

Speech-Language and Educational Consequences of Unilateral Hearing Loss in Children

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Background: In the past, unilateral hearing loss (UHL) in children was thought to have little consequence because speech and language presumably developed appropriately with one normal-hearing ear. Some studies from the 1980s and 1990s have suggested that a significantly increased proportion of children with UHL may have educational and/or behavioral problems, compared with their normal-hearing peers. Limited data exist about the effect of UHL on acquisition of speech and language skills.

Objective: To review the current literature about the impact UHL has on the development of speech and language and educational achievement.

Data Source: MEDLINE search between 1966 and June 1, 2003, using the medical subject heading "hearing loss," combined with the textword "unilateral."

Study Selection: Studies were limited to those written in English, reporting speech-language and/or educational results in children.

Data Extraction: Articles were read with attention to study design, population, recruitment of subjects, and outcomes measured.

Data Synthesis: Problems in school included a 22% to 35% rate of repeating at least one grade, and 12% to 41% receiving additional educational assistance. Speech and language delays have been reported in some but not all studies.

Conclusions: School-age children with UHL appear to have increased rates of grade failures, need for additional educational assistance, and perceived behavioral issues in the classroom. Speech and language delays may occur in some children with UHL, but it is unclear if children "catch up" as they grow older. Research into this area is necessary to clarify these issues and to determine whether interventions may prevent potential problems.

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IN THE PAST, UNILATERAL HEARING loss (UHL) was considered to be of little consequence because speech and language presumably developed appropriately with one normal-hearing ear. Prior to the establishment of universal newborn hearing screening programs, children with UHL were often undetected until they entered school and underwent hearing screenings, unless they had medical problems that led to an early hearing screen or audiogram.¹ Several studies from the 1980s and 1990s have suggested that a significantly increased proportion of children with UHL may have educational and behavioral problems, compared with their normal-hearing peers. Studies in adults have suggested that those with UHL have more communication problems than usually recognized.^{2,3} With universal newborn hearing screening now mandated in 38 states in the United States and many

countries in the developed world, infants are now being identified with varying degrees of UHL. Clinicians who deal with hearing loss in children have few data with which to make recommendations to parents of these infants. Should these children be treated as normal-hearing children, with no special concerns for speech and language, or should these infants be fitted with hearing aids as soon as possible, or is there a middle ground between these two approaches? Although the studies that reported the findings of educational problems may be biased in their populations and may have overestimated the proportion who has problems, most likely there is a group at risk who may benefit from some type of intervention.

This study was undertaken to review the current literature about the impact UHL in children has on the development of speech and language and educational achievement.

Table 1. Summary of Studies on Speech and Language Consequences of Unilateral Hearing Loss (UHL) in Children

Source	Design	Severity of UHL	N*	Speech and Language Problems
Kiese-Himmel, ⁴ 2002	Case series	≥30 dB	31	Delayed acquisition of 2-word phrases
Sedey et al, ⁵ 2002	Case series	Mild to profound	15	Significant language delay in 4 (27%) of 15
Peckham and Sheridan, ⁶ 1976	Case series	≥55 dB	44	"Higher proportion of speech difficulties" at 7 years old, and 4 of 44 with poor speech intelligibility at 11 years old
Klee and Davis-Dansky, ⁷ 1986	Case-control	≥45 dB	25	Few differences on standardized language tests
Cozad, ⁸ 1977	Case-control	≥70 dB	18	Lower vocabulary scores than controls, but not statistically significant
Borg et al, ⁹ 2002	Cohort	≥20 dB	58	Delayed language development compared with normal-hearing peers

*Refers to the number of children with UHL included in the study.

METHODS

DATA SOURCE

A MEDLINE search of the medical literature between 1966 and June 1, 2003, was performed to identify studies reporting results of the effect of UHL on speech-language development or educational achievement in children. The MeSH (medical subject heading) heading "hearing loss," limited to studies on humans, English language, and children (age 0-18 years), was combined with the textword "unilateral" to find original articles. A search of the CINAHL database between 1982 and June 1, 2003, revealed no further articles. Additional original articles were found when the references of the included studies or recent reviews were searched.

STUDY SELECTION

Titles and abstracts of articles identified from the MEDLINE search were reviewed for inclusion and exclusion criteria. Criteria for inclusion into this survey were that the articles were written in the English language, involved human subjects between the ages of 0 and 18 years, and reported speech-language or educational results in children with UHL. Studies were excluded if they were review articles. The MEDLINE search identified 351 articles using the stated search terms. Sixteen articles met each of the stated inclusion and exclusion criteria. Two other articles were identified when the references of recent reviews or these 16 articles were searched. Experts in evaluating children with hearing loss were queried to identify other published and unpublished studies, bringing to 19 the total number of articles or reports reviewed for this study.

