Evaluating factors associated with paediatric cochlear implant outcome in four cochlear implant satellite centres in Malaysia

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ABSTRACT

Introduction: Many factors are associated with cochlear implant (CI) outcomes and various methods of assessment for auditory and speech performance outcomes in CI are available globally. The objective of this study is to identify factors relating to CI outcomes in paediatric population that suits local context.

Materials and Methods: A total of 18 factors consisted of variables which emphasise on audiological, CI service team, speech therapy, and family-related factors. These factors were then retrospectively analyzed among CI recipients. The outcome measurements of categorical auditory performance II (CAP-II) and speech intelligibility rating (SIR) were used to individually study each factor. Kruskal–Wallis H Test and Fisher Exact Test used with *p*-value <0.05 were considered significant.

Results: There were significant associations between post-CI CAP-II with type of hearing loss, hearing aid usage per day and mode of communication, attention, attending audiology and speech session, and siblings. For post-CI SIR, hearing aid usage per day, attention, mode of communication, attending audiology and speech session, initiatives, and siblings were statistically significant.

Conclusion: The factors affecting the outcome of CI are dynamic. Some of the factors have demonstrated to be associated with the auditory and speech outcome in CI recipients while some factors failed to replicate similar findings. Further prospective research may refine the outcome of individual factors.

KEYWORDS:
Cochlear implant; factors; candidacy; outcome

INTRODUCTION

Cochlear implant (CI) has been the choice for treatment for both bilateral and unilateral severe to profound sensorineural hearing loss (SNHL). The application in paediatric population has significantly improved speech production and perception outcome.[1–3] In selecting the appropriate candidate, it requires an assertive tool that evaluates the biographic and audiologic factors that may affect the outcome and the success of the auditory and speech performance. Hellman et al.[4] designed the Children's Implant Profile (ChIP) in 1991. This tool uses 11 factors to determine suitability for cochlear implantation. This ChIP has been globally adopted for the past 25 years but evolution and expansion of science and knowledge in cochlear implantation have necessitated many implant centres to modify the tools in accordance to the local needs such as Children's Hospital of Philadelphia Children Implant Profile (CHOPChIP) and Great Ormond Street Hospital Children Implant Profile (GOSHChIP).[5,6]

The selection criteria for CI involve multidisciplinary approaches. Establishing an ideal assessment tool is difficult because the decision-making for CI is complex and influenced by many factors.[7] Although the existing ChIP is a good assessment apparatus in forecasting various factors that affecting the CI outcome, inconsistencies in decision-making are noted when it is applied to our population. Therefore, Hospital Sultan Ismail Cochlear Implant team had listed down factors that might affect the outcome of CI (Table I). There were a total of 18 factors identified and each factor was rated from a scale of 1 to 3. The scoring system was adapted from Edwards et al.[6] who divided the score into three categories; those who are suitable to be implanted, 50% suitable for implantation, and not favourable for CI. The scoring system were as follows; those who score 18–30 is suitable for CI, those with a score of 31–42 should be considered for CI based on individualized justifications, while those with a score of 43–54 is not favourable for CI.

The main aim of this study is to identify factors that are relevant to the local population and current timeline. These factors were then assessed categorically by means of post-CI categorical auditory performance II (CAP-II) and speech intelligibility rating (SIR).

MATERIALS AND METHODS

Data collection

Hearing-impaired children who successfully underwent CI in

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Table I: The Hospital Sultan Ismail Cochlear Implant Profile (HSIChIP)

