usually OME, is probably the most common problem encountered by the pediatric otolaryngologist. Hearing levels may range from 0 to 40 dB. Usually the child is not a candidate for a hearing aid unless the reduction in hearing sensitivity is expected to persist or if hearing fluctuates drastically during treatment. Amplification can be provided, especially to the child who is developing language and speech, until his hearing returns to normal.

In general, the child with a conductive loss merely requires louder auditory signals. By knowing the degree of the child's hearing loss, parents can inform the classroom teacher of the child's needs and can convey the child's need for special classroom consideration while the middle ear disease is active. The teacher should know that hearing may fluctuate and that there will be times when the child may need extra help in hearing instructions given to the class. The teacher will find that communication is enhanced if he or she gets the child's attention before giving an instruction, speaks clearly and distinctly in giving instructions, confirms that the child did understand the instruction accurately, does not talk while facing the blackboard, and rephrases the instruction, rather than merely repeating it, if the child does misunderstand. The child should know that he or she may miss what the teacher says. The child needs help to pay strict attention to the teacher's instruction. It is his responsibility to get the message. Parents and teachers must be careful, however, not to exaggerate the handicap a child may experience from mild reduction of hearing sensitivity. Usually, the brighter the youngster, the less handicap a mild conductive hearing reduction will impose.

When a child has a reduction in hearing sensitivity caused by a congenital malformation of the middle ear and sustains a conductive hearing impairment that is not amenable to surgery, amplification should be recommended. If the ears are dry, an air conduction hearing aid can be used. The aid can be either an ear-level or a body worn instrument. If the hearing reduction is 65 dB or less, the hearing aid can correct the loudness reduction in the ear in which it is worn. This leaves the child with only a unilateral hearing loss, and he can be treated as having essentially normal hearing for learning. Binaural amplification is another alternative. The classroom and parental adjustment suggested earlier is appropriate for this child, too. If the ears are not dry or if the child has congenital atresia, a bone-conduction receiver worn with a body hearing aid can be recommended.

Sensorineural Loss. Children with a sensorineural hearing loss require more extensive management. Their problem is not only elevated hearing threshold, but distortion of sound so that intelligibility of speech may be reduced.

The management process for these children begins with parent education. Quite often, parents are more prone to accept the use of a hearing aid when they recognize that their child's hearing loss cannot be corrected medically. The more severe the hearing reduction, the more amenable parents are to the use of amplification.

Once parents have accepted the reality of irreversible hearing loss, they often grast at the hope that the hearing aid will "correct" the serious impairment. However, hearing aids to not correct severe sensorineural hearing problems. The audiologist and hearing therapist must use considerable skill in helping parents and the hearing impaired child to adjust to the benefits and limitations of a hearing aid. The nature and extent of hearing loss, intellectual factors, and parental acceptance and support influence the success of amplification. Many well planned programs to provide hearing aid orientation are available to children, parents, and teachers.

Amplification

A personal hearing aid is a miniature, sound-reproducing system comprised of a microphone, amplifier, and receiver. The microphone picks up the sounds in the environment and changes them from acoustic to electric signals. The amplifier boosts the strength of the signals, and the receiver converts the amplified electric signals back into sound waves and sends them into the ear. An ear mold serves to focus the amplified sound into the ear.

Body hearing aids have a microphone, amplifier, and battery in one package from which a cord carries the electrical signal to the receiver worn at the ear (air conduction receiver) attached to a custom-made earmold which hold the receiver as close to the ear as possible. The cord may be attached to a small vibrator (bone conduction receiver) worn behind the ear and held on the head with a headband. Body worn hearing aids generally provide more amplification and are suitable for those with severe and profound hearing reduction or for infants whose ears are too tiny to hold an ear-level instrument.

Ear-level hearing aids, sometimes called over-the-ear or post-auricular aids, have the microphone, amplifier, receiver, and battery in a single package. The sound from the receiver is delivered to the ear by means of a tube which is attached to the custom-made earmold worn in the ear. Ear-level hearing aids are by far the most frequently used instruments by both adults and children.

In-the-ear hearing aids. All parts of the aid are built into the custom earmold or are in modular form and can be plugged into the mold. Generally, in-the-ear aids have less gain than ear-level instruments and are somewhat more noticeable than pictured in the advertisements. They are generally inappropriate for children because of the need to have the earmold re-made as the ear grows.

Sensorineural hearing impairment causes both a reduction in loudness of incoming auditory signals and distorted and blurred audition. Hearing aids increase the loudness and to some extent can provide selective amplification in the frequency range of the hearing reduction. Because hearing aids are small, they cannot provide the high-fidelity associated with sound systems generally, and they certainly cannot provide "normal" hearing. Also, the ear with distortion cannot be perfectly "corrected" with a hearing aid; the user must learn to accommodate to distortion and rely on other sensory avenues (speech reading, environmental clues, facial expressions, and body language) for accurate reception of sound messages.

The hearing aid user with a sensorineural loss often finds that the device cannot distinguish useful from distracting sounds (signal versus noise). Consequently, the user needs time and usually training to psychologically "tune in" an important auditory signal and "tune out" unwanted noise.

