

Intraoperative surgical findings and difficulties of pediatric cochlear implantation

Hazim Mohammed Khudhair[#], FICMS (ENT) MD-CABS (ORL-HNS), Yaseen Adeeb Sakran[†], FICMS, Ibraheem Abdul-Elah Noori[‡], MB. ChB. And Maha Faeq Majeed^{*}, FICMS

[#]Medical City: Ghazi Al-Hariri Surgical Specialties Hospital, Baghdad, Iraq

^{*}Al-Salam PHCC of Family Medicine, Baghdad, Iraq

[†]Al-Yarmook Teaching Hospital, Baghdad, Iraq

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Abstract

Objective: To assess the intraoperative surgical findings and difficulties of cochlear implantation in preschooler age group and how to overcome these difficulties.

Aims of the study: 1. To assess the intraoperative findings and difficulties of cochlear implantation in preschooler age group. 2. How to overcome these difficulties.

Study design: Cross sectional study.

Setting: This study was conducted in the department of otolaryngology in Al-Yarmook teaching hospital in Baghdad, from (April /2008) to (February /2015).

Patients selection: 426 patients between (18) months to the end of (6) years old, who had severe to profound S.N.H.L. were selected after no hearing improvement occurred with wearing of hearing aids for at least 6 months. A multidisciplinary team (otolaryngologist, audiologist, radiologist, pediatrician, psychiatrist, neurologist) was selected for assessment of the patients and subject them for the candidacy of patient for cochlear implantation, any patient not fulfilled the criteria of assessment was excluded. Unilateral cochlear implantation was done for all the patients. Data regarding the surgical findings and difficulties is designed according to the surgical steps of cochlear implantation (mastoidectomy, bone well setting, posterior tympanotomy, middle ear cavity and cochleostomy or round window approach).

Results: The most common age group was 3-4 years. The study showed that (54%) of patients were females, while (46%) of patients were males, female to male ratio was 1.2:1. The most frequent finding and difficulty during mastoidectomy for cochlear implantation was presence of Koerner's septum (29.81 %) while in bony well drilling, dural exposure (31.7%) was the most frequently encountered. During posterior tympanotomy, the most common finding was non-pneumatized antral threshold angle (40%). In the middle ear eight patients (1.87%) found to have O.M.E. The most common surgical finding and difficulty during cochleostomy or round window approach was abnormal round window niche position in postero-inferior direction (9.154%). The majority of these findings and difficulties had been overcome during surgery and successful C.I. was done for the patients, while only few cases were postponed.

Conclusion: 1- Cochlear implantation surgery had multiple steps with large number of difficulties, but most of these difficulties can be managed during surgery without complications. 2- Good assessment of patients by otolaryngeal examination, radiological and audiological investigations with good experience and multidisciplinary team work make cochlear implantation surgery with low rate of complications.

Keywords: Pediatric cochlear implantation, mastoidectomy, tympanotomy and cochleostomy

Introduction

Cochlear implantation is multi-step surgery with large number of difficulties, but most of these difficulties can be managed during surgery without complications. Dural exposure and C.S.F. leak can occur during housing of the receiver in subject with insufficient bone thickness, also during thinning of tegmen tympani and tegmen mastoideum in mastoidectomy.⁽¹⁾

Mastoid sclerosis occurs in perhaps 20 % of adult temporal bones and is seen in individuals with chronic ear

disease. The mastoid antrum may be the only air-filled space in the mastoid process when the name acellular or sclerotic is applied⁽²⁾. Korner septum is a petro-squamous lamina, a bony plate separating the mastoid air cells at the level of antrum into petrous part and squamous part, it starting from the posterior aspect of the glenoid fossa and extends above the level of the middle ear cavity courses in an inferior direction lateral to the facial canal and proceeds to mastoid apex⁽³⁾.

Otitis media with effusion (OME) is the chronic accumulation of mucus within the middle ear and

sometimes the mastoid air cell system, often following an upper respiratory tract viral infection⁽⁴⁾. Anterior displaced sigmoid sinus is a dural venous sinus, could be either posteriorly enlarging the Trautman's triangle or anteriorly diminishing the size of the Trautman's triangle or medially that also reduce Trautman's triangle⁽⁵⁾. Chorda tympani nerve originates from the facial nerve with anatomical sites in variation.

