

Vaccination rates in Cochlear Implant patients: A review of paediatric recipients

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Abstract

Aim

The study aimed to investigate whether children with cochlear implants (CI) received the recommended vaccinations according to New Zealand national immunization guidelines and to report the incidence of meningitis in this population after intervention.

Methods

A retrospective review of the vaccination coverage of paediatric patients receiving cochlear implants between 2005 and 2019 was performed.

Results

Data was collected on 203 children. Evidence of immunisation against Haemophilus influenza B was documented in 94.1% of this cohort and 21.2% received the seasonal influenza vaccine. The pneumococcal conjugate vaccine was fully administered in 81.8% of children however only 16.9% of eligible children had received the pneumococcal polysaccharide vaccine. There was marked improvement in compliance to the pneumococcal conjugate vaccine once it became fully funded for CI patients.

Conclusion

Despite established guidelines, the paediatric vaccination rates were less than expected. Work is in progress to address this.

Keywords – cochlear implant, immunisation

Introduction

Cochlear implantation has revolutionised the management of sensorineural hearing loss in the paediatric population. When paired with intensive auditory habilitation, cochlear implantation provides hearing adequate for the development of receptive and expressive language so that children with bilateral severe to profound sensorineural hearing loss have the ability to be educated in a mainstream environment.

Cochlear implants (CI) have an external component that receives and processes sound, as well as an internal component that stimulates the cochlear nerve, providing the recipient with sound perception¹. The surgical placement of the internal device is typically well tolerated and accomplished in a one to two-hour procedure. The biocompatible internal device has a 15 year survival rate of 99%, which is among the highest among medical implants^{2,3}.

Complications after cochlear implantation are rare, but an increased incidence of meningitis has been observed in children with cochlear implants in comparison to age-matched children from the general population⁴⁻⁸. Reefhuis *et al* reported a greater than 30 fold increase in the risk of meningitis associated with cochlear implantation⁴. Furthermore, children with inner ear malformations, who are often candidates for CI due to the severity of hearing loss, are at higher risk for bacterial meningitis^{9,10}. Pathogens are believed to migrate along the implanted electrode from the middle ear into the inner ear which in turn communicates with CSF^{9,10}. The risk was even higher in patients who received specific cochlear implants with an associated electrode positioner^{4,5}. These devices have since been recalled.

Meningitis itself is a common cause for sensorineural hearing loss often requiring urgent cochlear implantation and children with a previous history of meningitis are also at an increased risk of developing it again. Other risk factors include very young age, immune compromise and neural prostheses such as shunts⁹.

In view of this increased risk of meningitis, a number of countries have established immunisation guidelines for patients with cochlear implants^{9,11}. The New Zealand Immunisation advisory centre recommends *Streptococcus pneumoniae*, *Haemophilus influenzae* B and annual seasonal influenza vaccinations¹². There was no public funding for cochlear implant recipients in New Zealand before June 2008 for pneumococcal vaccines,

and before July 2015 for the influenza vaccine, however, vaccines could be obtained privately.

We recently reported a low vaccination rate amongst adult cochlear implant recipients in New Zealand¹³. Those findings led to this investigation in children.

While meningitis as a complication of cochlear implantation is rare, it has significant associated morbidity and mortality¹⁴. Disease prevention is therefore imperative.

Aim

The aim of this study was to investigate the vaccination compliance in children with cochlear implants according to the National Immunisation Guidelines and compare the immunisation rates before and after the addition of the pneumococcal conjugate vaccine onto the general funding list. We also wanted to compare the uptake rates before and after the introduction of publicly funded pneumococcal polysaccharide and seasonal influenzae vaccines for CI patients as a special population group.

Additionally, the local rate of meningitis following cochlear implantation was reviewed to identify potential risk factors for developing meningitis in our population.

Study design

This is a retrospective review of data from the paediatric database of the Northern Cochlear Implant Programme (NCIP), Auckland, New Zealand and immunisation records of the National Immunisation Register (NIR)¹¹. This study was approved by the NCIP research committee and met criteria for exemption from Health and Disability Ethics Committee (HDEC) under the audit and related activity provision.

Methods

Demographic information, date of surgery and indication for surgery were obtained from a de-identified database of CI recipients from the NCIP. All paediatric patients of the NCIP born after the introduction of the NIR in January 2005 to October 2019 were identified. Events of meningitis were reviewed.

Vaccination rates pre and post introduction of vaccination funding were compared. Compliance with vaccination was determined by reviewing the number and type of vaccines administered as per schedule (Table 1).

Table 1

The current recommended vaccination coverage for cochlear implant patients in New Zealand.

