Current Practice of Paediatric Cochlear Implantation in Nottingham

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Abstract

The number of integrated paediatric cochlear implantation programmes are very few in the world. In U.K. this pioneering integrated paediatric cochlear implantation programme has been started in the year 1989 under the supervision of a group of dedicated paediatric personnel comprising of ENT surgeons, neuro-radiologist, audiologist, speech therapist, orthophonists, teachers of the deaf and others associated with the deaf children.

Only the surgical procedure of cochlear implantation is not the answer of a profound sensorineural deaf child who can not be helped by conventional hearing aids. Proper selection of the cases, pre-operative counselling, pre-operative audiological and non-audiological investigations are of immense value.

Similarly the programme following surgery as a team approach is equally important for proper rehabilitation of profound sensorineural deaf child who can not be helped by conventional hearing aids.

The knowledge that electrical stimulation can produce auditory sensations dates back to 1751 was suggested by Benjamin Franklin. Later in 1800 Alessandro Volta inserted metal rods into each of his ears and connected them to a circuit containing 30 or 40 of his newly developed electrolytic cells. Apparently he heard the sound of bubbling water before he lost consciousness. This was the beginning of a long and difficult 'journey until, one and a half centuries later, in 1957, Djurno and Eyries in France, inserted a single copper wire inside the cochlea of a totally deaf fifty-year old man and the patient perceived speech rhythm.

During the 1960s, pioneering cochlear implant research was carried out by House in Los Angeles, Michelson at the University of California, San Francisco and Simmons at Stanford.

Amidst considerable controversy, House moved the concept of Cochlear implants from the research laboratory to the clinical arena in 1979, when he established the first national clinical trial to assess the safety and efficacy of the 3M/House single-channel cochlear implant system. U.S. Food and Drug Administration (FDA) - approval for its use in adults was granted in November 1984. The Nucleus 22 - multi-channel cochlear implant which had received FDA approval for use in both adults (1985) and children (1990) is currently the most commonly used multi electrode system. Cochlear implants were first used in prelingually deaf children by House in 1980 and the Nucleus 22 channel cochlear implant system was first used in children in 1985 and to date over 1300 deaf children worldwide have received the device.

For post-lingually deafened adults who have an established language base, implantation partially restores an auditory channel of communication. But totally deaf children have specific, more complex needs with children, the concern is to restore something of the normal channel by which language is acquired, with the objective of language development as well as communication. The primary channel by which oral communication skills and thus language are acquired is hearing. An interdisciplinary team approach is therefore required for proper assessment, implantation, rehabilitation and follow up of young deaf children.

The Nottingham Paediatric cochlear implant programme (NPCIP) in UK was established in 1989. It is the first paediatric programme in U.K. for provision of a range of specialist skills devoted to the care and rehabilitation of children with profound sensorineural deafness who cannot be helped by conventional hearing aids.

Basic Principle of Cochlear Implants

A cochlear implant is an electronic device, a portion of which is surgically implanted into the cochlea and the remaining portion worn externally like a hearing aid. Cochlear implants neither eliminate the underlying disease that resulted in deafness nor restore normal function to the end organ of hearing but they act as a sensory aid and as a sensory substitute for one of our keenest senses, that of audition. They produce a coded electrical stimulus that bypasses damaged or missing hair cells of the cochlea in patients with profound sensorineural hearing loss and directly stimulate the remaining auditory neural elements.

A variety of cochlear implant devices are currently in use around the world. All have in common a microphone that picks up external sound energy and converts it to an electrical signal. A signal processor (speech processor) modifies the signal, depending on the particular processor (speech processor) modifies the signal, depending on the particular processing scheme in use. The processed signal is amplified to a workable level and compressed to match the narrow electrical dynamic range of the ear. Typically the response range of a deaf ear to electrical stimulation is on the order of only 10 to 20 dB and even less in the high frequencies. Filters are generally used to permit cochlear implants to recognise acoustic information in the range of a 0.1 to 4 KHZ.

The processed signal is then sent to an external transmitter, where it is transferred across intact skin to an implanted electrode array. The transmission occurs by use of electro-magnetic induction or radio-frequency transmission to an internal receiver.

