Section: Anesthesia

Case Series

PERIOPERATIVE ANAESTHETIC MANAGEMENT FOR PAEDIATRIC COCHLEAR IMPLANTS: INSIGHTS FROM A CASE SERIES

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ABSTRACT

Background: Cochlear implants are a standard treatment for irreversible hearing loss and deaf-mutism, with anaesthesia playing a key role due to the surgery's complexity. Many patients have associated syndromes that may pose anaesthetic challenges, such as difficult airways or cardiac issues. Preoperative evaluation includes hearing tests, skull X-rays, and temporal bone CT scans, often requiring anaesthesia in young children. Familiarising with the patient and family before surgery helps reduce anxiety, and parental presence during induction is beneficial. Once the implant is placed, monopolar electro-surgical instruments should be avoided.

Materials and Methods: At our institution, 56 children underwent cochlear implantation under general anaesthesia. Midazolam and ketamine were given during the CT scan. Anaesthesia was tailored to allow nerve stimulator use, with glycopyrrolate and fentanyl administered pre-induction to reduce vertigo and nausea. Propofol, atracurium and sevoflurane (1.3 MAC in 1:2 O_2: N_2O) were used for maintenance, and electrocautery was stopped before implant insertion. Patients breathed spontaneously during facial nerve monitoring. Ondansetron (0.1 mg/kg) was given for antiemesis, and postoperative pain was managed with IV fentanyl (1 µg/kg) followed by oral ibuprofen.

Results: Recovery was uneventful and no significant anaesthetic or surgical complications were observed in our series except bronchospasm in 3 cases and postoperative nausea and vomiting in 5 cases.

Conclusion: Thorough assessment, careful anaesthesia, and teamwork are essential for safe and successful cochlear implantation.

Keywords: Anaesthesia technique; Cochlear implantation; Deaf-mutism.

INTRODUCTION

Cochlear implants are primarily indicated for individuals with severe to profound sensorineural hearing loss. These devices work on the principle that, in the majority of both congenital and acquired cases, the cochlear nerve retains enough function to be stimulated directly through electrical signals. In children born with hearing impairment, early intervention—ideally before 30 months of age—is crucial to support optimal speech and language development.[1]

The surgical technique for cochlear implantation necessitates a multidisciplinary team approach, with anaesthesia playing a key role in maintaining a bloodless surgical field and ensuring stable intraoperative hemodynamics. Given the complexity and cost of the procedure, the anaesthesiologist's contribution is vital to optimizing surgical conditions and improving overall outcomes.[2]

Anaesthesiologists face several challenges during cochlear implant surgery, including prolonged anaesthesia duration, the need to create optimal conditions for nerve stimulation, maintaining a bloodless surgical field, and effectively managing postoperative nausea and vomiting (PONV).[3]

This paper outlines key technical aspects of cochlear implant surgery and shares our anaesthetic experience based on a series of cases performed to date. A brief review of the relevant literature is also included.

MATERIALS AND METHODS

This retrospective study was conducted by analysing the medical, surgical, and anaesthetic records of all children (up to 6 years of age) who underwent cochlear implantation at our institute over the past five years. The analysis included preoperative evaluations, surgical details, anaesthesia protocols, and perioperative complications.

Preoperative Assessment: All children selected for cochlear implantation underwent comprehensive audiological evaluation along with high-resolution CT and MRI of the temporal bone. During the pre-anaesthetic assessment, medical comorbidities were ruled out, and efforts were made to establish rapport with the child. Particular attention was paid to identifying any congenital anomalies, QT interval prolongation, chronic ear infections (such as chronic suppurative otitis media or labyrinthitis due to meningitis), and anaemia. Age-appropriate immunizations were ensured according to national guidelines and updated at least two weeks prior to surgery.

Surgical Technique: The standard surgical approach involved a post-auricular incision, creation of an implant bed over the mastoid bone, and insertion of the electrode after achieving meticulous haemostasis. Facial nerve preservation was a key priority during the procedure.

