

AUDIOLOGY

Newborn hearing screening in the Campania region (Italy): early language and perceptual outcomes of infants with permanent hearing loss

Screening uditivo neonatale nella regione Campania (Italia): sviluppo delle prime competenze percettive e linguistiche nei bambini con deficit permanente dell'udito

E. MARCIANO¹, C. LARIA¹, R. MALESCI¹, P. IADICICCO¹, E. LANDOLFI¹, C. NIRI¹, C. PAPA¹, A. FRANZÈ^{2,3}, G. AULETTA¹

¹ Department of Neurosciences, University of Naples "Federico II", Naples, Italy; ² CEINGE- Biotecnologie Avanzate, Naples, Italy; ³ Institute of Genetics and Biophysics "A. Buzzati Traverso", CNR, Naples, Italy

SUMMARY

Hearing loss in children causes a deficit in early perceptive and language skills. The objective of this study was to evaluate early receptive and expressive language outcomes in children with hearing loss, identified by hearing screening, compared to the time of diagnosis. We studied 18 severely hearing impaired children who were divided into two groups according to the time of diagnosis. Evaluation of communicative language ability was carried out at 18 month of age using the "MacArthur Child Development Inventory" questionnaire, while evaluation of acoustic-perceptual abilities was assessed with the Genovese-Arslan protocol every three months following diagnosis. The linguistic communicative and acoustic-perceptual outcomes of hearing impaired children diagnosed before 6 months of age followed those expected for normally hearing children, with a trend of temporal progression of skills that were faster than those of children diagnosed after 6 months of age.

KEY WORDS: Newborn hearing screening • Neurosensorial hearing loss • Linguistic communicative and acoustic-perceptual outcomes

RIASSUNTO

L'ipoacusia neurosensoriale nel bambino è una delle principali cause del mancato sviluppo delle prime competenze percettivo linguistiche. Lo scopo di questo studio è quello di valutare lo sviluppo linguistico recettivo ed espressivo nei bambini con disturbi permanenti dell'udito, identificati attraverso un percorso di screening uditivo, in base all'epoca di diagnosi. Abbiamo studiato 18 bambini con ipoacusia neurosensoriale grave che sono stati divisi in due gruppi in base all'epoca di diagnosi. La valutazione delle abilità comunicativo linguistiche è stata effettuata all'età di 18 mesi, attraverso la somministrazione del questionario "MacArthur Child Development Inventory"; mentre la valutazione delle competenze acustico percettive è stata condotta con somministrazione del protocollo Genovese-Arslan, ogni tre mesi a partire dalla diagnosi. Lo sviluppo delle abilità comunicativo-linguistiche ed acustico-percettive dei bambini ipoacusici diagnosticati entro i 6 mesi dalla nascita è sovrapponibile a quello dei bambini normoacusici di pari età, con un trend di progressione temporale, rispetto ad alcune di queste competenze, più rapido di quello dei bambini ipoacusici diagnosticati dopo i 6 mesi.

PAROLE CHIAVE: Screening uditivo neonatale • Ipoacusia neurosensoriale • Abilità comunicativo linguistiche ed acustico-percettive

Acta Otorhinolaryngol Ital 2013;33:414-417

Introduction

Congenital deafness is one of the most common disabilities in children with an incidence of about 1.2-1.5 per 1,000 births, becoming about 2 per 1,000 in school children. If we consider the population at highest risk, such as children hospitalized in neonatal intensive care units (NICU) or those with a family history of hearing loss, the incidence can be 10-20 times greater^{1,2}.

Over the past decade there has been a widespread consensus in favour of universal newborn hearing screen-

ing programmes for permanent hearing disorders^{3,4} in order to identify the majority of children with bilateral hearing loss in a very stage of life, no later than 3-4 months after birth, so that the rehabilitative process can be started immediately, and no later than 6 months, i.e. during the period of greatest brain plasticity (American Academy of Pediatrics, Joint Committee on Infant Hearing 2007)⁵.

Studies in the literature⁶ have shown that the sooner proper acoustic-perceptual feedback is restored, the lower the

gap between performances of a hearing impaired child and those of a child with normal hearing considering communicative and cognitive-linguistic-relational skills^{7,8}.

To enable a hearing impaired child to acquire appropriate verbal patterns of perception that are not different from those of normally hearing child, it is essential to restore a suitable threshold of hearing through the immediate application of a hearing aid^{9,10}.

