



Anaesthetic Management for Cochlear Implantation in paediatric patients

Essay

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By

**Fatema Abdulkareem Abdu Shrf Alhamade
*M.B.B.CH. Sana'a University***

Under Supervision of

Prof. Dr. Rafaat Abdel-Azim Hamad

***Professor of Anaesthesia, Intensive Care and Pain Management
Faculty of Medicine, Ain Shams University***

Dr. Amal Hamed Rabie

***Lecturer of Anaesthesia, Intensive Care and Pain Management
Faculty of Medicine, Ain Shams University***

Dr. Wahba Zakaria Wahba

***Lecturer of Anaesthesia, Intensive Care and Pain Management
Faculty of Medicine, Ain Shams University***

Faculty of Medicine

Ain Shams University

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List of Abbreviations

CI : Cochlear Implant

ECF : Extracellular fluid

ESRT : Evoked stapedius reflex threshold

FRC : Functional residual capacity

GFR : Glomerular filtration rate

Hb : Haemoglobin

HbF : Fetal Hb

HL : Hearing Loss

ICF : Intracellular fluid

LMA : Laryngeal mask airway

MAC : Minimum alveolar concentration

MRI : Magnetic resonant image

PACU: Post-anaesthesia care unit

P₅₀ : O₂ tension at which haemoglobin is 50% saturated

PONV : postoperative nausea and vomiting

SNHL : Sensorineural Hearing Loss

TIVA : Total intravenous anaesthesia

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Introduction

The cochlear implantation surgery has gained popularity over the last decade and thus the attending anaesthesiologist is faced with the responsibility of safely conducting the surgery. The anaesthetic technique used may have implications on the method of stimulation of the electrodes of the cochlear implant intraoperatively. Moreover, most of these patients are children and it is the responsibility of anaesthesiologist to prevent any agitation and to ensure smooth induction and emergence from anaesthesia. A close cooperation between the anaesthesiologist and surgeon is essential for a positive outcome (*Sukhminder & Ashish, 2013*).

A cochlear implant is an electronic device which is used to restore hearing in patients with bilateral severe sensorineural deafness in order to provide improved communication abilities. These electronic devices have an ability to transform speech and other sounds into electrical signals used to stimulate the existing fibers of auditory nerve in the inner ear. These are different from usual hearing aids in that these devices do not just amplify the sounds, but actually stimulate the auditory nerve (*Pedersen et al., 2000*).

Cochlear implants are very expensive electronic devices which need a careful surgical technique to place the internal compressor assembly within the mastoid antrum and connect the electrodes to the cochlear neurons. The surgical technique requires a team

approach which includes use of such anaesthetic technique so as to maintain a bloodless surgical field with stable intraoperative haemodynamics. As such role of the anaesthesiologist is crucial during such expensive surgical procedures for a better outcome (***Sukhminder & Ashish, 2013***).

With the implementation of neonatal hearing screening, children are being identified as cochlear implant candidates below 12 months of age (***Miyamoto et al., 2008***). Children who receive a cochlear implant before 12 months of age can develop language skills at a rate more comparable to normal-hearing children (***Ching et al., 2009***).

Preoperatively, it is essential to screen for the presence of various congenital syndromes leading to deaf-mutism as the systemic involvement in these syndromes may affect the anaesthetic management. Also, the various types of dysplasia of temporal bone and cochlea associated with these syndromes may render the surgeons to change the surgical technique of cochlear implantation (***Baidya & Dehran, 2011***).

Total intravenous anaesthesia, locoregional anaesthesia, newer induced hypotension techniques, and advent of newer drugs in anaesthesia practice including newer sedative agents and many other techniques and drugs have allowed even complicated surgical procedures to be performed with a great ease (***Sukhminder & Ashish, 2013***).

Normal intraoperative findings provide immediate reassurance to the implant team and parents of young children that the implant is fully functioning and that electrical stimulation is activating the auditory pathways. These objective measures also identify potentially challenging cases, such as those with low levels of sensitivity to electrical stimulation and susceptibility to facial nerve stimulation. An audit showed that intraoperative measures provided valuable assistance in the initial fitting of the device (**Mason, 2004**).

Otologic surgical procedures are associated with facial nerve paralysis, and thus facial nerve protection is an important consideration. Preservation of the facial nerve can be easily confirmed if the patient is not paralyzed, but use of muscle relaxants compromises the interpretation of evoked facial electromyographic activity. Since any sudden movement could jeopardize surgery, it has been suggested that partial neuromuscular blockade as determined by train-of-four peripheral nerve stimulation be used (**Cai et al., 2009**).

At the end of surgery, the integrity of the implant is checked by brain stem auditory evoked responses and by electrically evoked stapedius reflexes. This is very essential for postoperative fitting of external speech processor which may be difficult in small children postoperatively (**Sukhminder & Ashish, 2013**).

The major postoperative concern in cochlear implant surgery is the prevention of PONV. The various measures employed are

adequate anxiolysis preoperatively, use of total intravenous anaesthesia with propofol, avoidance of prolonged starvation, avoidance of nitrous oxide, providing adequate hydration, administration of antiemetics like ondansetron 0.1 mg/kg intravenously at the end of surgery, and the use of dexamethasone 0.15 mg/kg intravenously at the beginning of surgery (**Gombar et al., 2007; Bajwa et al., 2011b**).

Aim of the work

The aim of this work is to provide an updated review of the role for the anaesthetist during cochlear implantation in paediatric patients.