Vaccine	New Zealand schedule
<p>Synflorix® (PCV10) Pneumococcal conjugate vaccine</p> <p>Pneumovax 23® (23PPV) Pneumococcal polysaccharide vaccine</p>	<p>Administered at 6 weeks, 3 months, 5 months and 15 months of age (National Immunisation Schedule since 2008)</p> <p>Up to two doses for high-risk children aged 2 years to under 18 years, or up to three doses for individuals aged 18 years or older (CI as a special group funded since 2008)</p>
<p>Haemophilus influenzae B</p> <p>Infanrix® – hexa</p> <p>Hiberix®</p>	<p>Administered at 6 weeks, 3 and 5 months (National Immunisation Schedule since 1994)</p> <p>Given as a Hib booster to infants at 15 months of age (National Immunisation Schedule)</p>
<p>Annual Influenza vaccine</p>	<p>Anyone aged 6 months to under 65 years with a medical condition that increases their risk of acquiring influenza or developing complications from influenza (CI as a special group funded since 2015), Funded for all individuals aged 65 or older</p>

Analysis

Results were compiled and calculated using Microsoft Excel software.

Results

The NCIP paediatric database contained information on 266 children who underwent cochlear implantation before the age of 18 years of age; sixty-three of these children were born prior to the introduction of the National Immunisation register in January 2005. Therefore, a total of 203 CI recipients were included in the study. There were 108 (53.2 %) males and 95 (46.8%) females. The mean age at the time of surgery was 8.1 years (range of 9 months to 15 years). Ethnicity data is displayed in table 2 below.

Vaccinations

A total of 191 (94.1%) children were immunised against Haemophilus Influenzae B (HiB), 4 children missed their booster (Hiberix[®]) at 15 months of age. Forty-three children (21.2%) received the influenza vaccine but 160 had no evidence of influenza immunisation. The pneumococcal conjugate vaccine was administered in 166 children (81.8%), however only 33 of 195 (16.9%) eligible children (age>2years) received the pneumococcal polysaccharide vaccine. Only 20 out of 195 eligible children (10.3 %) received the pneumococcal conjugate, pneumococcal polysaccharide, Infanrix[®] – hexa, Hiberex[®], and influenza vaccines. Three parents declined all vaccinations and an additional 2 declined the HiB and pneumococcal conjugate vaccines at 15 months of age. A greater number of parents declined the yearly influenza vaccines.

There were 2 incidences of meningitis among this population (N=203) post implantation.

Table 3 shows a comparison between the vaccination coverage of children that had their first implant before and after the introduction of funded vaccines for cochlear implant recipients.

Table 2

Vaccination rates according to ethnicity

	Total (n)	HIB	PCV	PPV	Influenza
Maori	48	45 (94%)	37 (77%)	4(8%)	7 (15%)
European	80	75 (94%)	67 (84%)	20 (25%)	24 (30%)
Pacific Islander	21	21 (100%)	17 (81%)	2 (10%)	4 (19%)
Asian	44	42 (95%)	38 (86%)	7 (16%)	7 (16%)
Other*	10	8 (80%)	7 (70%)	0 (0%)	1 (10%)

* Includes African, Latin American and Middle Eastern ethnicities

Table 3

Vaccination compliance before and after the introduction of funded vaccines

Vaccine	Pre-Funding	Post-Funding
Pneumococcal conjugate vaccine (added to schedule in June 2008)	26/59 (44.1%)	140/144 (97.2%)
Pneumococcal polysaccharide vaccine (funded from July 2008)	11/61(18%)	22/134 (16.4%)
Influenza (funded from July 2015)	23/111 (20.7)	20/92 (21.7%)

Immunisation events can also be retrospectively added to the NIR. Of the 63 patients born prior to the launch of the NIR in January 2005, 15 (23.8%) had a record of Haemophilus influenzae vaccination, 17 (26.9%) for seasonal influenza, 13 (19.7%) for pneumococcal conjugate vaccine and 7 (11.1%) for pneumococcal polysaccharide vaccine.

Discussion

The New Zealand NIR provides a comprehensive record where children are registered at birth. Less than 1% of parents and guardians choose to opt out of this process. The NIR is updated directly by recognised immunisation providers following an immunisation event¹⁵. HiB vaccination has been part of the National Immunisation Schedule since 1994 and the pneumococcal conjugate vaccination was added to the schedule in June 2008. It is of no surprise that once the pneumococcal conjugate vaccination became fully funded, the vaccination rate improved markedly from 44.1% before June 2008 to 97.2% after June 2008.

The overall immunisation coverage was low with only 10.3% receiving a complete schedule of Haemophilus Influenzae, Streptococcus Pneumoniae and Influenza vaccine.

There are limited studies on vaccination compliance in cochlear implant patients. Piotrowska *et al* observed a 49.2% streptococcal pneumonia vaccination rate despite the vaccine being mandatory and publicly funded for CI patients in Poland¹⁶. A recent Spanish study showed that only 5.71% of the CI patients had 100% compliance to their vaccination schedule. Their paediatric population had pneumococcal conjugate and Haemophilus influenzae B vaccine compliance rates of >90%¹⁷. This is comparable to our findings following the introduction of additional funding of vaccinations for cochlear implant recipients.