(1) Proximal 3rd of the mastoid segment of the facial nerve, it is usually at the level of the pyramidal eminence.
 (2) Middle 3rd of mastoid segment of facial nerve.
 (3) Distal 3rd of mastoid segment of facial nerve about 3mm proximal to the stylomastoid foramen. (4) Extra temporal origin it travels in its own canaliculus parallel to facial canal (rare)⁽⁶⁾. Rohrt and Lorentzen classified facial nerve displacement in the middle ear into four groups: 1. Facial nerve partially obliterates the stapes footplate; 2. Bifurcation of the facial nerve; 3. Facial nerve rests on the footplate with deformed stapes or oval window; 4. Facial nerve rests on the promontory⁽⁷⁾. Persistent stapedia artery traverses Jacobsen's canal for a short segment, exits at the promontory, passes through the stapes obturator foramen and enters the Fallopi canal close to the cochleariform process, then passes anteriorly, exiting the canal at the geniculate ganglion and passes into the extradural space of the middle cranial fossa, where it gives rise to the middle meningeal artery⁽⁸⁾.

High jugular bulb means that its dome reaching above the internal acoustic meatus and it has an intact sigmoid plate, if the plate is deficient the bulb is free to protrude into the middle ear cavity and is known as dehiscent jugular bulb⁽⁹⁾. Dehiscent carotid canal defined as absence of bone coverage of the intima of the carotid artery⁽¹⁰⁾. Round window niche directed either posteriorly, inferiorly or postero-inferiorly⁽¹¹⁾. Cochlear ossification means hardening or transforming of cartilage to bone, the result is bony growth, it make cochlear implantation difficult but not impossible, it interferes with insertion of the device, meningitis is not the only cause of ossification, auto-immune inner ear disease can also causes ossification⁽¹²⁾. Perilymph gusher can occur when a wide vestibular aqueduct present, it associated with abnormal communication between the C.S.F. and cochlea⁽¹³⁾.

Patients and methods

Cross sectional study was designed that include (426) pediatric patients who were implanted for bilateral sever to profound sensorineural hearing loss in Al-Yarmook Teaching Hospital from (Apr. /2008) to (end of Feb. /2015). The age of patients ranges between (18) months to (6) years. A questionnaire was formulated for data collection about surgical finding and difficulties that encountered the cochlear implant surgeons (from patients case sheet documents and surgeons). The data were organized according to the surgical steps.

1. Mastoidectomy

- Mastoid sclerosis
- Korner septum

- Dural exposure
 - Anterior displaced sigmoid sinus
2. Bony well drilling
- Dural exposure
 - C.S.F. leak
 - Dural Bleeding
3. Posterior tympanotomy
- Non- pneumatized antral threshold angle
 - Injury of the chorda tympani
4. Facial nerve course variations
- Partially obliterates the stapes footplate
 - Bifurcation
 - Rests on the footplate
 - Rests on the promontory
 - Dehiscent facial canal
 - Exposure of vertical segment
5. Variations in origin of chorda tympani
- Proximal 3rd of the mastoid segment of FN
 - Mid-3rd of mastoid segment of FN
6. In the middle ear cavity
- Otitis media with effusion
 - Mucosal thickening
 - Persistent stapedia artery
 - High jugular bulb
 - Dehiscence of carotid canal
7. Cochleostomy & round window approach
- Abnormal round window niche position
 - Inferiorly
 - Postero-inferiorly
 - Perilymph gusher
 - Cochlear ossification

Table 1 Age distribution

Age group	No. of patients	Per cent (%)
<1year	0	0
1-2 years	20	4.6
2-3 years	76	18
3-4 years	125	29.3
4-5 years	109	25.5
5-6 years	52	12
6-7 years	44	10
Total	426	100

Table 2 Gender distribution

Gender	No. of patients	Per cent (%)
Male	196	46
Female	230	54
Total	426	100

Table 3 Mastoidectomy findings and difficulties

Findings and difficulties	No. of patients	Per cent (%)
Sclerosis	39	9.15
Korner's septum	127	29.81
Dural Exposure	10	2.35
Anteriorly displaced Sigmoid sinus	8	1.87