Anatomy and Physiology of Human Ear

The ear consists of three parts: the outer ear; the middle ear; and the inner ear.

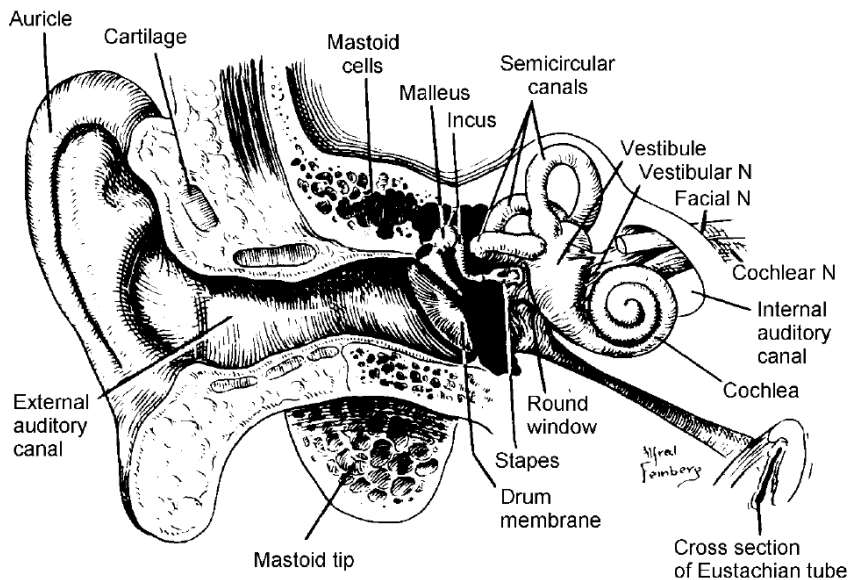


Figure 1: Human ear (Alberti, 1995).

The outer ear consists of the auricle and the ear canal. The skin of the ear canal is innervated by four cranial nerves: the trigeminal; the facial; the glossopharyngeal; and the vagus nerves.

The middle ear consists of the tympanic membrane and three ossicles: malleus; incus; and stapes. Two muscles are attached to the ossicles: the tensor tympani to the manubrium of malleus; and the stapedius to the stapes. The tensor tympani muscle is

innervated by the trigeminal nerve and the stapedius muscle is innervated by the facial nerve.

The inner ear consists of two parts: the vestibular apparatus for balance; and the cochlea for hearing.

The cochlea in humans has a little more than 2½ turns. It has three fluid-filled compartments: the scala tympani; scala media; and the scala vestibuli. The basilar membrane separates the scala media from the scala tympani and Reissner's membrane separates the scala vestibuli from the scala media (Møller, 2006).

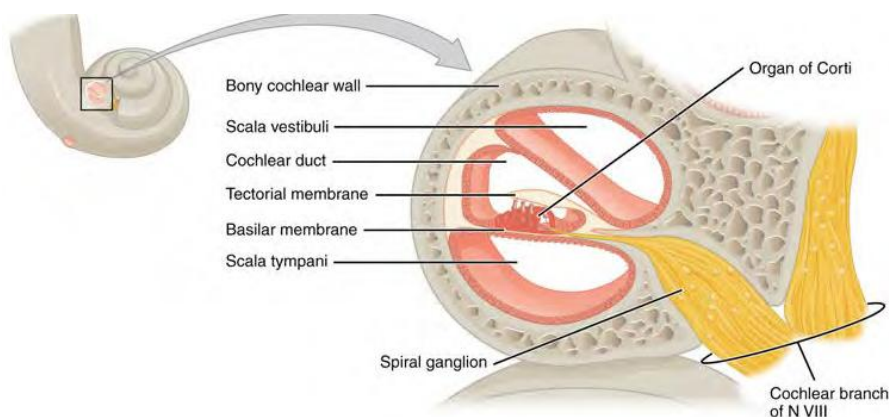


Figure 2: Cross Section of the Cochlea. The three major spaces within the cochlea are highlighted. The scala tympani and scala vestibuli lie on either side of the cochlear duct. The organ of Corti, containing the mechanoreceptor hair cells, is adjacent to the scala tympani, where it sits atop the basilar membrane (OpenStax College, 2013).

The cochlear duct contains several organs of Corti laying on top of the basilar membrane, they contain hair cells, which are

named for the hair-like stereocilia extending from the cell's apical surfaces. The stereocilia are an array of microvilli-like structures arranged from tallest to shortest. Protein fibers tether adjacent hairs together within each array, such that the array will bend in response to movements of the basilar membrane. The stereocilia extend up from the hair cells to the overlying tectorial membrane, which is attached medially to the organ of Corti (*OpenStax College, 2013*).

Hair cells are organized along the basilar membrane in one row of inner hair cells and 3–5 rows of outer hair cells. Each inner hair cell is innervated by many (type I) auditory nerve fibers, while each (type II) nerve fiber innervates many outer hair cells (*Møller, 2006*).

Sound Conduction to the Cochlea

The outer and middle ears serve to conduct and amplify the sound signal. The pinna presents a fairly large surface area and funnels sound to the smaller tympanic membrane; in turn the surface of the tympanic membrane is itself much larger than that of the stapes foot plate, so there is a hydraulic amplification: a small movement over a large area is converted to a larger movement of a smaller area. In addition, the ossicular chain is a system of levers which serve to amplify the sound. The outer and middle ears amplify sound on its passage from the exterior to the inner ear by about 30 decibels (*Alberti, 1995*).