DATA EXTRACTION AND SYNTHESIS

Each article was read critically with attention to study design, study population, recruitment of subjects, and outcome measures used.

Because of heterogeneity of the articles identified for this review, descriptive summary statistics were used to synthesize the data from the studies. The only exception to this was an evaluation for overall trend toward more speech-language or educational problems based on the severity of UHL in the children studied. The studies were categorized for severity of UHL as follows: mild to profound (≥20 to ≥35 dB), moderate to profound (≥40 to ≥65 dB), and severe to profound (≥70 dB to "anacusis"). The studies were then dichotomized as to whether they showed increased speech-language or educational problems in children with UHL. A χ^2 table was constructed, and the Cochran-Armitage trend test was performed using SAS software version 8.2 (SAS Institute, Cary, NC). A 2-sided *P* value of less than .05 was considered statistically significant.

RESULTS

CONSEQUENCES OF UHL ON SPEECH AND LANGUAGE DEVELOPMENT

Limited information exists about the effect of UHL on acquisition of speech and language skills. The studies reviewed are summarized in **Table 1**. Two studies have evaluated speech and language acquisition in infants and toddlers. Kiese-Himmel⁴ retrospectively asked parents when their child spoke their first word and first 2-word phrase. The average age of the first word spoken was 12.7 months (range, 10-33 months), and the average age of the first 2-word phrase spoken was 23.5 months (range, 18-48 months). Although the age of first word utterance was not delayed, the average age of the first 2-word phrase was delayed an average of 5 months, based on a norm of 18 months. The Colorado Home Intervention Program (CHIP) reported results on 15 children with UHL followed up since their identification as infants.⁵ Their speech and language skills were assessed using 3 separate tools when the children were at least 12 months old. None had any other known disability, but 4 (27%) had significant language delays, and 1 (7%) had a borderline language delay.

Four studies have looked at language skills in pre-school or school-age children. A longitudinal study of 44 children found to have severe UHL at 7 years of age followed them up at 11 years of age.⁶ Although as a group, these children had a higher proportion of speech difficulties, and "backwardness in oral ability and reading," only 4 children still had poor speech intelligibility at 11 years, and similar reading scores to normal-hearing peers. However, at least 13 of the original 44 children had temporary hearing losses, evidenced by normal audiograms at 11 years. Klee and Davis-Dansky⁷ reported that a subgroup of 25 children aged 6 to 13 years with UHL (out of a larger series of 60 children¹) had few differences from a control group of normal-hearing children on a battery of standardized language tests. Cozad⁸ compared 18 children and young adults with severe to profound UHL (age range, 8-20 years) with normal-hearing peers on standardized tests of vocabulary and lipreading. Although the group with UHL had lower vocabulary and higher lipreading scores, none of these differences were statistically significant. However, a recent Swedish study evaluating language development in hearing-impaired children

Table 2. Summary of Case Series on Educational Consequences of Unilateral Hearing Loss (UHL) in Children

Source	Severity of UHL	N*	Educational Problems
Studies Suggesting UHL Is Associated With Increased Educational Problems			
Brookhouser et al, ¹⁰ 1991	>15 dB	172	Educational or behavioral problems at school, 59%
Bovo et al, ¹¹ 1988	Profound or complete	115	Failed at least one grade, 22%; required assistance, 12%
Tieri et al, ¹² 1988	Mild to profound	280	"In the majority of cases the parents noticed some difficulties in their children's learning at school"
Bess and Tharpe, ¹ 1984	≥45 dB	60	Failed at least one grade, 35%; required additional educational assistance, 13%; had behavioral problems in school, 20%
Sezey et al, ⁵ 2002	Were on individualized educational plans for the 2000-2001 school year, 36%
Studies Suggesting No Association of UHL With Educational Problems			
Hallmo et al, ¹⁴ 1986	>20 dB	56	"Their school results were normal, as were their linguistic development"
Stein, ¹⁵ 1983	≥30 dB	19	Adequate classroom performance and grades as a group, but 8 (24%) may have excessive behavior problems

*Refers to the number of children with UHL included in the study.