Factor	Item	Score		
		1	2	3
Audiological factors:				
1	Age of diagnosis	< 1 year old	1 to 2 years old	> 2 years old
2	Age of hearing aid fitting	< 1 year old	1 to 2 years old	> 2 years old
3	Expected age to be implanted	6 months to 2 years old	2 to 3 years old	3 to 5 years old
4	Hearing aid usage per day	Consistent (>8 hours)	Persistent (4–8 hours)	Rarely (<4 hours)
5	Type of hearing loss	Severe to profound bilaterally	Only one ear profound with residual hearing at the other ear	Dead ear bilaterally
Cochlear implant team services factors:				
6	Hospital/ Surgeon availability	Within 50km	50–100km	>100km
7	Speech therapist	Consistent and committed	Frequent changes of speech therapist	Limited or no trained speech therapist service
Speech therapy factors:				
8	Behaviour	Cooperative	Easily distracted	Poor attention and not cooperating
9	Attention (Based on Reynell Attention Scale)	5 to 6	3 to 4	1 to 2
10	Mode of communication	Verbal	Gesture with some verbal	Predominantly gesture
Family factors:				
11	Family involvement	Both parents involved	Only 1 caretaker or parents involved seemed involved but with great attention	One caretaker involved but lack consistency and involvement
12	Attending audiology and speech session	Consistently attending	At least absent few times	Absent most of the time
13	Initiatives	Proactive and willing to spend time and money for child benefit	Not proactive but follow diligently	No initiative at all
14	Siblings	≥ 3	2	1
15	Household income	> RM5000	RM3000 to RM5000	< RM3000
16	Working parents	One of the parents has stopped working to focus on the child rehabilitation	Only one is working while another is house bound	Both working and are not willing to stop for the child benefit
Variables				**n (%)**
17	Marriage	Healthy and happy	Still together but thinking of separation or had separated before	Divorced or married to different partner
18	Language spoken	Malay	Malay and others	Others

Table II: Categories of auditory performances II (CAP-II) and speech intelligibility rating (SIR)

CAP-II	Score	Categories
	0	No awareness of environmental sounds or voice.
	1	Awareness of environmental sounds.
	2	Response to speech sounds.
	3	Identification of environmental sounds.
	4	Discrimination of speech sounds without lip reading.
	5	Understanding of common phrases without lip reading.
	6	Understanding of conversation without lip reading.
	7	Use conversation with known speaker.
	8	Follows group conversation in a reverberant room or where there is some interfering noise, such as classroom or restaurant.
	9	Use of telephone with an unknown speaker in unpredictable context.
SIR	**Score**	**Categories**
	1	Connected speech is unintelligible. Pre-recognizable words in spoken language (primary mode of communication may be manual).
	2	Connected speech is unintelligible. Intelligible speech is developing in single words when context and lip-reading cues are available.
	3	Connected speech is intelligible to a listener who concentrates and lip-reads within a known context.
	4	Connected speech is intelligible to a listener who has little experience of a deaf person's speech.
	5	Connected speech is intelligible to all listeners. The child is understood easily in everyday contexts.

Table III: The characteristics of the subjects

Age (month), (mean ± SD)	41.8 ± 28.40
Gender	
• Male	39 (45.9%)
• Female	46 (54.1%)
Race	
• Malay	52 (61.2%)
• Chinese	26 (30.6%)
• Indian	7 (8.2%)
Pre-CI CAP-II (mean ± SD)	1.71 ± 1.438
Post-CI CAP-II (mean ± SD)	4.78 ± 1.340
Pre-CI SIR	
• Poor	76 (89.4%)
• Good	9 (10.6%)
Post-CI SIR	
• Poor	45 (52.9%)
• Good	40 (47.1%)

Table IV: The relationship between HSIChIP factors with pre- and post-CI CAP-II and SIR

Factor	Items	*p* value	
		Post-CI CAP-II†	Post-CI SIR‡
Audiological factors:			
1	Age of detection	0.122	0.066
2	Age of hearing aid usage	0.300	0.515
3	Expected age to be implanted	0.175	0.062
4	Hearing aid usage per day	0.025	0.033
5	Type of hearing loss	0.026	0.625
Cochlear implant team services factors:			
6	Hospital/ Surgeon availability	0.820	0.405
7	Speech therapist availability	0.843	0.733
Speech therapy factors:			
8	Behaviour	0.460	0.156
9	Attention	**<0.001**	**0.001**
10	Mode of communication	**0.002**	**0.013**
Family factors:			
11	Family involvement	0.488	0.469
12	Attending audiology and speech session	**0.044**	**0.017**
13	Initiatives	0.078	**0.039**
14	Siblings	**0.036**	**0.029**
15	Household income	0.209	0.346
16	Working parents	0.924	0.543
17	Marriage	0.175	0.202
18	Language spoken	0.184	0.554

CAP-II: Categorical of auditory performance II; CI: cochlear implant; SIR: speech intelligibility rating.
†Kruskal–Wallis H test, ‡Fisher Exact Test, statistically significant with p-value <0.05.

