International Journal of Pediatric Otorhinolaryngology 101 (2017) 81–86

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: http://www.ijporlonline.com/

Speech processor data logging helps in predicting early linguistic outcomes in implanted children

Letizia Guerzoni*, Domenico Cuda

Department of Otorhinolaryngology, "Guglielmo da Saliceto" Hospital, Via Cantone del Cristo 40, 29121 Piacenza, Italy

ARTICLE INFO

Article history:
Received 21 May 2017
Received in revised form
17 July 2017
Accepted 19 July 2017
Available online 25 July 2017

Keywords:
Cochlear implant
Language development
Data logging
Listening environment

ABSTRACT

Objective: To analyse the value of listening-data logged in the speech processor on the prediction of the early auditory and linguistic skills in children who received a cochlear implant in their first 2 years of life.
Study design: Prospective observational non-randomized study.
Methods: Ten children with profound congenital sensorineural hearing loss were included in the study. The mean age at CI activation was 16.9 months (SD ± 7.2; range 10–24). The auditory skills were evaluated with the Infant Toddler Meaningful Inventory Scale and the Category of Auditory Performance. Lexical level was assessed with the MacArthur-Bates Communicative Development Inventory.
The overall data of average daily use and acoustic scene-analyses were extracted from Data Logging system.
The effect of the one-year cumulative listening time to speech (in quiet) and speech-in-noise on the auditory and lexical scores was analysed.
Results: A significant positive correlation was found between speech in quiet exposure time at low loudness level (<70 dB) and lexical quotient after one year of CI use. Infant Toddler Meaningful Inventory Scale was negatively correlated with the highest speech-in-noise loudness levels (>80 dB). The Category of Auditory Performance was not related to the logged data.
Conclusion: The listening environment can influence the early functional outcomes in younger implanted children. In this perspective, the data logging system is a promising tool in predicting early linguistic and auditory outcomes.

1. Introduction

The cochlear implant (CI) is a well-established effective treatment for severe-to-profound hearing loss in very young children [1,2]. Most children who receive a CI between 12 and 24 months of life develop skills similar to those of normal hearing peers in many domains of language [3–9]. However, a large variability in outcomes is usually observed [10,11]. Different factors potentially affect language development, such as age at diagnosis, degree of hearing loss, cognitive ability, additional disabilities, consistency of hearing device use and parental involvement [12–14]. Moreover, children need to be exposed to spoken communication so that they can listen and consequently develop speech and language skills [15–17]. Risley and Hart [18] demonstrated that normal hearing children need to hear approximately 21,000 words per day to achieve adequate levels of vocabulary. The acoustic environment characteristics, quiet or noisy, can also influence the development of language in implanted children; although the new technology of speech processors is increasingly sophisticated and promotes the achievement of good performance in speech recognition in quiet, speech understanding in noise remains challenging for most CI users [19,20]. Unfortunately, the amount of exposure to language and acoustic environment in real-life settings are difficult to objectify. The data logging implemented in the new generation of speech processors might help to analyse these aspects. Data logging systems are in fact capable of tracking information about the acoustic environment in which the device is worn. To our knowledge, there are no studies to date that have made use of these systems to investigate the different listening environments and their effect on the functional development of implanted children.

The present study aimed to analyse the value of the listening environment logged in the speech processor in predicting the early auditory and linguistic skills of children with severe-to-profound

* Corresponding author. Tel.: +39 3478555980.
E-mail address: guerzoni1@libero.it (L. Guerzoni).

http://dx.doi.org/10.1016/j.ijporl.2017.07.026

sensorineural hearing loss (SNHL) who received a cochlear implant in their first 2 years of life.

2. Materials and methods

2.1. Study design

This is a prospective observational, non-randomized, study. All parents signed an informed consent form. The study design and subject recruitment were in accordance with local ethics committee requirements.

2.2. Subjects

Ten children with profound congenital SNHL were included in the study. The children were followed-up at the "Guglielmo da Saliceto" Hospital CI program in Piacenza, Italy. The sample included implanted patients who fulfilled the following criteria: 1) 12 months of CI experience; 2) CI activation within 2 years of age; 3) device use throughout awake times; 4) inclusion in an auditory-verbal therapy (AVT) rehabilitation program; 5) normal hearing parents and 6) a monolingual Italian-speaking family. The following exclusion criteria were adopted: 1) evidence of inner ear malformation on high-resolution computed tomography (CT) scan and magnetic resonance imaging (MRI); 2) significant visual or motor problems that may interfere with speech and language development; 3) neurodegenerative disorders and 4) syndromes associated with psychological, development or physical disorders. Table 1 summarizes the sample characteristics.