4 to 6 years old found that the group of 58 children with unilateral deafness or severe hearing impairment had significantly delayed language development compared with normal-hearing peers.⁹

CONSEQUENCES OF UHL ON ACHIEVEMENT AND BEHAVIOR IN SCHOOL

Table 2 summarizes the case series reports of cognitive, educational/achievement, or behavioral issues in children with UHL. Several case series have reported that a substantial number of these children experienced educational problems. Brookhouser et al¹⁰ reported on 172 of (44%) 391 children with UHL with available school performance data, seen between 1982 and 1989. Of these 172, 102 (59%) had a history of academic or behavioral problems at school. When categorized by severity of hearing loss, those with more severe hearing loss did not have more problems in school than those with milder hearing loss. Bovo et al¹¹ reported that in a cohort of 115 children with profound UHL seen in 1981 to 1986, 22% failed at least one grade and 12% required assistance from a specialist in learning disabilities. The majority of these children (80%) presented for parent or teacher concerns about their hearing. Tieri et al¹² followed a cohort of 280 children with UHL from 1979 to 1986. Most of these children (79%) had profound UHL. They concluded, "in our series we didn't observe any case of speech or language problems. However, in the majority of cases the parents noticed some difficulties in their children's learning at school." Bess and Tharpe¹ reported in 1984 that among 60 children identified with UHL, 35% failed at least one grade, and 13% required additional educational assistance. Furthermore, 20% had behavioral problems identified by teachers.¹³ In the state of Colorado, 36% of school-age children known to have UHL for the 2000-2001 school year were on individualized educational plans.⁵ The reports summarized above suggest that a significant proportion of children with UHL have considerable difficulty in school: 22% to 35% repeated at least one grade, and 12% to 41% received additional educational assistance.

A few case series have suggested that children with UHL do not have increased educational problems compared with their normal-hearing peers. Hallmo et al¹⁴ identified a series of 56 children who presented with unilat-

eral sensorineural hearing loss (SNHL) between 1972 and 1982. In 21 children (37.5%), the parents had noticed a hearing loss; the remainder had been identified through a hearing screening. Upon reexamination 1 to 10 years later, "Their school results were normal, as were their linguistic development." However, they used no reproducible or testable measure on which to base their conclusion and had no comparison group. Stein¹⁵ used teacher judgments of children's classroom performance and intelligence to assess 19 children with UHL academically, and standardized ratings of behavior and self-esteem to measure psychosocial aspects of UHL. Only 1 of 19 students had repeated a grade, and as a group, these children had adequate classroom performance and grades. However, 8 (42%) had standardized rating scores suggesting excessive behavior problems.

As shown in **Table 3**, several controlled studies have documented that increased proportions of children with UHL have problems in school compared with normal-hearing peers. A subgroup of 25 children chosen from the same cohort as Bess and Tharpe's study¹ were compared with normal-hearing control children, and were found to have significantly lower scores on verbal academic tests.¹⁶ In addition, children with severe to profound UHL had significantly lower IQ scores compared with children with mild to moderate UHL.

Oyler et al¹⁷ found that 106 of 54 090 children in one school district were identified with UHL. Questionnaires were distributed to the teachers of 94 students. Of the 57 teacher questionnaires returned, 9 (24%) of 38 students repeated at least one grade, compared with the overall school district rate of 2%. They noted that children with right UHL repeated at least one grade more often than children with left UHL (34.8% vs 6.7%, respectively), and that more children with severe to profound UHL than mild to moderate UHL repeated a grade (36.7% vs 18.7%). In addition, 22 (41%) of 54 children had a record of receiving special services at school, compared with a district rate of 8.6%. However, teacher-rated overall performance (ie, below average, average, or above average) of 57 students was similar to children with normal hearing.

Hartvig Jensen et al¹⁸ compared 30 children with UHL with 30 control children. Only 40% of the children with UHL had a suspected hearing loss at identification. They

Table 3. Summary of Controlled Studies on Educational Consequences of Unilateral Hearing Loss (UHL) in Children

Source	Severity of UHL	N*	Educational Problems
Studies Suggesting UHL Is Associated With Increased Educational Problems			
Bess and Tharpe, ¹ 1984	≥45 dB	25	Poorer syllable recognition scores in conditions of background noise; lower verbal IQ among children with UHL who failed a grade; lower full-scale IQ among children with severe UHL
Oyler et al, ¹⁷ 1988	>25 dB	57	Repeated at least one grade, 9/38 (24%); received special services, 22/54 (41%)
Hartvig Jensen et al, ¹⁸ 1989	>45 dB	30	Children with right UHL had poorer performance on verbal tests than controls or children with left UHL
Dancer et al, ¹⁹ 1995	>40 dB	18	Cases performed worse than controls on 13 of 15 areas
Studies Suggesting No Association of UHL With Educational Problems			
Keller and Bundy, ²⁰ 1980	>25 dB	63	No differences on standardized test scores between cases, control siblings, and national norms, but cases scored lower than controls on every subscale; "It was not unusual for the child with a unilateral loss to be described as 'uncooperative and inattentive'"
Ito, ²¹ 1998	Mild to profound	†	UHL incidence of 0.96% (305/31902) among first-year students at the University of Tokyo vs 0.15% in preschool and 0.14% in school-age children

*Refers to the number of children with UHL included in the study.