Malaysian government hospitals from 2008 until 2018 were recruited retrospectively from four CI satellite centres. The inclusion criteria included all children less than 18 years old with severe to profound SNHL bilaterally who were enrolled in the CI candidacy evaluation program by the National CI Committee. Bilateral or reimplantation of CI was not included in this study. Defaulters or deceased subjects were also excluded. All data were retrieved from subjects' medical records and CI database.

Measurement outcomes

Categorical auditory performance II (CAP-II) and speech intelligibility rating (SIR) were used as tools to measure the outcome of CI in this study. Each factor was analysed using the post-CI of the CAP-II and SIR. CAP-II is used to assess the auditory perception ability of patients with hearing impairment, as depicted in Table II.[8] In addition, SIR determines the speech intelligibility of patients with hearing impairment as illustrated in Table III.[9] The CAP-II and SIR were routine outcomes measurements for all CI candidate under National MOH CI programme. Post-CI CAP-II and SIR scores were evaluated by the same dedicated audiologist and speech therapist after 2 years of the CI surgery.

Ethical approval

Ethical approval from Malaysian Research Ethics Committee (MREC) has been obtained and registered with the National Medical Research Register (NMRR-20-649-53756).

Statistical analysis

A descriptive analysis was conducted for this research. Kruskal–Wallis H test was used to analyze the data obtained for the CAP-II outcome. The statistical significance test standard was at $p<0.05$. On the other hand, SIR was

categorized into poor (score 1-2) and good (score 3-5). Therefore, Fisher Exact Test was conducted to analyze the data for the outcome of SIR. Each of the factors was categorized into four main themes which comprised of audiology, CI team services, speech therapy, and family factors. The relationship between these factors and the outcome were analysed using the tests stated above.

RESULTS

In this study, 85 hearing-impaired children were included, which comprises 45.9% males and 54.1% females. Malay, Chinese, and Indian comprised of 61.2%, 30.6%, and 8.2%, respectively. The mean age ± standard deviation of the children at the time of CI surgery was 41.8 ± 28.40 months old. The mean CAP score ± standard deviation prior to CI was 1.71 ± 1.438, and it increased to 4.78 ± 1.340 after 2 years of CI surgery. Furthermore, only 10.6% of children with good SIR before CI and the percent were improved to 47.1% after 2 years of CI surgery. The characteristics of the subjects are outlined in Table III.

There were statistically significant differences observed in post-CI CAP-II for six factors which were hearing age usage per day (p=0.025), type of hearing loss (p=0.026), attention (p<0.001), mode of communication (p=0.002), attending audiology and speech session (p=0.044), and siblings (p=0.036). The other factors appeared to be not statistically significant (p>0.05) (Table IV).

Following Fisher's Exact Test analysis, there were statistically significant differences in post-CI SIR for six factors which were hearing aid usage per day (p=0.033), attention (p=0.001), mode of communication (p=0.013), attending audiology and speech session (p=0.017), initiatives (p=0.039), and siblings (p=0.029). The relation between post-CI SIR with other factors was not statistically significant in this study (p>0.05) (Table IV).