The etiology of deafness was unknown in 4 subjects; a connexin-26 mutation was found in the other 6 subjects. The mean age at SNHL identification was 4.9 months (DS ± 3.9; range 2–17). Mean age at amplification was 5.4 months (DS ± 4.6; range 3–18). Amplification was given according with the best practice. Hearing loss was assessed using the click-evoked and tone-bursts-evoked auditory brainstem response. Depending on the age at amplification or during the follow-up behavioural threshold was obtained optimizing the HA fitting. All children were enrolled in an auditory-verbal program within 2 months of diagnosis. The VRA thresholds here reported were collected just before surgery at a mean age of 15.5 months (range 9–23; SD ± 3.7). The mean threshold across frequencies (0.5, 1, 2, and 4 kHz) was 104.9 dB HL (SD ± 12.5) on the implanted ear and 105.8 dB HL (SD ± 12.6) on the contralateral side. Most children had a symmetrical hearing loss. All children received a Nucleus 6 (Cochlear LTD, Sydney, Australia) CP 920 sound processor with a CI24RE series cochlear implant. The mean age at CI activation was 16.9 months (DS ± 7.2; range 10–24). Seven children wore a hearing aid on the unimplanted ear; 3 children wore a unilateral CI.

Table 1
Characteristics of the sample.

Characteristics	Mean (standard deviation); Range
Age at diagnosis (mo.)	4.9 (±3.9); 2–17
Age at first amplification (mo.)	5.4 (±4.6); 3–18
Age at cochlear implant activation (mo.)	16.9 (±7.2); 10–24
Age at 12th months of follow-up (mo.)	28.9 (±7.2); 20–36
Stimulation modality	
Bimodal (CI + HA)	7
Unilateral cochlear implant	3
Gender	
Male	6
Female	4
Etiology	
CX26	6
Unknown	4

2.3. Measure of auditory skills

The auditory skills were evaluated using the Infant Toddler Meaningful Inventory Scale (IT-MAIS) [21] and the Category of Auditory performance (CAP) [22]. The IT-MAIS is a parent report that investigates children's spontaneous listening behaviours in everyday situations. The IT-MAIS includes 10 items that cover different auditory skills grouped in three areas: changes in vocalizations (items 1 and 2), alerting to sounds in everyday situations (items 3–6), and deriving meaning from sounds (items 7–10). Answers are scored on a five-point scale that ranges from "never" (0) to "regularly" (4). The maximum score in the original version is 40. The mean IT-MAIS raw score of children sampled in the present study was 34.0 (SD ± 2.9; range: 30–38). The CAP is a worldwide used protocol that categorizes everyday auditory performance on a numerical scale; it ranges from 0 ("displays no awareness of environmental sounds") to 7 ("can use the telephone with a familiar talker"). The mean CAP in the present sample was 4.7 (SD ± 0.7; range: 4–6), which means that the children understood words and common phrases without lip-reading. All enrolled children exclusively used oral communication with parents.

2.4. Measure of lexical skills

Lexical level was assessed using the MacArthur-Bates Communicative Development Inventory (MCDI) [23] Italian edition [24] Words and Sentences form. The MCDI is a widely recognized parent report tool that assess children's early language skills development for clinical and research purposes. The Words and Sentences form is available for children ranging from 18 to 36 months of age. This form assesses the vocabulary production of words and phrases, grammatical development, and the length of sentences. The scores at the vocabulary section were analysed in the present study. This section is a 680-word vocabulary production checklist. The normal scores ranged between 65 and 597 (mean 326) [24] for NH subjects within the same chronological age range of the implanted children included in the study.

2.5. Data logging

The Data logging system of the CI Nucleus 6 sound processor scans the acoustic environment by analysing the frequency spectrum of microphone input signals. It classifies the sound environments into one of six scenes (Speech, Speech in Noise, Music, Quiet, Noise and Wind). Each environment is then divided into 6 subcategories of Loudness (Less Than 40 dB SPL, 40–49 dB SPL, 50–59 dB SPL, 60–69 dB SPL, 70–79 dB SPL, Greater than or Equal to 80 dB SPL). The daily exposure time to different acoustic scenes was extracted at every mapping session; one year's use data were then cumulated.

The scores of CAP, IT-MAIS and MCDI detected after 12 months of CI-use were compared with cumulative time of exposure to two auditory scenes: speech (in quiet) and speech-in-noise.

2.6. Procedure of administration

Children were evaluated after 1 year of CI experience to reduce the influence of confounding variables. The mean age at testing was 28.9 months (DS ± 7.2; range 20–36). The same speech-language therapist administered the It-Mais and MCDI questionnaires and categorized the auditory performance of the child with the CAP scoring system. The questionnaires and related instructions were