†Number of children with UHL not known.

found that children with right UHL seemed to have poorer performance on several verbal tests, whereas children with left UHL performed similarly to normal-hearing children.

Dancer et al¹⁹ used the SIFTER questionnaire, a validated teacher-based questionnaire developed to screen children for educational difficulties, to obtain teachers' perceptions of academic difficulties in 18 children with UHL compared with normal-hearing controls. The mean scores of children with UHL were lower than mean scores of controls on 13 of 15 questions, indicating an increased risk for educational difficulties.

Two controlled studies have suggested that children with UHL do not have increased educational problems compared with their normal-hearing peers. Keller and Bundy²⁰ reported a survey of 5 school districts around Buffalo, NY, and identified 97 with UHL out of more than 42000 students. Sixty-three of these students agreed to participate in the study, with 23 control siblings. However, they compared standardized test scores of only 13 with UHL with 14 control siblings and national norms. They found no statistically significant differences between those with UHL and the control siblings and national norms, but found that subjects with UHL scored lower than controls on every subscale of the tests. They also noted that "It was not unusual for the child with a unilateral loss to be described as 'uncooperative and inattentive.'" With their limited sample size, their study may suffer from a lack of statistical power (type II or beta error) to detect a difference between the 2 groups.

Ito²¹ in 1998 compared the prevalence of UHL among 31902 first-year college students (0.96%) at a prestigious university in Japan with schoolchildren in Japan (0.15% among 6825 preschool children, and 0.14% among 18422 schoolchildren). He argued that the increased prevalence of UHL among the students at the University of Tokyo suggested that there was no educational handicap attributable to UHL alone. However, prevalence of UHL increases with age, so one expects a greater prevalence of UHL in college students than in preschool or school-age children. The most appropriate comparative group would have been a similarly aged cohort of sec-

ondary school graduates who did not attend college or university, or a cohort who dropped out of school.

DEFINITIONS OF UHL FOR STUDY POPULATIONS

The study populations varied in the severity of UHL, from 15 dB or higher pure-tone average to "profound or complete" hearing loss. The normal-hearing (better hearing) ear was invariably defined as pure-tone average less than 15 dB. Tables 1, 2, and 3 show the severity of UHL in the study populations for each report. There was no definite statistical trend toward the more severely affected populations having more speech-language or educational problems ($P=.10$).

COMMENT

Much of the current literature summarized in this report suggests that a significant proportion of children with UHL have considerable difficulty in school: 22% to 35% repeated at least one grade, and 12% to 41% received additional educational assistance. However, all of these studies have selection biases, in that only an unknown fraction of all children with UHL presented to these groups of investigators; a substantial proportion eligible to participate did not; and the children participating in these studies probably represent the most seriously affected of all children with UHL. The majority of the children in these studies had severe to profound UHL, whereas one study of newborn hearing screening showed that more than 80% of those with impaired hearing had mild to moderate losses.²²

EPIDEMIOLOGY OF UHL

Unilateral hearing loss in school-age children has an estimated prevalence of 0.1% to over 5%.^{23,24} In the state of Colorado, the incidence of UHL in school-age children for the 2000-2001 school year was 1.5 in 1000.⁵ The estimated prevalence varies greatly because the studies that generated these estimates vary in their method of as-

certainment. The studies that based estimates on known cases result in a lower estimate, and probably missed “silent” cases of UHL. The studies with higher estimates are cross-sectional surveys that include temporary hearing losses and high-frequency or noise-induced hearing losses, and thus may overestimate the true prevalence of UHL.

The prevalence of UHL in newborns has been estimated to be 0.04% to 3.4%, based on follow-up studies from newborn hearing screening programs.^{22,25-27} The estimates also vary greatly because often only SNHLs are counted, omitting mixed or long-term conductive hearing losses, and poor follow-up rates may result in underestimation of the true prevalence. Overestimation of the true prevalence would occur if the estimates occurred from a high-risk population. One would expect that the prevalence of hearing loss in children would increase with time due to the onset of acquired hearing losses of varying etiologies, as well as delayed-onset congenital or hereditary hearing losses.

