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Hearing and Language Outcomes of Cochlear Implant Users in Zagazig University Program

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ABSTRACT

Introduction: The most common congenital sensory deficit is sensory neural hearing loss (SNHL), with a 1:3 occurrences per 1000 live births, this incidence increases to 4-5% in neonates with risk factors for SNHL. For severe to profound hearing- impaired persons, cochlear implantation has been used as a successful method to regain partial hearing. Children with CIs are now able to communicate and understand speech, learn spoken language, and attend regular schools. **Objectives:** The aim of this study was to assess auditory perception threshold of cochlear implant users in Zagazig University Hospitals and evaluate their speech and language outcomes.**Patients and methods:** This study included 62 participants operated in zagazig university hospital and follow the candidacy criteria for cochlear implantation of Zagazig University CI program. **All patients were subjected to** postoperative audiological and phonological assessment including Warble tone response thresholds in sound field, aided speech discrimination, language test and speech analysis.**Results:** The results of this study revealed a statistically significant improvement in hearing thresholds and increase in speech intelligibility in the studied group. By comparing total language age with CI age there was 56.5% of cases have total language age less than CI age and 43.3% of cases have total language age equal and more than CI age.

Key words: Cochlear implant, Children language, Post CI outcome.

INTRODUCTION

The most common congenital sensory deficit is sensory neural hearing loss (SNHL), with an occurrence of 3 per 1000 live births (1). Approximately 50% to 60% of pediatric SNHL is caused by hereditary factors, while 15% to 40% is due to an acquired cause, such as ototoxic medications, trauma, infection, anoxia, hyperbilirubinemia, low birth weight, metabolic, autoimmune diseases and 15-30% of unknown cause (2).

For severe to profound hearing-impaired persons, cochlear implantation has been used as a successful method to regain partial hearing. Children with CIs are now able to communicate and understand speech, learn spoken language, and attend regular schools (3).

Cochlear implantation benefits greatly in patients with acquired post-lingual hearing loss, and have limited period of hearing loss or auditory deprivation. However, in pre-lingual hearing-impaired children, there are also progressive, gradual changes in speech development and speech comprehension. (4).

The pre-selection criteria in children include: Bilateral severe to profound sensorineural hearing loss, 12-18 months of age or older, with little to no gain from hearing aids, no radiological or medical contraindications to surgery, placement in intensive auditory skill rehabilitation program, appropriate expectations from the family (5).

The reasoning behind early cochlear implantation is to reduce the sensory deprivation-related effects during the critical time. Several

studies have shown that children implanted before the age of 2 do substantially better than children implanted when they are older (6).

The pre-operative evaluation include: Full otologic and audiological evaluation to determine the degree and etiology of the child's hearing loss (if possible), speech and language evaluation to assess child's communication abilities with their hearing aids, imaging (CT scan /MRI) to evaluate anatomy of cochlea and internal auditory meatus, psychiatric evaluation to assess children developmental milestones and capacity to learn, others such as genetics testing, ophthalmology evaluation, and cardiology evaluation (7).

2. METHODS

Study design and subjects:

This retrospective study was applied at the Audio-Vestibular medicine and Phoniatrics Units – Otolaryngology Head and Neck Surgery Department – Zagazig University Hospitals from 12/2018 to 6/2019 to assess the auditory and language skills in children patients performed CI surgery in ENT department of Zagazig University Hospitals since 2010 (the date of beginning of zagazig university cochlear implant program).

Up to June 2019, 162 children were operated in zagazig university CI program. Only 62 children were included in this study, some parents didn't give consent to participate in research, some lost contact with them either changed their residence or phone number and some shifted to follow up in nearby other medical centers. These 62 participants follow the candidacy criteria for cochlear implantation used in Zagazig University CI program.

Postoperative audiological assessment: Warble tone response thresholds in sound field were assessed at frequency range 500 through 4000 Hz. Arabic monosyllabic phonetically balanced kindergarten words (8): Done by life voice, the speech was introduced at intensity 65 dBHL (9). The child was seated in a sound treated booth facing the speaker from which speech was introduced at 1m with zero azimuths.

Postoperative phoniatric assessment: Language test (10) in which language was assessed using the Standardized Arabic Language Test. This test measures receptive and expressive language skills, giving the total language age in years. The deficiency in language has been expressed as a quotient of language. It was calculated by dividing raw score of the children by the normal cut off point of the same chronological age. Language quotient was used to avoid biased results if language age was used, as children had different chronological ages at the time of evaluation.

Auditory abilities (11) which was achieved by using CAP scoring (Capacity of Auditory Performance score): 0 = No knowledge of environmental sounds 1 = Awareness of environmental sounds 2 = Response to speech sounds 3 = Recognition of environmental sounds 4 = Discrimination of certain speech sounds without lip-reading 5 = Understanding popular phrases without lip-reading 6 = Conversation understanding without lip-reading 7 = Telephone use with a known listener books.

