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Predictors of pediatric cochlear implantation outcomes in South Africa

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ABSTRACT

Objective: To identify and describe predictors of pediatric cochlear implantation outcomes in a South African population.
Methods: A retrospective study of 301 pediatric cochlear implant (CI) recipients from five CI programs was conducted and cross-sectional outcome data were added at the time of data collection. Twenty potential prognostic factors were identified from the retrospective dataset, including demographical, CI, risk and family factors. Multiple regression analyses were performed to identify predictor variables that influence outcomes in terms of auditory performance (CAP scores), speech production (SIR scores), communication mode and educational placement.
Results: Although implanted children within this sample did not have equal opportunity to access a second implant, bilateral implantation was strongly predictive of better auditory performance and speech production scores, an oral mode of communication and mainstream education. NICU admittance/prematurity were associated with poorer auditory performance and speech production scores, together with a higher probability for non-oral communication and non-mainstream education. The presence of one or more additional developmental condition was predictive of poorer outcomes in terms of speech production and educational placement, while a delay between diagnosis and implantation of more than one year was also related to non-mainstream education. Ethnicities other than Caucasian were predictive of poorer auditory performance scores and a lower probability for mainstream education.
Conclusion: An extensive range of prognostic indicators were identified for pediatric CI outcomes in South Africa. These predictive factors of better and poorer outcomes should guide pediatric CI services to promote optimal outcomes and assist professionals in providing evidence-based informational counseling.

1. Introduction

In recent years, significant improvement has been demonstrated in pediatric cochlear implant (CI) outcomes due to technological advances, earlier implantation and earlier intervention [1–3]. Speech and language skills comparable to normal hearing children can be achieved in some prelingually deaf children implanted within the first year of life, as indicated by recent reports [4–6]. Understandably, expectations for pediatric cochlear implantation are high [1]. However, outcomes vary as multiple internal and external factors have the potential to affect clinical outcomes [7–9]. As a result many pediatric cases present with sub-optimal outcomes. In order to counsel families pre-operatively about the range of possible outcomes and to plan for post-implantation intervention, accurate prognostic information is required [10,11].

Indications for pediatric cochlear implantation are becoming more complex with an increase in bilateral implantation and a

Abbreviations: CAP, Categories of Auditory Performance; CI, cochlear implant; HL, hearing loss; NICU, neonatal intensive care unit; SASL, South African Sign Language; SIR, Speech Intelligibility Rating.

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growing number of children with less severe hearing losses being implanted [10,12–15]. Also, children with multiple medical conditions resulting from prematurity or perinatal etiologies are more likely to be considered as candidates, expanding the criteria for implantation even more [16]. Consequently the number of pediatric cochlear implantation surgeries has increased significantly since 1990 [17], which necessitates a clear understanding of potential threats to overall outcomes in this population [9].

In a recent systematic literature review on prognostic indicators in pediatric CI surgery, Black et al. [10] identified only four factors influencing pediatric CI outcomes consistently, namely age at implantation, presence of inner ear malformations, as well as occurrence of meningitis and Connexin 26 GJB2 gene-related deafness. Firstly, early implantation is indisputably considered as a strong positive predictor of expressive and receptive language skills, as confirmed by a plethora of published studies [9,18–25]. Secondly, inner ear malformations are strongly associatedwith pediatric CI outcomes in terms of speech perception and expressive language skills, with children who have more severe cochlear malformations (e.g. cochlear dysplasia and common cavity) performing worse than children with less severe malformations (e.g. incomplete partition or enlarged vestibular aqueduct) [9,26–29]. Thirdly, despite the fact that the central effects associated with meningitis may impact language learning potential [30], children with postmeningitic hearing loss do appear to benefit from CIs in terms of auditory receptive abilities, provided they receive an implant early [31]. However, for children with ossified cochleae as a result of meningitis, speech perception is frequently poorer than children with non-ossified cochleae [32]. Lastly, Connexin 26 GJB2-related deafness in children with CIs appear to have lesser impacts predicting better speech intelligibility, speech discrimination and communication abilities when compared to implanted children with other etiologies of hearing loss [33–35].