ADVANTAGE OF BINAURAL HEARING

The physiologic advantage of having 2 normally hearing ears over 1 normal ear alone has been documented in multiple studies. These advantages can be summarized as binaural summation, the head shadow effect, sound localization, and binaural release from masking.²⁸ Several studies have investigated the performance of children with UHL on auditory tasks that are optimized with binaural hearing.

Sound localization in the horizontal plane is dependent on 2 primary cues: interaural time and intensity disparities.²⁹ Sound is localized much more easily with 2 ears, as documented in many studies of patients with UHL of varying causes, severity, and type (conductive vs sensorineural). Several investigators have demonstrated that children with UHL also make more errors on sound localization tests than children with normal hearing, although some children with UHL may perform as well as or nearly as well as children with normal hearing.^{1,11,29}

Binaural release from masking refers to the improvement in the ability to detect a signal of pure tones or speech in the presence of background noise (ie, masking) when 2 ears hear the presented sounds vs only 1 ear. This is the basis for the “cocktail party effect” in which a normal-hearing listener can engage in conversation in the midst of a room full of “masking” conversation. For a pure-tone signal at 500 Hz, the advantage of 2 ears over 1 ear is typically 12 to 15 dB; for speech signals, the advantage is typically 3 to 8 dB.²⁸ However, infants and young children require a greater signal-to-noise ratio than adults to identify speech sounds in the presence of masking noise,³⁰ suggesting that young children with UHL may experience more difficulty with speech in noise than adults with UHL.

Several studies have documented that children with UHL have more difficulty with speech discrimination in noise compared with normal-hearing children, especially in conditions where speech is presented at the same or less intensity than the background noise. Two studies suggested that this occurs in both the monaural direct (ie, speech directed to the normal ear and noise directed to the impaired ear) and indirect (ie, speech directed to the impaired ear and noise

directed to the normal ear) conditions,^{11,31} but one study suggested this occurs only in the monaural indirect condition.³² In other words, the children with UHL generally require a greater signal-to-noise ratio than their normal-hearing peers to understand speech. This places children with UHL at a disadvantage in school, where the poor signal-to-noise ratio can mask a teacher’s voice.

PROGRESSION OF HEARING LOSS IN UHL

Only a few studies have looked at what happens to the hearing of mildly affected and normal-hearing ears of children with UHL. Does hearing remain stable once it has been identified as a hearing loss, or does it progress? What is the incidence of hearing loss in the normally hearing ear? Bamiou et al³³ found that 5 of 35 children with UHL had progressive losses, and that 4 of the 5 with progressive losses had temporal bone abnormalities on computed tomographic scans. No study has documented the incidence of hearing loss in a previously normal-hearing ear in children initially identified with UHL.

Children with congenital cytomegalovirus infections are a high-risk population for progression of hearing loss and may have UHL. A longitudinal study of 59 asymptomatic (no clinically apparent sign of infection) children with congenital cytomegalovirus infection showed that 9 (15%) developed SNHL.³⁴ One of these children had delayed onset of hearing loss (diagnosed at 13 months), while 6 have showed progression of hearing loss. Seven of these 9 with SNHL had UHL at their latest reported assessment (15-60 months of age).

RISK FACTORS FOR EDUCATIONAL PROBLEMS ASSOCIATED WITH UHL

A few risk factors for educational problems have been suggested: early age of UHL onset, perinatal and/or postnatal complications, severe to profound SNHL, and right UHL.³⁵ Early onset of UHL, such as in infancy, may result in speech and language delays that have been traditionally the hallmark of children with congenital bilateral hearing losses. These delays may result from the lack of auditory stimulation from one ear during the critical period for auditory maturation. Severe-to-profound UHL may accentuate all the disadvantages of monaural hearing vs binaural hearing, because the degree of hearing impairment is so severe. In the setting of a noisy classroom, a child with severe-to-profound UHL may be at particular disadvantage. However, since only one study stratified some results based on severity of hearing, it is impossible to discern whether the severity of UHL alone is associated with speech-language or educational problems. Perinatal and/or postnatal medical complications may result in global developmental delays or cognitive impairments that would not allow a child to develop strategies for overcoming or adapting to disadvantages of having a UHL. A right UHL may be a greater risk for educational problems if people have a “dominant” ear for certain functions, in an analogous fashion to dominant handedness or vision. Since the left cerebral hemisphere is known to be dominant for language in the majority of people, it is possible that a right UHL may have

a greater impact on central perception and processing of sound than a left UHL. Each of the risk factors mentioned may adversely affect the maturation of functional neuroanatomical pathways, which may not be complete until after age 10 years.³⁶