Electric current flows between one or more active electrodes and return electrodes, stimulating the auditory nerve and thereby producing a sensation of sound.

The various cochlear implant devices differ with

respect to processing scheme (e.g. Analog or feature extraction), number of electrodes (e.g. single channel or multi-channel), placement of the electrodes (e.g. monopolar or bipolar), and method of transmission through the skin (e.g. transcutaneous or percutaneous). The implantable electrode array consists of platinum iridium band electrodes placed in a silastic carrier.

The Nottingham Paediatric Cochlear implant Programme (NPCIP)

The whole programme is divided into three major parts :-

- I) The programme prior to implantation
- II) Implantation proper i.e. surgery
- III) The programme following surgery

The Programme Prior to Implantation

Fig. 1 INITIAL REFERRAL

NPCIP currently considers cochlear implantation for children who are fulfilling the following criteria :-

- Audiological thresholds greater than 60 dB bilaterally when using the most powerful hearing aids.
- Age under five years.
- Show no material benefit from binaural hearing aids over time.
- have no other major learning difficulties.
- are in good physical health
- have parents committed to support the continuing rehabilitation programme
- have teachers willing to be involved in the rehabilitation programme
- have access to local medical audiological and technical expertises.

Preliminary Assessments

In order to obtain a full picture of the child's potential hearing function and communication needs, assessments are carried out at the implant centre in Nottingham and at the child's home and school in the following manner -

- 1) Sending for further audiological and background information to parents and local professionals.
- 2) Full audiological assessment is carried out, including technical performance tests on the child's hearing aid. Testing of unaided plus aided thresholds is undertaken in order to determine the hearing threshold and any possible hearing aid benefit. Middle ear admittance measurements and otoacoustic emissions are also carried out. Time is allowed by the programme coordinator during this visit for full discussion with parents (and child, where appropriate) as to the process of implantations, the system being offered and its implications.
- 3) M.R.I. imaging are carried out in Queen's Medical Centre, Nottingham under general anaesthesia, in order to determine the patency of the inner ear. High resolution thin sections are taken.
- 4) Otological and medical examinations are

carried out, giving time for parental discussion with the surgeon with regard to the risks and likely outcome from the implantation. Setting realistic parental goals is crucially important.

- 5) ERA is carried out to provide objective support for the behavioural thresholds.
- 6) Contact is made with the local support services, visiting the child at home and at school, sharing information and observing the child's communication abilities in every day life.
- 7) Parents and teachers are encouraged to meet other implanted children and their families, as well as giving opportunities for considering other options, such as manual form of communication and vibro-tactile devices.

The main aims during this period are :-

- to assess the child's appropriateness for implantation
- to enable parents to make an informed decision regarding implantation.
- to establish the basis for future co-operative relationships should implantation proceed.
- to set realistic goals for the parents.

The Programme Implantation i.e. Surgery

When the child is under anaesthesia immediately prior to implantation, bilateral transtympanic promontory stimulation tests are done. When all other indications are equal, this test may help to select the ear neural innervation.

The incision must be carefully planned. The selected ear is implanted using a standard posterior tympanotomy and cochleostomy approach. The Nucleus 22 - multichannel cochlear implant is used routinely. Cochleostomy is usually closed by muscle graft.

While the child is still anaesthetised, Electrically evoked Auditory Brain stem Responses (EABR) and electrical stapedial reflex thresholds are measured and observed to indicate electrical threshold and comfort levels which are useful for the later tuning of the system. Closure of the wound is done by non-

absorbable suture. Usually prophylactic antibiotic cover is given for the 24 hours during and immediately after surgery.

Plain X-ray of cochlea is taken routinely postoperatively to confirm satisfactorily positioning of the electrode array.

Usually the child is discharged from hospital on the second postoperative day.

The Programme Following Surgery

This period is subdivided into four parts.

- 1) Preparation for 'Switch on'
- 2) 'Switch on' or 'tuning'
- 3) Follow up visit
- 4) Rehabilitation

Preparation for 'switch on'

After discharge, the child is visited at home by the teacher of the deaf and prepared with their families for the next stage - the initial switch-on' of the device. They are able to familiarise themselves with the equipment and its controls, view photographs of other children with the device, share books about it and are generally prepared for what lies ahead.