Speech analysis (12) which was performed using a speech assessment protocol, which included analysis of supra-segmental phonology (rate, stress, and tonality), segmental phonology (consonants and vowels), nasal resonance, and general intelligibility of speech, as well as voice (dysphonia). Every item was given a score that ranged from 0 (normal) to 4 (denoting severe abnormality) except for general intelligibility, for which score 4 indicated normal and 0 indicated severely unintelligible speech. This test could not be applied to all children because it needs language age > 2 years as it is difficult to assess the speech before this age.

STATISTICAL ANALYSIS

The IBM computer used the SPSS to analyze data as follows: quantitative variables description as mean, standard deviation. A number and percentage are used for the description of qualitative variables. The quantitative variables in parametric data was compared using an independent t-test. In non-parametric data, the independent quantitative variables were compared using the Mann-Whitney test.

3. RESULTS

The age of the studied group ranged from 3y 7m to 13 years with mean 7.74 years. Regarding gender 48.4% were male and 51.6% were female. the age at implantation ranged from 1 y 5m to 7y with mean 4.10 years while duration of CI use ranged from 1y 3m to 8y 9 m with mean 3.63 years. Table (1) showed that there was statistical significance improvement in hearing threshold and increase in discrimination among the studied group post-operative aided response compared to pre-operative unaided response. Table (2) describe regularity of postoperative auditory training. Table (3) shows the results of CAP scale. Table (4) shows speech analysis of the studied group while table (5) shows language assessment of the studied group. Table (6) shows comparison of total language age with CI age of the studied group.

Table 1: Preimplant PTA results Versus postoperative sound field hearing threshold.

Variable		Pre (unaided) (n=62)	ɔst (aided) (n=62)	Paired test	P
500 Hz	Mean±SD	82.39 ± 7.54	32.9 ± 6.93	**T 8.3**	**<0.001 ****
	Median	80	35		
	Range	70 – 100	20 – 55		
1000 Hz	Mean±SD	89.21 ± 5.38	30 ± 7.41	**T 10.5**	**<0.001 ****
	Median	90	30		
	Range	80 – 110	20 – 55		
2000 Hz	Mean±SD	104.65 ± 3.27	20.97 ± 7.18	**W 22.45**	**<0.001 ****
	Median	105	20		
	Range	100 – 110	10 – 55		
4000 Hz	Mean±SD	109.82 ± 2.35	22.82 ± 8.23	**W 24.67**	**<0.001 ****
	Median	110	20		
	Range	100 – 115	10 – 55		
Discrimination: %	Mean±SD	7.65 ± 3.42	54.45 ± 24.22	**W 19.74**	**<0.001 ****
	Median	8	60		
	Range	0 – 16	0 – 88		

Sd: Standard deviation t: Paired t test W: Paired Wilcoxon test **: Highly significant

Table 2: Post-operative auditory training among the studied group:

Variable		(n=62)	
		N	**%**
Training:	Regular	17	27.4
	Irregular	45	72.6

This table shows that 27.4% of the studied group had regular post- operative auditory training.

Table 3: CAP scale (Categorical of Auditory Performance) among of the studied group:

Variable		(n=62)
CAP scale	Mean ± SD	4.82 ± 1.15
	Range	0 – 6

Table 4: Speech assessment among the studied group:

Variable		(n=50)$
Prosody	Mean ± SD Range	0
Articulation (Consonants)	Mean ± SD Median Range	2.74 ± 0.72 3 0 – 4
Articulation (Vowels)	Mean ± SD Median Range	0.12 ± 0.52 0 0 – 3

Variable		(n=50)$
Resonance	Mean ± SD Median Range	0.16 ± 0.42 0 0 – 2
Voice	Mean ± SD Range	0
Intelligibility of speech	Mean ± SD Median Range	2.5 ± 0.79 3 1 – 4

NB:12 cases had total language age less than 2 years so can't be assessed Sd: Standard deviation

Table 5: Language test among the studied group:

Variable		(n=62)
Receptive	Mean ± SD	2.92 ± 1.35
	Median	2.42
	Range	1 – 6y 3m
Expressive	Mean ± SD	2.68 ± 1.10
	Median	2.42
	Range	10m – 5y 8m
Total	Mean ± SD	2.78 ± 1.19
	Median	2.5
	Range	11m – 5y 9m

Table 6: Outcome of CI among the studied group:

Variable		(n=62)	
		No	**%**
Outcome:	Total language age < CI age	35	56.5
	Total language age ≥ CI age	27	43.5

4. DISCUSSION

This retrospective study was carried out to assess auditory perception threshold and evaluate speech and language outcome of cochlear implant users in Zagazig University Hospitals and explore the effects of different factors on the postimplant outcome of prelingual CI children, to highlight both predictive and prognostic values of these factors on the progress of such children.