One potential explanation for how UHL can handicap some children but not others in a classroom setting is that children have great variation in their ability to hear speech in the midst of background noise. Two studies have documented that among children with UHL, their performance on speech perception in noise (SPIN) tests varies greatly.^{11,31} Experimental UHL in young adults have shown clear decrements in overall SPIN test scores as compared with normal hearing conditions, but with considerable person-to-person variability.^{37,38} In adults, self-perceived handicap from UHL was generally assessed to be similar in magnitude (mild to moderate) as from mild bilateral hearing losses, but with great variation between subjects.³ Thus, differences in the ability to hear and process a signal (eg, speech) in background noise may account for some of the differences in educational achievement that children with UHL have demonstrated.

Other risk factors for educational delay may be extrapolated from studies of children with bilateral hearing loss. Moeller³⁹ has shown that in young children who are deaf or hard of hearing, the level of parental involvement and age at enrollment into a comprehensive intervention program were the 2 factors most strongly associated with speech and language outcomes at 5 years of age. Geers⁴⁰ reported that in children with cochlear implantation, reading competence was associated with higher nonverbal intelligence, higher socioeconomic status, female sex, and later onset of deafness (after birth). In the same study, speech production and language skills predicted the greatest amount of variance in the reading outcome, suggesting that avoiding speech and language delay is associated with improved prognosis for the development of literacy. Variables related to the child, family, and socioeconomic status, other than the hearing loss itself, may therefore impact speech and language development, reading competence, and by extension, educational achievement.

INTERVENTIONS IN CHILDREN WITH UHL

Little has been done to identify which children are at risk for problems related to their UHL. Similarly, little is known about whether children with UHL benefit from any intervention to avoid speech and language or academic delay. Interventions may include preferential classroom placement, parental education, child education, teacher education, screening for speech and language delays or difficulties, or amplification (including FM systems, conventional hearing aids, bone-anchored hearing aids, contralateral routing of sound [CROS] hearing aids).

A few small studies have addressed the issue of which form of amplification is preferred in children with UHL. Kenworthy et al⁴¹ examined the use of CROS aids or FM systems in 6 children with UHL between 56 and greater than 120 dB hearing level to compare speech recognition scores in noise. They found that only the FM system produced high speech recognition scores in all the listening conditions tested (monaural direct, monaural indirect, and

omnidirectional). Updike⁴² also examined the use of conventional hearing aids, CROS aids, or FM systems in 6 children with UHL to compare speech recognition scores in quiet and in noise. With the conventional hearing aid and CROS aid, speech recognition decreased in noise. Only use of the FM systems resulted in improved speech recognition scores in both quiet and noise. A retrospective survey of 28 parents of children (aged 2-17 years) with UHL who were fitted with hearing aids, suggested that the majority obtained some benefit from the use of hearing aids.⁴³ While FM systems may be easily used in the classroom setting, they may be more difficult to use at home, during play, or during organized activities outside a school building. Thus, further studies to compare the different amplification options in various "real-world" settings and in younger children are needed.

Although a significant proportion of children with UHL may have some problems with education and learning, most of those with UHL do not. Thus, determining who is at risk for educational problems related to their UHL is important in targeting populations for intervention studies. In the absence of any clear evidence of speech or language delay, some state hearing screening programs or audiology departments are attempting to fit hearing aids on all infants identified with UHL⁷ (A. Stredler-Brown, e-mail communication, 2003).

CONCLUSIONS

Children with UHL appear to have an increased rate of grade failures, need for additional educational assistance, and perceived behavioral issues in the classroom. Possible risk factors include lower cognitive ability, right ear hearing loss, and severe-to-profound hearing loss. Speech and language development may be delayed in some children with UHL, but it is unclear if children "catch up" as they grow older. Research into this area is necessary to clarify the following and other important issues: (1) Which children are at risk for speech and language delays? (2) Which children are at risk for poor educational performance and behavioral problems in school? (3) Is UHL the major culprit in the speech-language and school-related problems these children have, or are there unmeasured cognitive and other factors associated with UHL that actually put these children at risk for problems? (4) Is amplification or any other intervention helpful in preventing speech and language delay, or educational problems in school? (5) What is the rate of hearing impairment in the normal-hearing ear, and what is the rate of hearing loss progression in the affected (poorer) ear? (6) Is genetic testing for etiology or susceptibility to hearing loss helpful in determining which children will have more difficulty coping with UHL?