'Switch on' or 'tuning' :-

The initial tuning takes place over three days. The child receives the external part of the system i.e. the microphone, transmitter and processor.

If all active electrodes have been successfully inserted during the operation, there are 22 electrodes to be tuned in. This involves the measurement of the threshold level and maximum comfort level for each electrode which defines the usable dynamic range of that electrode. These measurements are used to create a 'MAP' -an individualised programme stored in the patients speech processor that contains information about his or her hearing.

Wide range electrical stimulation may seem strange initially and usually the children's responses improve in reliability as they gain experience of listening to the new signals. The sessions are deliberately relaxed with

the necessary computer equipment and operating staff behind a one-way screen, allowing the audiological scientist to interact with the child and the family.

The rehabilitation staff and audiological scientist liaise closely and it is mutually useful to share the child's responses in clinic and in the outside world. Play with sound makers and musical instruments develops the child's confidence and pleasure in using the device before carrying out more structured listening tasks - both linguistic and non-linguistic. The final day of the initial visit involves the child's own teacher of the deaf, speech therapist and audiologist for exchange of views regarding different aspects of rehabilitation.

Follow-up Visits

Following the initial tuning in, a teacher of the deaf from Nottingham regularly visits the child at school and at home to ensure that all is well with the system and to monitor early changes and the use of the diaries. The role of the teacher of the deaf is to monitor, advise and evaluate, to ensure that the management of the child at home and at school promotes the optimum use of the device.

Rehabilitation

As the child begins to learn to listen again, regular contact is kept between Nottingham and their families and local professionals. The families visit Nottingham for one day for further tuning and monitoring of listening skills, two weeks, one month, three months, six months after switch on and thereafter six monthly.

The teachers of the deaf and speech therapists make fortnightly visits to school and home initially and thereafter monthly.

The follow up visits to Nottingham involve the surgeon, audiological scientist, speech therapist and teacher of the deaf and include :-

- a medical check up
- further tuning of the device
- monitoring of its use
- evaluation of listening skills
- evaluation of spoken language skills
- discussion of diary entries
- discussion of progress so far and guidelines for future progress.

The visits to school involve the teacher of the deaf, speech therapist, class reader, nursery nurse and many others working with the child.

The visits to home and school are designed to ensure that the system is being working satisfactorily in the child's everyday environment.

Results

Up to the end of 1996, total 135 children have been given cochlear implants in Nottingham Paediatric cochlear implant programme. Out of that two were explanted as no useful auditory sensations were perceived. Device failures occurred in six cases and re-implantation was needed successfully in five of these six cases.

Mean sound field thresholds using the cochlear implant measured six months after implantation compared with mean thresholds using hearing aids before provision of the implant, show that there is an average gain of 44 dB and a larger gain of 50 dB at the high frequencies which are essential for good speech intelligibility.

The available data in NPICP show that all children gain substantial hearing benefit from use of the cochlear implant and these benefits increase steadily over a period of at least five years. After five years 73% can understand conversation without lip reading.

Conclusion

About 1300 children throughout the world have been implanted to date. To obtain the best results, the selection of the patients must be thorough and carried out by a multi-disciplinary team of dedicated paediatric specialists. In addition the implanted child must be subject to regular and intensive rehabilitation by audiologists, speech therapists and orthophonists familiar with the specific needs of implanted children. The major determinant of success in paediatric cochlear implantation is the duration of hearing loss prior to implantation, the earlier the implant - the better the result.

It can be predicted from the Nottingham data that for children implanted below the age of five years, over 90% will be using spoken language as the primary means of communication five years after implantation.

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Announcement

Due to the sudden notification of general elections in West Bengal on 3rd October 1999, the dates of the 1st Course on **Neurotology & Audiology** for Otolaryngologists (to be conducted by Drs. M.V. Kirtane & Anirban Biswas) scheduled to be held in Calcutta on 2nd & 3rd October 1999, is being Changed to 9th & 10th November 1999. Venue and other details remain unchanged.

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