Aesthetic Technique: All patients received general anaesthesia. No premedication was administered. Standard intraoperative monitoring included electrocardiogram (ECG), pulse oximetry, end-tidal CO_2 ($EtCO_2$), temperature and non-invasive blood pressure (NIBP).

- **Premedication and Induction:** Intravenous glycopyrrolate (4 µg/kg) and fentanyl citrate (2 µg/kg) were administered prior to induction. Anaesthesia was induced with propofol (2.5 mg/kg) and muscle relaxation was achieved using atracurium (0.5 mg/kg IV). Endotracheal intubation was performed with an appropriately sized tube, and bilateral air entry was confirmed before securing the tube.
- **Maintenance:** Anaesthesia was maintained with sevoflurane in a 1:2 mixture of oxygen and nitrous oxide. Fentanyl was repeated intraoperatively as required. Maintenance fluids consisted of N/5 saline in 5% dextrose.

To attenuate the pressor response to intubation and maintain intraoperative hemodynamic stability, dexmedetomidine (1 µg/kg) was administered just before intubation. Patients were positioned for mastoidectomy, and electro diathermy was switched off before device implantation.

To facilitate intraoperative facial nerve stimulation, the muscle relaxant effect was weaned off using Train-of-Four (TOF) monitoring, and anaesthesia was temporarily maintained with a propofol infusion during this period.

- **Hemodynamic and Thermal Management:** Mild hypotension was maintained primarily with inhalational agents to reduce bleeding and provide a clear surgical field. Warming blankets were used throughout the procedure to prevent hypothermia.
- **Postoperative Nausea and Vomiting (PONV):** A combination of ondansetron (0.1 mg/kg) and dexamethasone (0.15 mg/kg) was administered prophylactically to reduce the risk of PONV.
- **Reversal and Extubation:** At the end of surgery, muscle relaxation was reversed using neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg).

Postoperative Care: Postoperative pain relief was initiated with intravenous fentanyl (1 µg/kg), followed by oral ibuprofen syrup (10 mg/kg) as needed. All patients were observed in the recovery unit for 24 hours to monitor for any surgical or anaesthetic complications.

The average duration of surgery was approximately 4 hours.

RESULTS

Table 1: Demographic characters of patients

Parameter	Mean (n=56) ±SD
Gender%	
Male	48
Female	52
Weight in kg	15.41±0.29
Age in years	3.5±0.5
Duration of surgery in minutes	240±40

The study included 56 paediatric patients with a balanced gender distribution (48% male, 52% female). The mean age was 3.5 years (±0.5), appropriate for early cochlear implantation, and the average weight was 15.41 kg (±0.29), indicating a generally healthy cohort. The average surgery duration was around 4 hours (240 ± 40 minutes), reflecting the procedure's complexity and need for precise surgical and anaesthetic management.

Table 2: Perioperative complications

Complications	No of patients(n=56)	Percentage%
Fever	Nil	0
PONV	5	8.9
Bronchospasm	3	1.68
Hematoma	Nil	0
Leak	Nil	0

The perioperative complications were minimal in this study. Postoperative nausea and vomiting (PONV) was the most common issue, occurring in 8.9% of patients, while bronchospasm was seen in 5.4%. No cases of fever, hematoma, or cerebrospinal fluid leak were reported, indicating effective surgical and anaesthetic management with a low complication rate.

Table 3: Special preoperative history considerations

Special history considerations	No of patients (n= 56)	Percentage %
Convulsion	4	2.24
NICU/PICU admission	3	1.68
Low birth weight	6	3.36
ECG changes	11	6.16
h/0 congenital heart disease	3	1.68
h/o congenital developmental defects	4	2.24
Phimosis	1	0.56
Allergy to drugs and any other	1	0.56
Delayed milestones	5	2.80

A notable number of patients had special preoperative considerations, with ECG changes being the most common (19.6%), followed by low birth weight (10.7%) and delayed milestones (8.9%). Other conditions such as convulsions, congenital heart disease, and developmental defects were present but less frequent. These findings highlight the importance of thorough preoperative evaluation to address potential risks in this paediatric population.

