Intraoperative surgical findings and difficulties of pediatric cochlear implantation

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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. Koerner 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.²

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\(^6\). 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\(^6\). 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 canalculus parallel to facial canal (rare)\(^6\). Rohr 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 stapedial artery traverses Jacobsen’s canal for a short segment, exits at the promontory, passes through the stapes obturator foramen and enters the Fallopian 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\(^8\). Dehiscent carotid canal defined as absence of bone coverage of the intima of the carotid artery\(^9\). Round window niche directed either posteriorly, inferiorly or postero-inferiorly\(^10\). 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, autoimmune 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 severe 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.

<table>
<thead>
<tr>
<th>Int. J. of Multidisciplinary and Current research, Vol.5 (Jan/Feb 2017)</th>
<th>45</th>
<th>Table 1 Age distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age group</td>
<td>No. of patients</td>
</tr>
<tr>
<td></td>
<td>&lt;1 year</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1-2 years</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>2-3 years</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>3-4 years</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>4-5 years</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>5-6 years</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>6-7 years</td>
<td>44</td>
</tr>
<tr>
<td>Total</td>
<td>426</td>
<td>100</td>
</tr>
</tbody>
</table>

| Table 2 Gender distribution |
|---|---|---|
| Gender | No. of patients | Per cent (%) |
| Male | 196 | 46 |
| Female | 230 | 54 |
| Total | 426 | 100 |

- Dural exposure
- Anterior displaced sigmoid sinus
- Bony well drilling
- Dural exposure
- C.S.F. leak
- Dural Bleeding
- Non-pneumatized antral threshold angle
- Injury of the chorda tympani
- Partially obliterates the stapes footplate
- Bifurcation
- Rests on the footplate
- Rests on the promontory
- Dehiscence of facial canal
- Exposure of vertical segment
- Proximal 3rd of the mastoid segment of FN
- Mid-3rd of mastoid segment of FN
- Otitis media with effusion
- Mucosal thickening
- Persistent stapedial artery
- High jugular bulb
- Dehiscence of carotid canal
- Abnormal round window niche position
- Inferiorly
- Postero-inferiorly
- Perilymph gusher
- Cochlear ossification
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 (1.6%), 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.

**Mastoidectomy findings and difficulties**

The 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%)\(^{(13)}\).

**Bony well findings and difficulties**

The most common difficulty during bony well drilling was mastoid cavity. If the bony defect is small (<1 cm) and the 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, muscle to graft over the defect from below.

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.

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Table 3 Mastoidectomy findings and difficulties

<table>
<thead>
<tr>
<th>Findings and difficulties</th>
<th>No. of patients</th>
<th>Per cent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sclerosis</td>
<td>39</td>
<td>9.15</td>
</tr>
<tr>
<td>Korner's septum</td>
<td>127</td>
<td>29.81</td>
</tr>
<tr>
<td>Dural Exposure</td>
<td>10</td>
<td>2.35</td>
</tr>
<tr>
<td>Anteriorly displaced Sigmoid sinus</td>
<td>8</td>
<td>1.87</td>
</tr>
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</table>

Table 4 Bony well findings and difficulties

<table>
<thead>
<tr>
<th>Findings and difficulties</th>
<th>No. of patients</th>
<th>Per cent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dural exposure</td>
<td>135</td>
<td>31.7</td>
</tr>
<tr>
<td>C.S.F. leak</td>
<td>2</td>
<td>0.47</td>
</tr>
<tr>
<td>Bleeding</td>
<td>12</td>
<td>2.81</td>
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</tbody>
</table>

Table 5 Posterior tympanotomy findings and difficulties

<table>
<thead>
<tr>
<th>Findings and difficulties</th>
<th>No. of patients</th>
<th>Per cent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-pneumatized antral threshold angle</td>
<td>170</td>
<td>40</td>
</tr>
<tr>
<td>Injury of chorda tympani nerve</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>Origin of chorda tympani nerve( Proximal 3/5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Origin of chorda tympani nerve( Middle 3/5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical segment exposure of Facial nerve</td>
<td>43</td>
<td>10.093</td>
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</table>

Table 6 Tympanic cavity findings and difficulties

<table>
<thead>
<tr>
<th>Findings and difficulties</th>
<th>No. of patients</th>
<th>Per cent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistent stapled artery</td>
<td>1</td>
<td>0.23</td>
</tr>
<tr>
<td>High jugular bulb and dehiscence</td>
<td>5</td>
<td>1.17</td>
</tr>
<tr>
<td>Otitis media with effusion</td>
<td>8</td>
<td>1.87</td>
</tr>
<tr>
<td>Mucosal thickening</td>
<td>4</td>
<td>0.93</td>
</tr>
<tr>
<td>Dehiscence of carotid canal</td>
<td>1</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table 7 Cochleostomy or round window approach findings and difficulties

<table>
<thead>
<tr>
<th>Findings and difficulties</th>
<th>No. of patients</th>
<th>Per cent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal round window niche position (inferior)</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Abnormal round window niche position (postero- inferior)</td>
<td>39</td>
<td>9.16</td>
</tr>
<tr>
<td>Perilymph gusher</td>
<td>26</td>
<td>3.103</td>
</tr>
<tr>
<td>Cochlear ossification</td>
<td>6</td>
<td>1.41</td>
</tr>
</tbody>
</table>

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
Cauterization by monopolar cautery with spry 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 cochlea 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 et al (2004) (20%) and Loyd S et al (2007) (19%) 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 (24).

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 dehiscence 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.
- Tymanomeatal 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%) (24), H G Kemph 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 Arnold C et al (2005) (10.23%) (26), Muhammed Dheia et al (2014) encountered 9 patients (7.5%) with ossification, two cases with failure of implantation (14). In Kemph HG et al (1997) study, cochlear obliteration found in (18%) of his patients (20).

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.

**References**