This work is a prospective longitudinal study of acoustic and cognitive linguistic skills in a sample of profound hearing impaired children belonging to the Campania programme of neonatal audiological screening, in relation to early detection of hearing loss and early inclusion in rehabilitation therapy.

Materials and methods

Newborn hearing screening

In the Campania region, a programme of universal newborn hearing screening structured on three levels was started in 2006: the first level is represented by birth points, the neonatal intensive care unit (NICU) and the neonatal department of pathology, and the second by the ENT and audiology departments of hospitals in the Campania Region. The third level is the Regional Reference Center (RRC), located at the functional area of Audiology of the University Hospital "Federico II" in Naples.

In this structure, diagnosis of hearing impairment is confirmed, aetiologic diagnostic tests are performed¹¹, a hearing aid device is selected, rehabilitation treatment is initiated and a periodic monitoring of the development of auditory perception and language and communication skills is performed.

From June 2006 to September 2011, 262,267 babies were examined. Of these, 259 were identified as affected by bilateral sensorineural hearing loss, 36 as affected by mono-lateral sensorineural hearing loss and 7 as affected by conductive hearing loss.

Patient selection and clinical evaluation

A group of 18 unrelated subjects (age range: 6-29 months) attending the Audiology Unit, Department of Neuroscience, University of Naples "Federico II", diagnosed between March 2006 and December 2007, was enrolled in this study. Medical history and pedigree information were obtained from parents to verify that hearing loss did not result from such acquired environmental factors as infection, trauma, acoustic trauma or ototoxic drugs, to evaluate the type of transmission of hearing loss and to exclude a syndromic form of hearing impairment. To evaluate hearing loss, all selected patients, according to international standards¹², underwent TEAOE, ABR, tympanometry and acoustic reflex, which are without risk, fast, easy to perform, highly sensitive and specific. For ABR

recordings, a replicable waveform at 30 dB nHL within the expected latencies was considered 'normal'. The 18 subjects enrolled were all affected by bilateral sensorineural hearing loss (SNHL) with a replicable waveform at 70-80dB nHL.

The sample was divided into two groups according to the time of diagnostic confirmation of hearing loss:

- group 1: 12 patients with a diagnosis before or within 6 months of age;
- group 2: 6 patients with a diagnosis between months 7-11 of age.

The sample had the following characteristics:

- all patients are carriers of conventional hearing aids, continuously used since diagnosis of hearing loss;
- lack of disease associated with deafness (without disabilities);
- cultural level of families: average (parents possess a high school diploma);
- rehabilitation: All patients had regular counseling sessions with audio-speech therapists, within the Audiology service and based on the principles of the audio-verbal methodology, from diagnosis to inclusion in a rehabilitation program on a local circuit.

Follow-up (3, 6, 9, 12, 18 months from the application of the hearing aid device) was performed to monitor perceptual abilities. All patients, at 18 months of chronological age, were evaluated to compare the development of the first communicative and linguistic skills using of the *MacArthur questionnaire – "Gestures and Words"*, both receptive and impressive.

The family was actively involved (parent training) in stimulation training.

The evaluation of communicative language ability was carried out through administration of the "MacArthur Child Development Inventory" questionnaire – "*Gestures and Words*", and the results were compared with normative values of the test⁹.

This questionnaire evaluates the development of receptive and expressive vocabulary in children from 9 to 18 months of age by computing the number of words understood and produced. It is administered by parents.

The evaluation of acoustic-perceptual abilities was carried out using the Genovese-Arslan protocol at 3, 6, 12 and 18 months after fitting of a hearing aid¹³.

This test classifies the perceptual skills of children in 6 categories (Moog & Geers categories):

- category 0: no detection of words;
- category 1: no perception of verbal patterns;
- category 2: perception of verbal patterns;
- category 3: first perception of words;
- category 4: identification of words by recognition of vowels;
- category 5: identification of words by recognition of consonants;
- category 6: identification of words in open sets.

Table I. Time of progress in perceptual skills in group I.

Perception's categories	Time after application of hearing aid device			
	3 months (n = 12)	6 months (n = 11)	12 months (n = 5)	18 months (n = 6)
1	11 (92%)	1 (9%)		
2	1 (8%)	10 (91%)		
3			5 (100%)	2 (33%)
4				3 (50%)
5				1 (17%)
6				

Table II. Time of progress in perceptual skills in group II.