Table 4 Bony well findings and difficulties

Findings and difficulties	No. of patients	Per cent (%)
Dural exposure	135	31.7
C.S.F. leak	2	0.47
Bleeding	12	2.81

Table 5 Posterior tympanotomy findings and difficulties

Findings and difficulties	No. of patients	Per cent (%)
Non-pneumatized antral threshold angle	170	40
Injury of chorda tympani nerve	21	5
Origin of chorda tympani nerve(Proximal 3 rd)	2	0.47
Origin of chorda tympani nerve(Middle 3 rd)	12	2.82
Vertical segment exposure of Facial nerve	43	10.093

Table 6 Tympanic cavity findings and difficulties

Findings and difficulties	No. of patients	Per cent (%)
Persistent stapedial artery	1	0.23
High jugular bulb and dehiscence	5	1.17
Otitis media with effusion	8	1.87
Mucosal thickening	4	0.93
Dehiscence of carotid canal	1	0.23

Table 7 Cochleostomy or round window approach findings and difficulties

Findings and difficulties	No. of patients	Per cent (%)
Abnormal round window niche position (inferior)	17	4
Abnormal round window niche position (postero- inferior)	39	9.16
Perilymph gusher	26	3.103
Cochlear ossification	6	1.41

Discussion

Age and gender distribution

Cochlear implant was done at Al-Yarmook teaching hospital for paediatric age group with ages range between (18) months to the end of (6) years. The most

common age group was 3-4 years (125 patients, 29.3%), because many parents began to notice that there is delay in speech and attention of their children at this age. The second most common age group was 4-5 years old (109, 25.5%), while the least age group was patients with 1-2 years old (20, 4.6%). No cochlear implant was done to patient <1 year in our study.

The study shows that 230 patient were female (54%), while 196 patients were male (46%), female to male ratio was 1.2:1.

Paul J. Govaerts *et al* (2002) found that the common age group was 3-4 years (16 patients, 27.1%), while patients with 4-5 years old were the second most common age group (14.5%), the least age group was patients < 1 years old and > 5 years old (12.5%)⁽¹²⁾. Anjan Das *et al* (2014) found that the mean age group was 3-4 years old (53.33%), the second most common age group was 2-3 (20%), the least age group was 1-2 years old (10%)⁽¹³⁾.

Mastoidectomy findings and difficulties

The most common finding and difficulties encountered during mastoidectomy was the Korner septum. It was present in (127) patients (29.81 %), the way used to enter the antrum is to follow drilling of sinodural angle in an anterosuperior direction.

Anterior displaced sigmoid sinus was the least found (1.87%), this was in agreement with Mohamed Dheia *et al* (2014) (1.6%)⁽¹⁴⁾, Ma X *et al* (2008) (0.74%)⁽¹⁵⁾. Management of this difficulty is by thinning of the posterior canal wall and removing of incus bone.

Dural exposure was found in (2.35%) of patients, it result from aggressive drilling along the roof of the mastoid cavity. If the bony defect is small (<1 cm) and the surgeon is certain that the dura has not been injured; the defect need not be repaired because the risk of encephalocele is low. Alternatively, larger bony defects or injury to dura necessitate repair, which can be accomplished at the time of surgery by using fascia or muscle to graft over the defect from below.

Sclerosed mastoid bone was found in (9.15%), this finding made surgeons need more time for drilling of mastoid bone in comparison to pneumatized mastoid bone.

Bony well findings and difficulties

The most common difficulty during bony well drilling was dural exposure (31.7%). In pediatric patients, the limited thickness of the skull may necessitate removal of bone down to dura, to allow for adequate recessing of the device. It has occurred when drilling the bony well for the internal receiver in patients with thin temporal squama. A small dural tear can be covered with soft tissue graft or repaired primarily. While the least finding was C.S.F. leak only occurred in (2) patients (0.47 %).

Bleeding during well drilling occurred in (12) patients (2.81 %), management of bleeding with applying of pressure over the bleeding site with Gelfoam, bone wax,

cauterization by monopolar cautery with spray mode or indirect cauterization with instrument with wide base.

Posterior tympanotomy findings and difficulties

The most common finding during tympanotomy was non-pneumatized antral threshold angle (40%), while the least finding was origin of the chorda tympani from proximal part of vertical segment of facial nerve (0.47%).

