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Consequences of Unilateral Sensory Neural Hearing Loss

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Abstract

This article will review most important consequences of unilateral hearing loss especially on speech and language, binaural advantages, speech understanding in noise, educational, behavioral and intellectual functions. In this paper controversies about intervention in unilateral hearing loss are discussed.

Keywords: Unilateral hearing loss; Binaural hearing; Speech in noise

Abbreviations: SNHL: Severe to Profound Hearing Loss; UHL: Unilateral Hearing Loss; BHL: Bilateral Hearing Loss; SNR: Signal-To-Noise Ratio; WRS: Word Recognition Scores; WISC: Wechsler Intelligence Scale for Children; FM: Frequency Modulation; CROS: Contralateral Routing of signals; BAHA: Bone-Anchored Hearing Aid

Introduction

Prevalence of unilateral hearing loss

The incidence of severe to profound hearing loss (SNHL) in children is about 1:2000 at birth and 6:1000 by 18 years of age [1,2]. Unilateral hearing loss (UHL) in children affects 0.4 to 34 per 1000 neonates and 1 to 50 per 1000 school-aged children [3]. Although these numbers indicate that SNHL is relatively prevalent, it remains highly underdiagnosed in children. Unilateral severe to profound hearing loss often remains unrecognized until pre-school age, when the child undergoes the first audiometric screening [1,2].

Prior to universal newborn hearing screening programs, children with UHL were often undetected until they entered school and underwent hearing screenings unless they had other medical problems that led to an early hearing screening [4,5]. Moreover, although bilateral hearing loss (BHL) in children will cause speech-language delays and academic, the effects of UHL on a child's speech-language development and academic achievement have not been well documented. This is another reason for late diagnosis of UHL [3].

Effects of unilateral hearing loss on speech and language

In the 1960s, it was thought that UHL has minor effects (if any) on auditory function and language. Back then parents were informed about dangers of poor sound localization (e.g. in crossing the street) and about protecting healthy ear (e.g. avoiding from loud noises and treating ear infection) [6]. In present time, there is information about the effects of UHL on the acquisition of speech and language skills in children [4]. Kiese-Himmel reported that in UHL 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 was 23.5 months (range: 18 – 48 months). Although the age of utterance of the first word was not delayed, the average age of the first 2-word phrase was delayed about 5 months [6,7]. Kiese-Himmel maintained that there was not any serious verbal cognitive function limitation in children with UHL. It seems that the effects of UHL on language are greater in children with congenital UHL (early-onset). Therefore the degree of hearing loss and its' onset time are determining [6]. In one longitudinal study on school-aged children, 44 children with severe UHL at 7 and 11 years of age were evaluated. Although these children had a higher proportion of speech difficulties, only 4 children still had poor speech intelligibility at age of 11 years old, and their reading scores were similar to their normal-hearing students [8].

Effects of unilateral hearing loss on binaural advantages

Studies of children and adults with asymmetric binaural hearing loss (BHL) have shown that sound localization and speech discrimination are more difficult than in subjects with the symmetric binaural hearing loss [3,9]. Therefore, a person with UHL may also experience difficulty with sound localization or speech discrimination [3]. In fact, most important acoustical problem related to UHL is losing binaural hearing advantages [6]. The physiologic advantage of having two normally hearing ears over one normal ear alone has been documented in multiple studies. These advantages can be binaural summation, the head shadow effect, sound localization, and binaural release from masking [4]. Sound localization in the horizontal plane is dependent on binaural cues including interaural time and intensity differences (ITDs and ILDs). Several investigators have demonstrated that children with UHL make more errors on sound localization tests than children with normal hearing [4].

Binaural release from masking refers to the improvement in detecting a signal in the presence of background noise when two ears hear the presented sounds in comparison to only one ear. This is the basis for the «cocktail party effect». For a pure-tone signal at 500 Hz, the advantage of two ears is about 12 to 15 dB. This advantage for speech signals can be around 3 to 8 dB. In general, even in normal hearing subjects, infants and young children require a greater signal-to-noise ratio (SNR) than adults to identify speech in the presence of masking noise, so children with UHL may experience more difficulty with understanding speech in noise than adults with UHL [4]. Studies show that ease of listening and word recognition scores (WRS) during the monaural hearing is poorer than binaural hearing and it is affected by ear orientation in relation to direction of speech signal (sound source) [10]. Several studies have documented that children with UHL have more difficulty with speech discrimination in noise compared with normal-hearing peers, especially in less than optimal listening conditions (conditions where speech has the same or less intensity than the background noise) [4,9]. The children with UHL generally require a greater SNR to understand speech than their normal-hearing children. This might affect their performance in school, where the poor SNR can mask a teacher's voice. Children with UHL show great variability in speech understanding in noise [4].