Perception's categories	Time after application of hearing aid device			
	3 months (n = 6)	6 months (n = 6)	12 months (n = 5)	18 months (n = 3)
1	2 (34%)			
2	4 (66%)	3 (50%)		
3		3 (50%)	4 (80%)	2 (67%)
4				
5			1 (20%)	1 (33%)

Results

Evaluation of acoustic perceptual abilities

At 3 months after hearing aid first fit, 92% of children fell into the first category of perception; at 6 months, 91% of children fell into the second category of perception; at 12 months, 100% of children fell in a third category of perception and at 18 months, 50% of patients fell in the fourth category of perception.

Thus, in group I, a linear and constant growth profile of the investigated skills was seen (Table I). In the group of patients with hearing aid first fit between 7 and 11

months (9 ± 2): at 3 months, 60% of children fell in the second perceptual category; at 6 months, 50% of children are split over the second one and the remaining 50% in the third category of perception; at 12 months, 80% of children fell in the third category of perception; and finally, at 18 months, only 67% were in the third category and 33% fell in the fifth category of perception.

In this second group, it therefore is evident that there is a linear growth profile as above, but with slower progression (Table II). Patients in the second group, at three months, fell in higher categories of perception because

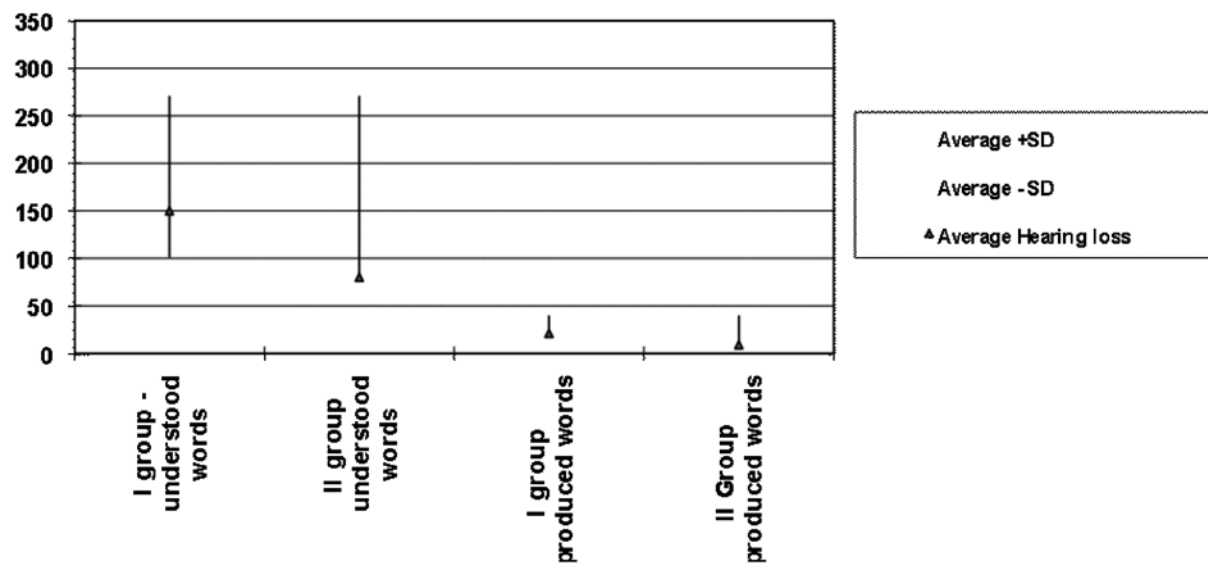


Fig. 1. Number of words understood and produced in Groups I and II at 18 months compared to normative data.

of longer exposure time to language than the first group (greater chronological age).

Evaluation of development in language abilities

Through the administration of the MacArthur questionnaire, in the two groups of hearing impaired patients, it can be observed that the average number of words understood by patients in the first group (with a diagnosis before 6 months) is 150 ± 90 words, which is at the 50th percentile compared with normative values of the test (Fig. 1). With regard to expressive language, the average number of words produced is 21 ± 11 ; which is between the 25th and the 50th percentile.