Injury of chorda tympani occurred in (5%) of the patients (21 patients) and this is less than found by Bhatia K *et al* (2004) (20%)⁽¹⁶⁾ and Loyd S *et al* (2007) (19%)⁽¹⁷⁾ and Ruben Brito *et al* (2012) study chorda tympani injury was (0.5%)⁽¹⁸⁾.

This difficulty occurred in patients with either narrow angle between facial nerve and chorda tympani or in chorda tympani with anatomical variation in the site of origin so sacrificing the chorda tympani was done for completing the surgery.

Even with exposure of vertical segment of facial nerve in (10.093%) of patients, no facial nerve injury was encountered in our study.

Findings and difficulties of tympanic cavity

Otitis media with effusion is the most common finding in the tympanic cavity during cochlear implantation, it was found in (8) patients (1.87 %). Implantation was done successfully for six patients while two of them were staged for second session of implantation (also they had mucosal thickening in the cavity), this agreed with Yang H *et al* (2006) (1.5%) of cases found to have Otitis media with effusion, implantation was done for all cases successfully⁽¹⁹⁾.

Mucosal thickening was found in (4) patients (2.1%), these patients were suffered from otitis media before implantation and treated medically, removing of the thickened tissue was done at time of surgery and implantation was completed successfully for two patients, while the other two patients, were staged for second session.

Muhammed Dheia *et al* (2014) reported five patients (4.16%) to have mucosal thickening during implantation, one of the cases had failure to complete implantation⁽¹⁴⁾. Five patients (1.17%) found to have High jugular bulb and dehiscence, while only one patient (0.23%) had Persistent stapedial artery, displacement of the artery anteriorly from the field was sufficient to complete the procedure, in case reported by Wardrop P *et al* (1995) \ persistent stapedial artery preventing successful implantation⁽²⁴⁾. One patient had Dehiscence of carotid canal (0.23%). No trauma or bleeding was encountered to our patients with high jugular bulb or dehiscent of carotid artery.

Cochleostomy or round window approach

The most common surgical finding and difficulties during cochleostomy or round window approach was abnormal round window niche position in postero-inferior direction (9.16%). The steps to overcome this difficulty and getting good exposure of the round window by:

- Identification of long process of incus and incudostapedial joint, round window will be below it.
- Removing much bone from facial recess over the anterior aspect of vertical segment of facial nerve, thinning the posterior bony meatal wall, thinning the bony buttress at the fossa incudis.
- Filling the middle ear with normal saline and utilizing the phenomenon of refraction
- Tympanomeatal flap elevation (this also used for inferiorly directed round window niche).

These steps also used for identification of inferiorly directed round window.

Perilymph gusher occurred in (3.103 %) of patients, this is agreed with Muhamed Dheia *et al* (2014) (5.83%)⁽¹⁴⁾, H G Kempf *et al* (1999) (1%)⁽²⁵⁾ and Eftekharian A *et al* (2014) (6%)⁽²²⁾. Kim LS *et al* (2006) reported (10.37%) of patients to have C.S.F. gusher⁽²³⁾.

Firm packing of the cochleostomy site with periosteal tissues was used to overcome this problem.

The least surgical finding was Cochlear ossification (1.41%) and this is less than found by Amnold C *et al* (2005) (10.23%)⁽²⁴⁾, Muhamed Dheia *et al* (2014) encountered 9 patients (7.5%) with ossification, two cases with failure of implantation⁽¹⁴⁾. In Kempf HG *et al* (1997) study, cochlear obliteration found in (18%) of his patients⁽²⁵⁾.

This problem was overcome by further drilling through the basal turn of the cochlea till reach patent scala tympani or by drilling through the second turn of the cochlea.

Conclusions

- 1) Cochlear implantation surgery had multiple steps with large number of difficulties, but most of these difficulties can be managed during surgery without complications.
- 2) Good assessment of patients by otolaryngeal examination, radiological and audiological investigation with good experience and multidisciplinary team work make cochlear implantation surgery with low rate of complications.

Recommendations

- 1) Good experience and training is essential for the surgeons to deal with the difficulties encountered during cochlear implant surgery.
- 2) Training in temporal bone lab achieves safe cochlear implantation.
- 3) Multidisciplinary team work is necessary for assessment of patient and coordination between surgeons makes these difficulties with low rate of complications.

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