The user with bilateral hearing loss who wears one aid has all the problems associated with unilateral hearing loss. Two hearing aids may provide truly binaural hearing which makes both localization and the speech-to-noise ratio more natural. Unfortunately, financial considerations can determine whether a child is to have one or two aids. There are children whose hearing impairment in each ear is so different that two aids cannot provide true stereophonic hearing. A competent audiologist will advise parents of the type of aid or aids best suited to the child's special needs. The audiologist may lend the child a second hearing aid for trial and instruct the parents on what to look for to determine the benefit of a second aid and warrant its purchase.

Education

Education for the hearing impaired child entails more than listening to sound. It includes the development of both receptive language (learning what is said) and expressive language (learning to express needs, thoughts, and ideas). In addition, it includes speech development or correction so the child can be understood by others. In general, severe hearing reduction has its greatest effect on language and speech. A hard-of-hearing person is one who, generally with the use of a hearing aid, has residual hearing sufficient to enable successful processing of linguistic information through audition. A deaf person is one whose hearing loss precludes successful processing of linguistic information through audition, with or without a hearing aid. Deaf and hard-of-hearing children are on quite different ends of a continuum and, depending on the hearing impairment, a variety of educational aids may be required.

Educational management is also affected by age of onset, nature of hearing loss, intellectual status, presence of other handicaps, and educational resources in the community, as well as parental understanding, expectancies, and ability to participate in the child's education.

When a significant hearing loss is identified in infancy, the child's home is the school setting and the parents are his teachers. A special educator trained to work with very young children helps parents to learn to communicate with their hearing impaired child and helps the child begin to use his residual hearing with amplification. The special educator plans an individual education program (IEP) for the child; parents are required to be involved with planning this program (Education for All Handicapped Children Act, Public Law 94-142).

Nursery programs for hearing impaired children are located in large metropolitan areas in which there are enough children to constitute a class. Many infant stimulation programs designed for developmentally delayed youngsters have personnel trained to work with hearing impaired children. It seems best, however, that a severely hearing impaired child attend a school designed for his educational needs rather than a program for children with widely different problems.

Special schools are available in large communities for hearing impaired children who are two years of age and can use full-time special education. If the child lives too far from such programs, he may need to attend a residential school. All states have at least one residential school for the deaf. Parents should visit all existing facilities and judge them on the basis of class size (a school's clases for deaf children should not exceed seven youngsters), the availability of supervision, a sufficient number of classes to allow a homogeneous grouping of pupils and teacher training to teach hearing impaired children. The choice of school often must be based on geography. Yet, with the current right-to-education movement, many small school districts are developing classes for hearing impaired children. Parents should be warned, however, that it is a disservice to a child to place him in an inferior educational program in order to keep him close to home.

The child who is hard-of-hearing and who, with the aid of amplification can learn language and speech will probably have educational resources within the public school system. These may include a self-contained classroom for the youngster who cannot be placed in regular classes, or a special resource room to which the child goes for part of his day with a special teacher, while the rest of the day is spent in regular classes with his normal hearing peers. The special teacher tutors him academically so that he can compete with the children in regular classes. Some hearing impaired children can manage in regular schools with the help of a hearing therapist who sees the child once or twice a week for academic tutoring, speech-reading training, auditory training, and speech correction. The therapist can serve as a consultant to the regular classroom teacher, helping the teacher to accommodate the hearing impaired child in the classroom.

Hearing impaired children who have other handicaps, such as mental retardation, specific learning disabilities, or severe visual handicaps, require more than the special education designed for the hearing impaired child. Placement in a class is often determined by the child's most severe problem. The children most likely to be integrated into regular classrooms, even though they require supportive help, are those whose parents can participate in the child's education, and those youngsters whose language facility, including reading, is not seriously abnormal.

Educational Methods For Deaf Children

There are differences of opinion among educators as to how to educate the hearing impaired child, especially the deaf child. Should he be taught with an oral approach - learning to lipread, talk, and use his residual hearing? Or should he learn manual communication skills

- sign language and finger spelling? The communication mode used by the school which the child attends will determine how he is to be educated. If a child cannot learn orally, a "total communication" (simultaneous oral-manual approach) may be feasible. No approach is a panacea for the difficult job of language education for a deaf child. The audiologist must inform parents of the conflict of approaches and make recommendations based on the child's hearing levels, language aptitude, and the parents' wishes.

Parents of Hearing Handicapped Children

The physician and audiologist have the unique responsibility to teach parents who, in turn, teach their hearing impaired child, about why he has a hearing handicap, the benefits of hearing aids, how the aids work, how to listen, how to take advantage of visual clues, and how to stage-manage himself for ease of communication. However, the most important goal is to help the parents and their child to maintain good mental health. The child needs to know that he is important. Parents need help to deal with their guilt feelings, grieving, lack of self-confidence in facing the realities of an irreversibly hearing handicapped child, frustration at well-meaning friends and family who give free advice that may not be helpful, and disappointments with professionals and hearing aids that cannot "cure" the problem. Being part of a parent group may be helpful. Well-informed and knowledgeable parents provide the handicapped child with the support and self-esteem he needs to feel that he is not the cause of his parents' grief. The goal of the physician is to constantly search for ways to meet the needs of parents who will in turn, provide a healthier climate in which their hearing impaired child can grow and learn.