Effects of unilateral hearing loss on education and social behavior

Several studies from the 1980s and 1990s have suggested that children with UHL may have educational and behavioral problems, compared with their normal-hearing peers [3,4]. The recent studies suggest that children with UHL show delays in educational and academic progress and may manifest some behavioral difficulties [11]. A study showed that high proportion of children with UHL have difficulty in school: 22% to 35% repeated at least one grade, and 12% to 41% received additional educational assistance [4]. Some studies revealed that approximately one-third of the children with the UHL had failed at least one grade [9]. 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. Since the left cerebral hemisphere is more commonly dominant for language processing, a right UHL may have a greater impact on central perception and processing of speech than a left UHL. Each of the risk factors mentioned may affect the maturation of functional neuroanatomical pathways during child development [4].

Studies in adults have suggested that those with UHL have communication problems that usually overlooked [4]. Adults with UHL have expressed negative psychosocial effects of UHL, such as decreased quality of life; feelings of frustrations, embarrassment, and annoyance; and increased hearing handicap [3]. In one study on subjects from 30 to 55 years old, suffering from sensorineural UHL since early childhood, superiority of binaural hearing over the monaural hearing was confirmed. This superiority was clearly demonstrated in psycho-acoustical performance in sound localization, speech recognition in noise, and appreciation of music. However, educational, social and employment achievement did not show any significant difference between binaurally and monaurally hearing subjects [11]. In conclusion, it seems that an early-onset UHL (PTA more than 44 dB in 500, 1000 and 2000 HZ) has negative effects on academic achievements, education, and behavior [6]. However variables related to the child, family, and socioeconomic status, other than the hearing loss itself, may impact speech and language development, reading competence, and educational achievement [4].

Effects of unilateral hearing loss on intellectual abilities

Speech processing centers are usually located in the left hemisphere and the perception is connected with the opposite ear. It means that the right ear is dominating in the perception of speech sounds. This has been confirmed by Kimura with the dichotic listening technique. When any of the senses (like hearing) gets impaired there is a disorder in information contact between peripheral and central systems and this affects correct intellectual development [12].

In children with UHL, general intelligence level does not differ from the intelligence of children with normal hearing. However, the side of the hearing loss is very important. The right ear hearing loss results in the deterioration of the verbal intelligence level. The children with right-sided hearing loss have a poorer scope of concepts, lower ability to learn the verbal material and logical thinking, abstract thinking and classifying [12]. Hartvig showed that children with left ear UHL perform more poorly on Wechsler Intelligence Scale for Children (WISC) verbal subtest digit span. This subtest is sensitive to minor auditory processing damage [13]. Moreover, the left ear hearing loss results in deterioration of intellectual skills within non-verbal intelligence. These children have lower abilities to analyze, synthesize and visual memory, poorer spatial imagination, worse visual-motor coordination [12].

Intervention

Unlike for children with BHL, who are routinely fitted with hearing aids and receive rehabilitation, children with UHL may not be considered to have a significant hearing loss and usually it is thought that UHL is not sufficient to interfere with speech or language development. Recommended interventions for children

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with UHL usually include preferential seating in class and a Frequency Modulation (FM) system that amplifies the teacher's voice relative to the background noise. FM systems help children with UHL considerably (1). Preferential seating in the classroom is recommended but this strategy does not provide many benefits if the teacher moves about the classroom [6]. A few small studies have addressed the issue of which form of amplification is preferable in children with UHL. Kenworthy et al examined the use of Contralateral Routing of signals (CROS) aids or FM systems. They found that only the FM system produced high speech recognition scores in all the listening conditions tested (monaural direct, monaural indirect, and omnidirectional). With the conventional hearing aid and CROS aid, speech recognition decreased in noise. Only FM systems could result in speech recognition scores improvements in both quiet and noise [4,6]. They suggested that children with severe to profound UHL benefit more from FM than CROS both in quiet and in noise [6].

Kiese-Himmel in 2002 showed that traditional amplification may be successful with UHL if the hearing sensitivity of two ears is not significantly different. When there was severe to profound UHL, children did not benefit from hearing aid and did not accept the device [6]. Other studies show that Bone-anchored hearing aid (BAHA) on the side of deaf ear provides more benefit than CROS amplification. This advantage may be due to not interfering with speech reception in the better ear (unlike CROS aids) [14]. A study on three children with non-congenital UHL showed that cochlear implantation can be beneficial in UHL. They showed that one year after cochlear implant, children showed better speech understanding in noise, sound localization, and listening abilities. Therefore, cochlear implant can be an option to restore binaural hearing for children with severe to profound UHL [15].

In children with UHL following considerations are important: Manage recurrent otitis media and chronic otitis media with effusion, evaluate the etiology of UHL (e.g. cytomegalovirus that can be progressive), obtain an ophthalmologic evaluation (visal cues are important for the child), consider amplification (FM systems, hearing aids, or CROS aids especially in case of speech-language delay or academic problems), engaging in early intervention programs in infants, educational evaluation in school-aged children, routine hearing evaluations on at least an annual basis to monitor for progression of hearing loss [4].

Conclusion

Although a significant proportion of children with UHL may have some problems with education and learning, others do not. Thus, determining who is at risk for educational difficulties related to the UHL is important for in time intervention. It is important that audiologists, speech-language pathologists, and educators evaluate these children carefully and if necessary start suitable intervention. This can lead to meaningful improvement in their educational progress and psychosocial well-being.

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