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Differences and similarities in early vocabulary development between children with hearing aids and children with cochlear implant enrolled in 3-year auditory verbal intervention

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ABSTRACT

Objective: The overall objective of this study was to evaluate the implementation of a Nordic Auditory Verbal (AV) intervention for children with all degrees and types of hearing impairment (HI) using all kinds of hearing technology. A first specific objective was to identify differences and similarities in early vocabulary development between children with cochlear implant (CI) compared with children with hearing aids (HAs)/Bone anchored hearing aids (Bahs) enrolled in a 3-year AVprogram, and to compare the group of children with HI to a control group of children with normal hearing (NH). A second specific objective was to study universal neonatal hearing screening (UNHS) using the 1-3-6 Early Hearing Detection and Intervention (EHDI) guidelines.
Introduction: Effect of AV intervention for children with HI using different hearing technology is not thoroughly studied. It is relevant to question, whether children with mild to moderate HI encounter the same intensive need for AV intervention as children with congenital deafness.
Methods: A longitudinal and comparative study design was used involving two cohorts of children, i.e. 36 children with CI and 19 children with HA/Bahs. The children were the first in Denmark to receive a 3-year AV intervention by formally trained AV-practitioners. Children were tested annually with standardized speech and language tests, i.e. Peabody Picture Vocabulary test, Reynell test and a Danish test for active vocabulary, Viborgmaterialet. Categorical variables were compared using Fischer's exact test and continuous variables were compared using Wilcoxon-Mann-Whitney test, as data was not normally distributed.
Results: Median age of diagnosis was 6 months and median age at intervention was 13 and 12 months respectively. There was no statistically significant difference between the two groups in terms of scores according to age equivalency for the three tests. However, there was a significant difference between children with HI regardless of hearing technology and children with NH.
Conclusion: Children with HI progressed over a three-year period, but they did not reach the same level as children with NH. The high completion rate of 98,2% of families over a three-year period indicates the relevance of AV practice in a Nordic country. Children were diagnosed later than 3 months and intervention also started later than recommended. A result that warrants further investigation.

1. Introduction

In Denmark, the National Board of Health recommends basing the initial first year post implant on the principles from auditory verbal (AV) practice [1]. The National Board of Social Affairs recommends the use of AV practice in the (re)habilitation used for children with hearing impairment (HI) using all kinds of hearing technology [2]. Annually 150 children are born with bilateral HI requiring treatment with hearing technology in Denmark and between 35 and 45 of these children are candidates for CI [1,2]. The AV practice is an educational intervention specifically targeted children with HI regardless of degree of HI and type of hearing device. AV practice underlines the importance

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of parents and professionals working closely in partnership and makes use of specific techniques and strategies to develop and grow the child's auditory cortex toward the preferred listening and spoken language outcomes. No other educational approach is as specifically described and targeted children with HI and their families and AV practice is defined as a family-centred approach and an applied science with its objectively measured goals [3]. Effects of AV intervention have been documented in several studies [4–6] with a clear benefit in terms of listening and spoken language outcomes for children and families enrolled in AV intervention as compared to programs with an oral-aural or sign supported approach. However, the effect of AV intervention for children with HI using different hearing technology, i.e. hearing aids (HA), cochlear implants (CI), Bone anchored hearing systems (Bahs), auditory brainstem implant (ABI), is not thoroughly studied. It is relevant to question, whether children with moderate HI, using HAs/Bahs encounter the same intensive need for AV intervention as children with congenital deafness using CI/ABI. This study investigated differences and similarities in early vocabulary development in two groups of children using different hearing technology, when all children were enrolled for a 3-year AV program.

The Nordic countries provide an interesting research arena in terms of investigating impact of pediatric HI as universal neonatal hearing screening (UNHS) was implemented from 2005 countrywide and because the influence of socioeconomic factors is minimized as intervention with bilateral hearing technology is offered to all candidates regardless of socioeconomic status. However, listening and spoken language outcomes for children using HA/Bahs are not thoroughly studied in the Nordic countries and until this study no larger studies have investigated outcomes for this pediatric group since introduction of UNHS. Research in the Nordic countries has focused on outcome for children with CI [7–9]. Hence, an assessment of the UNHS is lacking and it is relevant to study to what extent a Nordic country lives up to the three components of Early Hearing Detection and Intervention (EHDI) guidelines which recommends hearing screening by one month, diagnosis of hearing loss by 3 months and intervention by 6 months. Intervention is defined as both technical i.e. by fitting of HAs and educational, i.e. providing guidance to parents in early communication with a baby with HI [10].