In the absence of clear indicators that can predict which children with UHL will experience speech and language delay, or have educational and/or behavioral problems school, it may be helpful to consider the child with UHL in the same context as a child with a mild to moderate bilateral hearing loss. The following suggestions for management may help parents, educators, audiologists, and physicians to help children with UHL before problems arise:

- Manage recurrent otitis media and chronic otitis media with effusion aggressively to minimize further impairment of hearing in the affected ear, or hearing loss in the normal ear.
- Evaluate the etiology of UHL in the same manner as one would for a bilateral hearing loss. In newborns identified soon after birth, consider cytomegalovirus testing.
- Obtain ophthalmologic evaluation to rule out associated sensory syndromes, and to ensure the child has optimal vision to enable him or her to use visual cues when hearing conditions are less than optimal.
- Communicate with audiologists so that they understand physicians' and parents' concerns about speech and language development and school performance. They may not be familiar with the recent literature on UHL in children.
- Consider amplification, whether with FM systems, hearing aids, CROS aids, or bone conduction aids, especially if a child is showing any signs of speech-language delay, or struggling in school or in social interactions. The device chosen should be tailored to the needs of the individual child.
- Consider enrolling newborns into early intervention programs, and following them up with routine speech-language evaluations in early childhood prior to entering school.
- In school-age children, consider screening them for educational problems at routine intervals.
- Obtain follow-up audiograms on at least an annual basis to monitor for progression of hearing loss, and repeat audiograms if any change in hearing is suspected.