The research was conducted in Zagazig University Hospital on a group of children who performed cochlear implantation 48.4% were male and 51.6% were female, the age of the studied group ranged from 3 yrs 7 ms to 13 yrs at the time of testing as shown in table (1).

The age at implantation in the studied group ranged from 1 y 5m to 7y (one patient had implantation at age of 7 y) with mean 4.10 years while duration of CI use ranged from 1y 3m to 8y 9 m with mean 3.63 years.

The mean aided response among studied group using CI was 32.9 at 500 Hz with median 35, 30 at 1000 Hz with median 30, 20.97 at 2000 Hz with median 20, 22.82 at 4000 Hz with median 20, as regard aided speech discrimination the mean was 53.55 with median 60. There was statistical significance decrease in hearing threshold and increase in discrimination among the studied group post-operative aided response compared to preoperative unaided response as shown in table (1).

As regard phonological results; Post-operative auditory training among studied group shows that 27.4% of the studied group had regular post-operative auditory training while 72.6% had irregular post-operative auditory table (2). The mean CAP score (Capacity of Auditory Performance) was 4.82 as shown in table (3).

Speech assessment among studied group shows that no cases had score in Prosody or voice. Regarding articulation mean consonants and vowels were 2.74 & 0.12 respectively. Mean resonance was 0.16 and mean intelligibility of speech was 2.5 as shown in table (4). Finally, the language test show that mean receptive age was 2.92 years, mean expressive age was 2.68 years and total was 2.78 years as shown in table (5).

This data indicates that receptive language tests better than expressive language. Three researches (13,14,15) distinguished by an exemplary review of all subjects have shown that very few of these children reach age in either receptive or expressive abilities. It is also noted that very few of the children in these and other studies exceed the average age level of maturity of normal hearing children.

Tomblin proposed that early implantation benefits language development in two ways; first, it shortens the period of deafness which is associated with a lower rate of language learning and development; second, it may provide language development by adjusting the rate after initial stimulation (16). Several researchers found similar results in line with our findings (17,18).

By comparing total language age with CI age there was 35 cases have total language age less than CI age and 27 cases have total language age equal and more than CI age as shown in table (6).

The most important cause responsible for poor speech and language development is defective rehabilitation program as the patients were from different regions and they received rehabilitation training in local rehabilitation centers close to their home instead of in the same rehabilitation center. Also, most of families have low expectations and once child begins to repeat few words, they become satisfied with the results and stop rehabilitation training.

The mean implantation age was also 4 years, considered to be comparatively late implantation age, as it is recognized that the younger the implantation age, the better the outcomes. An intact, functional auditory processing pathway from spiral ganglion cells in the cochlea to the auditory cortex is necessary for successful cochlear implantation (19).

Most of the CI studies focused only in medical, demographic, hearing and educational factors instead of the underlying neurocognitive processing abilities, as certain patients with suboptimal results may have other neurological and cognitive sequelae arising from long time of auditory deprivation (20).

The inconsistency seen in the production of language and speech after implantation is not only due to hearing, but also indicates the contribution of other neurocognitive factors related to the way sensory information is coded, processed and extracted from memory, i.e. how children with a significant hearing impairment "process" the sensory information supplied from a cochlear implant (20).

One of the most daunting research problems in the field of CI is the individual variability in speech recognition following CI. Even though most deaf children who fulfill the candidacy requirements set by the FDA perform very well with their CI, still some of cochlear implant users do not show optimal levels of speech recognition and perform badly with their CIs even after many years of use (21).

CI researchers and clinicians were unable to recognize readily available pre-implant predictors of outcome after implantation, over and above the standard variables of demographic and hearing history, such as implantation age and duration of auditory deprivation (22).

More significantly, the restricted outcome predictors make it difficult to recognize children who may be at high risk of adverse outcomes at a period in development when changes and modifications may be made to alter and strengthen their abilities for speech recognition.

The small sample size was also a limitation in this study as some parents didn't give consent to participate in research, some lost contact with them either changed their residence or phone number and some shifted to follow up in nearby other medical centers.

Also, we should search about advanced methods that help in assessment and evaluation of CI children rather than routinely used tests in our audiology and phoniatric unit.

5. CONCLUSION

There is a significant improvement in aided response threshold and aided speech discrimination of CI users. There is a significant improvement in language acquisition and speech intelligibility of CI users. The improvement in aided threshold is not the

only factor affecting speech and language development.

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