DISCUSSION

In this study, we attempted to identify preoperative candidacy factors befitting our local patients. For more than 13 years, the National MOH CI Programme was using CHOPChIP as one of the CI candidacy assessment tools.[5] However, some of the factors seem unsuitable to Malaysian context. So far, more than 400 children with hearing impairment had successfully received CI through this program.[10]

In this study, some factors mentioned in previous ChIP were maintained as these factors still hold true during pre-CI assessment. Previous ChIP included chronological age as one of the important factors. Similarly, age was emphasized in this study. Literature had shown that infants who received CI demonstrated better speech development as compared to older children.[11,12] In agreement, Gaurav et al.[13] reported that implantation below age of 5 years is preferable as the effects of auditory rehabilitation show promising results. Responding to this matter, the MOH had introduced the Universal Newborn Hearing Screening Programme (UNHS) and High Risk Newborn Hearing Screening Programme (HRNHS) in many Malaysian hospitals. However, these factors were not statistically significant in our analysis. Perhaps it was contributed by the low implementation of hearing screening at the moment.[14]

In agreement with previous CHOPChIP and NChIP, children's behavioural and attention issues were given priority. Children with attention deficit hyperactivity disorder with concurrent hearing impairment has less favourable outcome post-CI as these children have decreased ability in auditory, language, speech, cognition, motor, and communication skills.[15] Although hearing-impaired children with additional disabilities demonstrated some benefit from early CI, there is an issue in tackling the behavioural problems with greater parental stress.[16] Thus, pre-CI evaluation and counselling are important to facilitate family adaptation and also shape realistic expectations following CI.

Conducive family environment between parents and siblings was strongly related to social and cognitive development of children with hearing impairment.[17] Family factors form integral part of healthy family structures. The previously established ChIP also reported similar findings.[5] It has become evidence that family factors such as compliance in attending the audiology and speech session, parents' initiatives on home-based programme, and presence of siblings are important in predicting the speech development as shown in this study. Although family involvement, working parents, and marital harmony were unable to replicate similar results, we strongly believe that these factors are important based on our experience. In accordance with the previous analysis on CHOPChIP, some of the family factors did not represent a significant association with the speech outcome.[5] Dynamic family patterns might reflect the ambiguity of the results. Therefore, the ultimate decision should be individualized. In our opinion, it is strongly recommended that family environment should be thoroughly evaluated prior to CI and this commitment should be continuously monitored post-implantation as well.

Although the provision of CI is fully or partially funded by the government or third party, the long-term expenditures are fully borne by the family.[18] This is the reason why this factor is included in our analysis. A local study by Umat et al.[19] mentioned that parents of children with CI expressed their concern on financial support. Another study reported lower socioeconomic background associated negatively with the outcome post-CI surgery, such as poorer compliance to follow-up appointments, higher rates of complications postoperative, and lower chances of sequential bilateral cochlear implantation.[20]

Criticism may arise on the importance of spoken language. This factor indicating candidate who speaks in Malay language is favourable as compared to other languages. Multiracial and multiethnic population are unique features in Malaysia. There are multiple spoken languages and dialects used. As Malay language is the most commonly spoken language in this country, the speech rehabilitation using this language is widely available. This is important to ensure the continuity of rehabilitation as well as for the school placement later on.

These study limitations pertain to methodological issues, which may cause bias to the study findings. First, the CI outcome was analyzed by recruiting subjects retrospectively in which most of the subjects had undergone thorough assessment during National CI Programme. Secondly, subjects who have failed the initial candidacy and not implanted were not included and assessed in our study. Another limitation in this study is inter-rater variability in CAP-II and SIR was not assessed in this study. It is because the CAP-II and SIR were routine assessments and the data were extracted from subjects' medical records and CI database. For quantitative studies, limitations may include small sample size, which may limit the validity that affects the generalisability of the findings. Perhaps bigger sample size in multicentre studies in prospective manner will yield more significant results.

CONCLUSION

Upon scrutiny of each factor associated with paediatric CI outcome, the study finds that some of the factors appeared to be associated with the audiological and speech outcome among CI subjects. On the contrary, some of the factors failed to show statistically significant correlations. Hence, it can be inferred that the factors contributing to CI outcome are complex. Based on these findings, we are optimistic to develop our own Hospital Sultan Ismail Cochlear Implant Profile (HSIChIP) in future research. Future research will be directed towards content validation of the HSIChIP and its applicability in our local setting.

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