Many other prognostic factors are described in literature, but only anecdotally, mostly due to small sample sizes [10]. Likewise, emerging trends in pediatric cochlear implantation such as multiple disabilities, family influences and the impact of prematurity still require further evaluation as prognostic indicators [9]. The presence of additional disabilities negatively effects the language development of implanted children [1,23,35,36]. Yet outcomes after cochlear implantation for these children with associated disabilities, even if variable, show a positive evolution in speech perception, communication abilities, social engagement and quality of life [3,37]. Problematic family environments are significantly associated with poorer speech and language outcomes [9,38]. Then again, family factors such as a high socioeconomic level [5,35,39], sufficient parental involvement in the rehabilitation process [23,40,41] and higher levels of maternal education [42] are all related to improved language outcomes. Prematurity is considered as an anecdotal prognostic factor often described in pediatric CI literature, but has not been consistently proven [43]. The same holds for other likely etiological factors or risk indicators associated with permanent childhood hearing loss, such as neonatal intensive care unit (NICU) admittance, low birth weight and assisted ventilation [44].

In recent years there has been increasing interest in outcomes of bilateral cochlear implantation, since it has become the standard of care for children with severe to profound hearing loss in developed countries [14,45]. The benefits of bilateral implantation in children are well documented in terms of improved localization [46–48] and enhanced speech recognition in quiet [49,50] and in noise [46,51,52] when compared to listening with a unilateral CI. Also recently confirmed, children with bilateral CIs have significantly better language outcomes compared to children with unilateral CIs [45,53]. However, there is still a lack of evidence regarding the effect of bilateral cochlear implantation on broader outcomes such as literacy, academic skills and overall quality of life, particularly concerning long-term outcomes [45,48,54].

Prognostication is considered as a key component in pediatric cochlear implantation. Parents will only be able to set evidence-based and achievable expectations for their children if they are guided by professionals who are able to discern the factors that will exert an adverse effect on outcomes [3,43]. Given the paucity of proven prognostic factors in pediatric cochlear implantation [43], this current work aims to identify possible predictors of outcomes and to investigate the prognostic significance of these factors, in a large caseload of pediatric CI recipients in South Africa. Since the first multichannel cochlear implantation took place in South Africa in 1986, more than 1500 individuals has been implanted at nine respective CI programs [55,56]. Therefore, this study also provides a broad depiction of the current status of pediatric cochlear implantation in South Africa and reports on an extensive range of prognostic indicators identified in an unselected group of pediatric CI recipients.

2. Materials and methods

A retrospective study of 301 pediatric CI recipients was conducted. Institutional ethics committee approval was obtained before data collection commenced.

2.1. Study population

Five South African CI programs participated in this multicenter study, from which four programs are situated in the Gauteng Province (University of Pretoria Cochlear Implant Unit, Johannesburg Cochlear Implant Program, Chris Hani Baragwanath Academic Hospital Cochlear Implant Program, Steve Biko Academic Hospital Cochlear Implant Program) and one program in the Free State Province (Bloemfontein Cochlear Implant Program). Patient files of pediatric CI recipients at participating programs were reviewed retrospectively and cross-sectional outcome measures were added during an eight month data collection period. All children ($\leq$18 years), implanted between 1996 and 2013 with a minimum of six months implant use at the time of data-collection and with data available on at least one outcome measure, were considered as eligible participants for this study. No case selection occurred and children from the complete range of educational and communication environments were included. The final sample consisted of 301 children, including eight (2.7%) children who were non-users of their CI devices (n = 301). Of the total sample, 190 (63.1%) children were implanted unilaterally and 111 (36.9%) were implanted bilaterally at the time of data collection (n = 301). All bilateral implants were performed sequentially, except for two children who were implanted simultaneously (2/111, 1.8%). The mean interval between first and second implant was 35 months (range: 1–156 months; 34.6 SD; n = 107). Characteristics of the study population are presented in Table 1. Most children (94%) were implanted with Cochlear© devices and 18 children (6%) with Med-el© devices (n = 301). With the exception of 13 children (5.3%), all children had a fully inserted electrode array in at least one cochlea (n = 243). Nine children (9/301, 3%) had explant/re-implant procedures of their 1st/only implant, while 4 children (4/111, 3.6%) with bilateral implants were reimplanted in their 2nd ear. Of the children implanted unilaterally, most (81.8%, 108/132) used bimodal amplification. Less than a third of the children (29%, 77/265) made use of assistive listening devices. Almost all children had normal hearing parents (96.4%, 268/278).

2.2. Description of variables

Regression modeling was performed to determine prognostic factors that will influence outcomes in terms of auditory