DISCUSSION

Patients with bilateral severe to profound sensorineural hearing loss (SNHL) often gain limited benefit from conventional hearing aids. In such cases, cochlear implantation offers an effective option for auditory rehabilitation in both children and adults.4 Since this type of deafness usually results from damage to the sensory structures within the cochlea, the implant bypasses these damaged areas by directly stimulating the auditory nerve, thereby restoring sound perception.[5]

Some children have residual hearing at birth, providing them with greater access to sound before cochlear implantation, which may benefit older patients with residual hearing.[6] However, implantation before 12 months of age is associated with faster development of auditory skills and earlier acquisition of oral communication. Although the mean age in our series was 3.5 years—somewhat higher than ideal—it is expected that increased awareness will encourage parents to seek intervention earlier in the future.

Candidates for cochlear implantation should meet specific diagnostic criteria and are preferably over two years of age, as the facial ridge is better developed in older children, facilitating facial nerve identification. The child must have an implantable cochlea and be medically fit for surgery. Conditions such as labyrinthitis from meningitis or chronic suppurative otitis media can complicate the procedure and may be contraindications. Other important medical exclusions include uncontrolled otitis media, autism, severe intellectual disability, and central nervous system disorders that could impair auditory pathways and speech perception.[3]

Preoperative counselling is crucial; patients and their families must be well-informed and motivated, with realistic expectations about the surgery's outcomes.

Preoperative evaluation involves assessing the extent of hearing loss, with parental history playing a crucial role. Some children presenting for cochlear implantation may have underlying congenital syndromes, such as Stickler or Klippel-Feil syndrome, contributing to their sensorineural hearing loss.[7] These conditions are often linked to difficult airways, necessitating careful preoperative assessment. Congenital sensorineural deafness may also be associated with QT interval prolongation, either alone or as part of Jervell and Lange-Nielsen syndrome, making preoperative ECG screening essential. About 50% of hearing loss cases are acquired, commonly due to perinatal infections from TORCH organisms. In our series, all cases had deafness of unknown cause.[3]

Preoperative assessment includes psychological testing to exclude organic brain dysfunction, intellectual disability, and undiagnosed psychosis. It is essential to rule out retro cochlear hearing loss and confirm that the child's communication difficulties cannot be managed with hearing aids. For candidates with severe to profound hearing loss, further evaluation involves objective hearing tests, skull X-rays, and high-resolution CT (HRCT) scans of the temporal bone. HRCT helps assess cochlear patency, detect ossification (especially post-meningitis), evaluate mastoid pneumatization, middle ear fluid, and congenital inner ear anomalies. Vision assessment is also important; for example, children with congenital cataracts linked to Usher syndrome should have vision corrected to optimize lip-reading during postoperative rehabilitation.[8]

Preoperative evaluation should assess developmental milestones and neurological status. Basic measurements such as height, weight, blood pressure, and head circumference must be recorded. Examination of the skull and head-neck region helps identify conditions like macrocephaly, microencephaly, craniosynostosis, cerebral palsy, congenital syphilis, microphthalmia, cataracts, cranial nerve palsies, and cutaneous lesions. Certain physical signs, such as a whorl hair pattern or

abnormal palmar creases, may indicate cerebral malformations or Down's syndrome, respectively. Routine investigations are not mandatory but a complete blood count and blood grouping are recommended; specific tests like ECG or renal function should be performed in syndromic cases.

Facial abnormalities may suggest difficult airway management, as seen in Treacher Collins syndrome, while eye disorders could be part of Usher syndrome. Klippel-Feil anomaly involves cervical vertebrae fusion, complicating tracheal intubation. Alport syndrome is linked to renal and endocrine issues, and Pendred syndrome presents with goitre and metabolic disturbances. Children with congenital hearing loss may have Jervell and Lange-Nielsen syndrome, characterized by syncopal episodes and prolonged QT interval on ECG, necessitating beta-blocker treatment before surgery to prevent arrhythmias.[3]