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REFERENCES

- Bess FH, Tharpe AM. Unilateral hearing impairment in children. *Pediatrics*. 1984; 74:206-216.
- Giolas TG, Wark DJ. Communication problems associated with unilateral hearing loss. *J Speech Hear Disord*. 1967;32:336-343.
- Newman CW, Jacobson GP, Hug GA, Sandridge SA. Perceived hearing handicap of patients with unilateral or mild hearing loss. *Ann Otol Rhinol Laryngol*. 1997;106:210-214.
- Kiese-Himmel C. Unilateral sensorineural hearing impairment in childhood: analysis of 31 consecutive cases. *Int J Audiol*. 2002;41:57-63.
- Sedey AL, Carpenter K, Stredler-Brown A. *Unilateral Hearing Loss: What Do We Know, What Should We Do?* Presented at: National Symposium on Hearing in Infants. August 1, 2002; Breckenridge, Colo.
- Peckham CS, Sheridan MD. Follow-up at 11 years of 46 children with severe unilateral hearing loss at 7 years. *Child Care Health Dev*. 1976;2:107-111.
- Klee TM, Davis-Dansky E. A comparison of unilaterally hearing-impaired children and normal-hearing children on a battery of standardized language tests. *Ear Hear*. 1986;7:27-37.
- Cozad RL. Speechreading skill and communication difficulty of children and young adults with unilateral hearing loss. *J Aud Res*. 1977;17:25-29.
- Borg E, Risberg A, McAllister B, et al. Language development in hearing-impaired children: establishment of a reference material for a "Language test for hearing-impaired children", LATHIC. *Int J Pediatr Otorhinolaryngol*. 2002;65:15-26.
- Brookhouser PE, Worthington DW, Kelly WJ. Unilateral hearing loss in children. *Laryngoscope*. 1991;101(12, pt 1):1264-1272.
- Bovo R, Martini A, Agnoletto M, et al. Auditory and academic performance of children with unilateral hearing loss. *Scand Audiol Suppl*. 1988;30:71-74.
- Tieri L, Masi R, Ducci M, Marsella P. Unilateral sensorineural hearing loss in children. *Scand Audiol Suppl*. 1988;30:33-36.
- Bess FH, Tharpe AM. Case history data on unilaterally hearing-impaired children. *Ear Hear*. 1986;7:14-19.
- Hallmo P, Moller P, Lind O, Tonning FM. Unilateral sensorineural hearing loss in children less than 15 years of age. *Scand Audiol*. 1986;15:131-137.
- Stein DM. Psychosocial characteristics of school-age children with unilateral hearing loss. *J Acad Rehabil Audiol*. 1983;16:12-22.
- Culbertson JL, Gilbert LE. Children with unilateral sensorineural hearing loss: cognitive, academic, and social development. *Ear Hear*. 1986;7:38-42.
- Oyler RF, Oyler AL, Matkin ND. Unilateral hearing loss: demographics and educational impact. *Lang Speech Hear Serv Schools*. 1988;19:201-210.
- Hartvig Jensen J, Borre S, Johansen PA. Unilateral sensorineural hearing loss in children: cognitive abilities with respect to right/left ear differences. *Br J Audiol*. 1989;23:215-220.
- Dancer J, Burl NT, Waters S. Effects of unilateral hearing loss on teacher responses to the SIFTER: Screening Instrument for Targeting Educational Risk. *Am Ann Deaf*. 1995;140:291-294.
- Keller WD, Bundy RS. Effects of unilateral hearing loss upon educational achievement. *Child Care Health Dev*. 1980;6:93-100.
- Ito K. Can unilateral hearing loss be a handicap in learning? *Arch Otolaryngol Head Neck Surg*. 1998;124:1389-1390.
- Widen JE, Folsom RC, Cone-Wesson B, et al. Identification of neonatal hearing impairment: hearing status at 8 to 12 months corrected age using a visual reinforcement audiometry protocol. *Ear Hear*. 2000;21:471-487.
- Everberg G. Etiology of unilateral total deafness. *Ann Otol Rhinol Laryngol*. 1960; 69:711-730.
- Niskar AS, Kieszak SM, Holmes A, Esteban E, Rubin C, Brody DJ. Prevalence of hearing loss among children 6 to 19 years of age: the Third National Health and Nutrition Examination Survey. *JAMA*. 1998;279:1071-1075.
- Barsky-Firsker L, Sun S. Universal newborn hearing screenings: a three-year experience. *Pediatrics* [serial online]. 1997;99:E4.
- Finitzo T, Albright K, O'Neal J. The newborn with hearing loss: detection in the nursery. *Pediatrics*. 1998;102:1452-1460.
- Mehl AL, Thomson V. Newborn hearing screening: the great omission. *Pediatrics* [serial online]. 1998;101:E4.
- Bess FH, Tharpe AM. An introduction to unilateral sensorineural hearing loss in children. *Ear Hear*. 1986;7:3-13.
- Humes LE, Allen SK, Bess FH. Horizontal sound localization skills of unilaterally hearing-impaired children. *Audiology*. 1980;19:508-518.
- Nozza RJ, Wagner EF, Crandell MA. Binaural release from masking for a speech sound in infants, preschoolers, and adults. *J Speech Hear Res*. 1988;31:212-218.
- Bess FH, Tharpe AM, Gibler AM. Auditory performance of children with unilateral sensorineural hearing loss. *Ear Hear*. 1986;7:20-26.
- Hartvig JJ, Johansen PA, Borre S. Unilateral sensorineural hearing loss in children and auditory performance with respect to right/left ear differences. *Br J Audiol*. 1989;23:207-213.
- Bamiou DE, Savy L, O'Mahoney C, Phelps P, Sirimanna T. Unilateral sensorineural hearing loss and its aetiology in childhood: the contribution of computerized tomography in aetiological diagnosis and management. *Int J Pediatr Otorhinolaryngol*. 1999;51:91-99.
- Williamson WD, Demmler GJ, Percy AK, Catlin FI. Progressive hearing loss in infants with asymptomatic congenital cytomegalovirus infection. *Pediatrics*. 1992; 90:862-866.
- Bess FH. The unilaterally hearing-impaired child: a final comment. *Ear Hear*. 1986; 7:52-54.
- Schlaggar BL, Brown TT, Lugar HM, Visscher KM, Miezin FM, Petersen SE. Functional neuroanatomical differences between adults and school-age children in the processing of single words. *Science*. 2002;296:1476-1479.
- Feuerstein JF. Monaural versus binaural hearing: ease of listening, word recognition, and attentional effort. *Ear Hear*. 1992;13:80-86.
- Nia J, Bance M. Effects of varying unilateral conductive hearing losses on speech-in-noise discrimination: an experimental study with implications for surgical correction. *Otol Neurotol*. 2001;22:737-744.
- Moeller MP. Early intervention and language development in children who are deaf and hard of hearing. *Pediatrics* [serial online]. 2000;106:E43.
- Geers AE. Predictors of reading skill development in children with early cochlear implantation. *Ear Hear*. 2003;24(1 suppl):59S-68S.
- Kenworthy OT, Klee T, Tharpe AM. Speech recognition ability of children with unilateral sensorineural hearing loss as a function of amplification, speech stimuli and listening condition. *Ear Hear*. 1990;11:264-270.
- Uptdike CD. Comparison of FM auditory trainers, CROS aids, and personal amplification in unilaterally hearing impaired children. *J Am Acad Audiol*. 1994;5:204-209.
- McKay S. To Aid or Not to Aid: Children With Unilateral Hearing Loss. Healthy Hearing. 7-29-2002, Audiology Online, Inc. Available at: http://www.healthyhearing.com/healthyhearing/newroot/articles/arc_disp.asp?id=156&catid=1053. Accessed May 6, 2003.