The average number of words understood by patients in group II (with a diagnosis between 7 and 11 months) is 80 ± 40 words, which is between the 25th and the 50th percentile compared with normative values of the test. With regard to expressive language, the average number of words produced was 9 ± 6 ; which is at the 10th percentile compared with normative values.

Discussion and conclusions

The purpose of this study was to confirm the hypothesis that the time of diagnosis and consequently hearing aid first fit have a significant impact on the language skills in children with severe bilateral neurosensorial hearing loss. In particular, our data demonstrate that the perceptual abilities of hearing impaired children diagnosed before 6 months of age follow values that are similar to those expected for normally hearing children of an equivalent chronological age, with a trend of temporal progression faster than the group diagnosed later.

Moreover, restoring acoustic feedback has an important impact on language development, and in particular on vocabulary skills. In fact, children in Group I at 18 months of chronological age had a normal receptive and expressive vocabulary development (> 25th percentile), while the second group had poorer performance.

These results confirm the importance, in a neonatal hearing screening programme, of early diagnosis, followed by the immediate rehabilitation with hearing aids through speech therapy and family¹⁴.

The data in this study, however, should be considered preliminary to a larger one that will analyze the development of linguistic, perceptual and curricular skills, related to hearing impaired, in children identified through the Neonatal Auditory Screening Program of the Campania region.

References

- Altunta EE, Yenicesu AG, Mutlu AE, et al. *An evaluation of the effects of hypertension during pregnancy on postpartum hearing as measured by transient-evoked otoacoustic emissions*. Acta Otorhinolaryngol Ital 2012;32:31-6.
- Paludetti G, Conti G, DI Nardo W, et al. *Infant hearing loss: from diagnosis to therapy Official Report of XXI Conference of Italian Society of Pediatric Otorhinolaryngology*. Acta Otorhinolaryngol Ital 2012;32:347-70.
- Ciorba A, Hatzopoulos S, Petrucci J, et al. *Identifying congenital hearing impairment: preliminary results from a comparative study using objective and subjective audiometric protocols*. Acta Otorhinolaryngol Ital 2013;33:29-35.
- Kennedy C, McCann D. *Universal neonatal hearing screening moving from evidence to practice*. Arch Dis Child Fetal Neonatal Ed 2004;89:F738-83.
- Year 2007 position statement: principles and guidelines for early hearing detection and intervention programs*. Pediatrics 2007;120:898-921.
- Nelson HD, Boutgatos C, Nygren P. *Universal newborn hearing screening: systematic review to update the 2001. US Preventive Services Task Force recommendation*. Pediatrics 2008;122:e266-76.
- Tomita M, Eggermont JJ. *Cross-correlation and joint spectro-temporal receptive field properties in auditory cortex*. J Neurophysiol 2005;93:378-92.
- Turchetti G, Bellelli S, Palla I, et al. *Systematic review of the scientific literature on the economic evaluation of cochlear implants in paediatric patients*. Acta Otorhinolaryngol Ital 2011;31:311-8.
- DesJardin JL, Eisenberg LS. *Validity of the MacArthur-Bates Communicative Development Inventories for measuring language abilities in children with cochlear implants*. Am J Speech Lang Pathol 2007;16:54-64.
- Forli F, Arslan E, Bellelli S, et al. *Systematic review of the literature on the clinical effectiveness of the cochlear implant procedure in paediatric patients*. Acta Otorhinolaryngol Ital 2011;31:281-98.
- Chinetti V, Iossa S, Auletta G, et al. *Mutational analysis for GJB2, GJB6, and GJB3 genes in Campania within a universal neonatal hearing screening programme*. Int J Audiol 2011;50:866-70.
- Declau F, Doyen A, Robillard T, et al. *Universal newborn hearing screening*. B-ENT 2005;(Suppl 1):16-21.
- Genovese E, Orzan E, Turrini M, et al. *Speech perception test in Italian language for profoundly deaf children*. Acta Otorhinolaryngol Ital 1995;15:383-90.
- Calderon R. *Parental involvement in deaf children's education programs as a predictor of child's language, early reading, and social-emotional development*. J Deaf Stud Deaf Educ 2000;5:140-55.

Received: August 5, 2012 - Accepted: June 27, 2013

Address for correspondence: Elio Marciano, University "Federico II", via Pansini 5, 80131 Naples, Italy. Tel. +39 081 7463496. Fax +39 081 7463885. E-mail: marciano@unina.it