Cochlear implants have been successfully done under local anaesthesia without any adverse effects on the implants.[9] At our centre, all cochlear implant procedures were performed under general anaesthesia due to the evolving nature of the surgery and its lengthy duration. Additionally, local anaesthesia requires patient cooperation, which is often difficult to obtain in paediatric patients. For CT scans, all children received intravenous midazolam (0.5 mg/kg) and ketamine (1 mg/kg). Our general anaesthesia protocol was adjusted to allow the use of nerve stimulators during the operation and to reduce the risk of vertigo, especially following cochleostomy, as well as to minimize postoperative nausea and vomiting. Brainstem Evoked Response Audiometry (BERA) was conducted at the conclusion of surgery to assess function and integrity of the implant.

Establishing a good rapport with the patient and their family before surgery is essential, as it builds trust and facilitates communication during the postoperative period, although challenges in communication with deaf-mute patients should always be anticipated.[10]

Parental presence during anaesthesia induction is highly beneficial, as communication barriers with deaf-mute children can make establishing rapport challenging. Like other children, these patients experience fear of unfamiliar environments, separation, pain, and physical discomfort. Having a parent nearby significantly reduces separation anxiety and decreases distress during induction. Both gaseous and intravenous induction methods are appropriate, with the choice of anaesthetic agents guided by concerns about postoperative nausea and vomiting. Standard intraoperative monitoring is employed throughout the procedure.

Active warming with forced-air devices may be necessary if there are concerns about temperature regulation due to low ambient temperatures or other factors. While blood loss during surgery is usually minimal, it can be significant if a large mastoid emissary vein is present, which should be identified preoperatively through X-rays or CT scans. To minimize bleeding, mild hypotension and mild hypocapnia can be maintained during surgery.

Facial nerve identification is critical during the procedure and is typically achieved using a nerve stimulator. This requirement limits or excludes the use of muscle relaxants, necessitating an appropriate anaesthetic technique. Because the cochlear implant is an electronic device, static electricity discharge can damage its components or interfere with the speech processor's programming. Therefore, electrosurgical instruments must be avoided once the implant is in place. Although this restriction may limit haemostasis due to the inability to use cautery, bleeding is generally manageable. Complete haemostasis is essential during electrode array insertion, and monopolar cautery is contraindicated once the electrode is inserted.

At the end of the surgery, the function and integrity of the implant are verified through Brainstem Evoked Response Audiometry (BERA) or electrically evoked stapedius reflex testing. During these tests, inhalational anaesthetic concentration should be minimized, and fluctuations in blood carbon dioxide levels must be avoided to ensure accurate results.

Common postoperative complications include flap-related issues, delayed facial nerve palsy, dizziness, and, rarely, electrode migration. Ear surgery is known to have a high incidence of postoperative nausea and vomiting (PONV), reported between 40-50% in comparison to other head and neck procedures.[11] However, in our series, the incidence was notably low at 8.9%. Factors contributing to higher PONV rates include younger patient age, longer surgical duration, direct stimulation of the vestibular system during drilling near the inner ear, and suction irrigation, which can act as a caloric vestibular stimulus.

Preventing PONV is important not only for patient comfort but also because persistent vomiting can compromise the surgical site. Both ondansetron and dexamethasone are effective in preventing PONV, with their combination providing enhanced efficacy.[12] TIVA also reduces early PONV.[13]

CONCLUSION

Cochlear implantation is a complex and specialized procedure where the anaesthesiologist's understanding of potential challenges and ability to manage communication barriers in paediatric patients is crucial. Given the high cost of the implant and the expectations for successful outcomes, meticulous care is essential. The key to success lies in thorough preoperative assessment, careful and appropriate anaesthetic management, and effective collaboration between the surgical and anaesthesia teams throughout the perioperative period to minimize complications and optimize results.

Declaration of Patients' Written Informed Consent: The authors confirm that written informed consent was obtained from the parents of all

paediatric patients for the use of clinical information and images in this publication. The parents/patients were informed that their names and initials would not be published and every effort would be made to maintain anonymity, although complete confidentiality cannot be guaranteed.

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