In the US, Carpenter *et al* found improvement in pneumococcus vaccination rates ranging from 49% to 99% across various population groups following various methods of information dissemination and reminders¹⁸. Volsky *et al* observed a 70% pneumococcal vaccination compliance. The most important factor appeared to be encouraging patients to vaccinate prior to surgery¹⁹.

The majority of meningitis cases following cochlear implantation reported in the literature were related to Streptococcus pneumoniae and Haemophilus influenzae type B, two of the most common causative agents in acute bacterial otitis media. Acute otitis media is the most likely cause for meningitis beyond the first 30 days following cochlear implantation due to bacterial spread along the pathway of the electrode²⁰. Seasonal influenza vaccine has been shown to reduce the incidence acute otitis media^{21,22}. Pneumococcal infections predominantly affect children younger than 2 years of age and

adults above the age of 60²³. These two groups account for the overwhelming majority of cochlear implant recipients.

Our first meningitis case occurred within 3 weeks following cochlear implant surgery and it was secondary to a non-typeable *Haemophilus influenzae* infection. This is suggestive of a surgical/patient related factor as opposed to acute otitis media. The patient also had an inner ear malformation. Unfortunately an effective vaccine against non-typeable *Haemophilus influenzae* is not currently available. Our second patient required a cochlear implant due to bilateral profound sensorineural hearing loss following recurrent streptococcus pneumonia meningitis. This patient had an associated inner ear dysplasia.

Cost is a well-recognised barrier to access to health care. Free vaccination is provided to New Zealand residents according to the National Immunisation Schedule and as expected our study showed a clear improvement in compliance with pneumococcal conjugate vaccination following additional funding for CI patients as a special group and its subsequent addition to the National Immunisation Schedule. However, we did not observe a similar increase in the uptake of yearly influenza and pneumococcal polysaccharide vaccination. As such, this raises the possibility of a lack of awareness of vaccination guidelines for cochlear implant recipients. The findings of this study are different to those observed in our adult cohort¹² as the majority of adult CI recipients received their childhood vaccinations before *haemophilus influenzae* B and pneumococcal conjugate vaccination were added to the National Immunisation Schedule. Compared to adults our paediatric patients had lower coverage with vaccines usually indicated for adults over the age of 65 years (Seasonal influenza and pneumococcal polysaccharide vaccination). Individuals under the special group provision, including cochlear implant recipients, have not been extensively studied for their compliance with recommended vaccines. The overall influenza vaccine uptake for adults older than 65 years was only 56% in 2018 despite being eligible for funded vaccines²⁴. A survey of 101 pregnant women carried out at Wellington Hospital, New Zealand showed a 76% influenza vaccine uptake rate. The primary reason for vaccination was neonatal protection. The most common reasons given for non-compliance was not receiving information about the vaccine or not receiving the vaccine²⁵.

The literature suggests that a lack of knowledge on influenza disease and vaccine represents the biggest barrier to vaccination. This revolves around concerns about vaccine safety, doubts about its effectiveness and the misconception that influenza is not a serious condition^{26,27}. Seasonal Influenza can cause severe illness and even death in high risk individuals. Unfortunately, it is often confused with the common cold despite being responsible for 490,600 hospitalizations and 34,200 deaths in the US during the 2018-2019 season²⁸.

The use of reminders and recall systems has been associated with an improvement in influenza vaccination rates²⁹. In addition, some cochlear implant programmes have recruited an infectious disease vaccine specialist to help address their low compliance and this has resulted in a substantial improvement in compliance³⁰. These are options that we are considering.

An underestimation of the true impact of funded vaccines is a potential limitation of this study because we excluded children born before the NIR was introduced in 2005. Most of these children had no data available on Hib coverage which is usually administered in the first 15 months of life. Hib vaccination has been part of the National Immunisation Schedule since 1994 hence these children were probably vaccinated before 2005 but not recorded. On the other hand, funding for pneumococcus and influenza vaccination was initiated in 2008 and 2015 respectively and some are missing out on these vaccines.

In conclusion, despite established vaccination guidelines the Northern Cochlear Implant Programme paediatric vaccination rates among children who are cochlear implant recipients were lower than expected. Work needs to be done to address this. A letter from NCIP has been drafted to be sent to general practitioners regarding the availability and requirement of these vaccines for children whose immunisations are not up to date. Furthermore, we also plan to add vaccination coverage to our database at the NCIP and implement a formal process to check and ensure that the appropriate vaccines have been administered. We will also recommend and document vaccination before cochlear implant surgery on our patients.

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Summary

What is already known on the subject

- Children with cochlear implants have a higher incidence of meningitis compared to the general population
- Risk factors included inner ear malformations and very young age
- There is an unsatisfactory vaccination rate in these high risk patients

What the paper adds to our understanding

- The positive impact of adding recommended vaccines to the publicly funded national immunisation schedule
- The complexities of improving compliance to fully funded vaccines that are not part of the national immunisation schedule