2. Objectives

The overall objective of the AV project was to evaluate the implementation of a Nordic AV intervention at preschool level for children with all degrees and types of HI using all kinds of hearing technology. To ensure a representative population, children with a diagnosed additional disability were included. The first specific objective was to identify differences and similarities in early vocabulary development between children with CI compared with children with HA/Bahs, when all children were enrolled in a 3-year AV-program, and to compare the whole group of children with HI to a control group of children with NH. A second specific objective was to study universal neonatal hearing screening (UNHS) using the 1-3-6 Early Hearing Detection and Intervention (EHDI) guidelines.

3. Materials and methods

A longitudinal and comparative study design was used involving a total of 55 children with HI. The children represented two cohorts consisting of 36 children with bilateral CI (one child was bimodal, i.e. CI on one ear and HA on the other ear) and 19 children with bilateral HA/Bahs. No children with ABI participated. All children had bilateral HI. Information on the hearing threshold levels (HTL) of the children with HA/Bahs was retrieved from medical files and all children had moderate HTLs, i.e. 41–70 dB. In Denmark children are offered CI, when HTLs are above 80 dB HL [1]. Children were born between 2009 and 2013 and were between 0 and 4 years of age at the start of project in September 2013. All children with CI came from one of the two pediatric CI centres in Denmark and all children with HA/Bahs were enrolled at the two major audiological clinics in Denmark, i.e. university hospitals in Copenhagen and Århus. AV intervention involved attending AV sessions every other week, monthly or every other month depending on the child's and the family's individual progress. AV practice was carried out by speech and language pathologists, who were either certified AV practitioners or who had completed the 3-year AV education provided by the AG Bell Academy for Listening and Spoken Language [11]. The 55 children were the first in Denmark to receive a 3-year AV intervention by formally trained AV-practitioners. Children were tested and assessed annually with standardized speech and language tests and assessments. Trial registration was not relevant as the study constituted prospective case series.

In both cohorts, all parents were normally hearing (NH). Parents completed a questionnaire stating their educational background, the child's diagnosis, any additional disability, the time of diagnosis and the time of intervention with hearing technology. The diagnostic data from parents were also retrieved and checked from the child's medical file. The etiologies of the HI were retrieved from the medical file and from parents' questionnaire and were divided into four etiology groups: Degeneratio Labyrinthi Acustici (DLA) congenita hereditaria, DLA congenita non specificata, DLA congenita postinfectiosa and other, i.e. auditory neuropathy and meningitis. Children with additional disabilities were included to ensure representative populations. Some children were diagnosed with more than one additional disability, i.e. autism problems and epilepsy. A total of 12 children (22%) was diagnosed with additional disability and distribution between the two groups of children was not significant. The additional disabilities were as follows: mental retardation (N = 6), cerebral palsy (N = 2), autism (N = 2), microcephaly (N = 1), epilepsy (N = 1). Table 1 shows the distribution of participants in terms of age of diagnosis, age and distribution of technical intervention, i.e. age at implantation of CI or fitting of HA/Bahs, etiology, gender, hearing device, additional disability and parent's education. There was no significant difference between the etiology groups and appearance of an additional disability, gender and hearing device. A control group of 59 children with NH were carried out in a cross-sectional study design. The children with NH

Table 1
Characteristics of CI and HA/Bahs recipients.

	Total (n = 55)	CI (n = 36)	HA/Bahs (n = 19[a])
Median age at diagnosis (months)	6	6	6
Median age at CI-implant/HA/Bahs (months)	12	12	13
Gender			
Boy	34 (62%)	20 (56%)	14 (74%)
Girl	21 (38%)	16 (44%)	5 (26%)
Maternal education			
< 13 years	6 (11%)	5 (14%)	1 (5%)
> 13 years	49 (89%)	31 (86%)	18 (95%)
Paternal education			
< 13 years	11 (21%)	8 (22%)	3 (16%)
> 13 years	41 (79%)	27 (75%)	14 (74%)
Missing	3 (5%)	1 (3%)	2 (11%)
Etiology			
Cong non specificata	26 (47%)	16 (44%)	10 (53%)
Cong hereditaria	17 (31%)	9 (25%)	8 (42%)
Congenita postinfectiosa	9 (16%)	8 (22%)	1 (5%)
Other	3 (5%)	3 (8%)	0 (0%)
Additional disabilities			
Yes	12 (22%)	7 (19%)	5 (26%)
No	45 (78%)	29 (81%)	16 (74%)
Bilateral/bimodal			
Bilateral	54 (98%)	35 (97%)	19 (100%)
Bimodal	1 (2%)	1 (3%)	0 (0%)

[a] N = 3 (16%) of the children had Bahs.