Auditory Brainstem Implantation

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Disclosures

• Consultant for
  • Cochlear Corporation
  • Advanced Bionics
  • Med El Corporation
Objectives

• What is it?
• How does it work?
• Who is it for?
• How is it placed?
• What are the results?
• What is in the future?

History

• 1979 Drs. W. F. House and W. E. Hitselberger placed first device
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• 1991 25 patients implanted
  • Percutaneous to wireless
  • Ball electrode to flat electrodes

• 1992 an 8 electrode was developed for the US market by Cochlear Limited
  • 21 electrode developed for Europe
History

- Med-El and Advanced Bionics also developed arrays based on the C40+ and Clarion 1.2
- 1999 21 electrode array based on Nucleus 24

Device Anatomy
Patient Anatomy
Results

• 60 of 61 no useful auditory sensation
• 24% of electrodes could not be used due to non-auditory sensations
• Initial disappointment with sound quality common
Results - CUNY

Sound only

- Some patients have no auditory sensation
- ABI will not provide normal sound quality
- Most do not achieve open-set speech
- Regular follow up required
- Takes time to develop full potential

Vision + sound

Conclusions
Auditory Brainstem Implants in NF2 Patients: Results and Review of the Literature

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- 24 patients (25 implants)
- Median age 35 years (18-69 yr)
• Only the number of useful electrodes correlated with outcome
  • “it remains hard to predict the outcome of a individual NF2 patient receiving an ABI”
Literature Review (18 studies)

- Daily users: 44 - 97%
- Non-auditory side effects: 20 - 92%
- Open-set recognition: 0 – 42%
- No auditory response: 4 – 22%

Teenagers with NF2

Auditory Brainstem Implantation in 12- to 18-Year-Olds

Steven B. Otto, MA; Donald E. Brackmann, MD; William Hinesberger, MD

Objectives: To assess the effects of the side of implantation (first vs second vestibular schwannoma), the presence of nonauditory sensations, the general health, expectations, and motivations of the patients, and a support group on the use of a multichannel auditory brainstem implant (ABI) in 12- to 18-year-old patients with neurofibromatosis 2.

Design: Since 1992, 21 individuals (age range, 12-18 years) who were deafened by neurofibromatosis 2 have undergone implantation with a multichannel ABI at the House Ear Institute, Los Angeles, Calif. The patients were categorized regarding side of implantation, presence of remaining hearing, (in first-side implant recipients), incidence of nonauditory sensations, and ABI use or nonuse. They were also rated on factors of general health, personal motivation, expectations, and family support.

Results: Nineteen (95%) of 20 teenagers tested received hearing sensations from their ABIs. Eleven teenagers used their ABIs regularly, but 8 did not. Of the nonusers, 2 had good remaining hearing on the side with the second vestibular schwannoma, 2 had persistent nonauditory sensations, and 4 became program dropouts. None of the dropouts had remaining hearing, significant nonauditory sensations, or poor health, however, their general health was poorly in terms of personal motivations, expectations, and family support. One patient with good family support returned with excellent ABI results after 4 years of absence.

Conclusions: The multichannel ABI is an effective means of providing hearing sensations to young patients deafened by neurofibromatosis 2. Preoperative counseling regarding the importance of such factors as expectations, personal motivation, and family support is invaluable and can promote successful adaptation to the device. With patience and support, even young nonusers (including program dropouts) can become successful device users.

Arch Otolaryngol Head Neck Surg. 2004;130:636-639
Teenagers with NF2

Auditory Brainstem Implantation in 12- to 18-Year-Olds

Steven R. Otto, MA; Donald E. Brackmann, MD; William Hinouberger, MD

- 19 (95%) had auditory sensations
- 11 full time users
  - 8 non-users
    2 had good hearing in other ear
    2 had non-auditory sensations
    4 program drop outs*

Outcomes in Non-Tumor Adults

- 48 implants placed with > 1 year f/u

Outcomes in Nontumor Adults Fitted With the Auditory Brainstem Implant: 10 Years’ Experience


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Patients

- Head trauma (7) 32-80%
- Auditory neuropathy (4) 12-18%
- Cochlear malformations (6) 37-61%
- Altered cochlear patency (31) 34-100%
  - 18 ossification
  - 14 malformation
Outcomes

- Severe post-meningitic obliteration
  - CI performance may decrease over time
- Advanced otosclerosis
- Post traumatic 8th nerve avulsion
- Severe cochlear malformation
Penetrating ABI

Receiver/Stimulator 10 mm
Antenna Coil
Electrodes: Ground Surface Penetrating

Penetrating ABI
Penetrating ABI Results

- N=10, all with NF2
  - 3 years f/u
  - Less than 25% of penetrating electrodes produced auditory sensation vs 60% for surface
Penetrating ABI Results

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  • 3 years f/u
  • Less than 25% of penetrating electrodes produced auditory sensation vs 60% for surface

Conclusion: The PABI met the goals of lower threshold, increased pitch range, and high selectivity, but these properties did not result in improved speech recognition. Key Words:

ABI in Children

• Labyrinthine aplasia
• Cochlear aplasia
• Narrow or absent IAC, cochlear nerve
• Auditory Neuropathy
ABI in Children

• 11 patients, ages 2.5-5 years
• Retrosigmoid approach
• No major surgical complications
• All had non-auditory sensations

ABI in Children - Results

Preliminary Results of Auditory Brainstem Implantation in Prelingually Deaf Children With Inner Ear Malformations Including Severe Stenosis of the Cochlear Aperture and Aplasia of the Cochlear Nerve

Ling's six sound detection

Word identification

FIG. 9. Closed-set word identification scores over time.
ABI in Children

• Controversial!
  • Atretic nerve
  • Auditory neuropathy

• Long term performance unknown
  • Likely to be highly variable

• Should be reserved for those who fail CI?

• What about timing of surgery and how this relates to language acquisition
Cochlear Implantation in NF2

• 10 patients in our series
  • 5 prior surgery
  • 4 radiosurgery
  • 1 no treatment

• 43 total cases (31 surgery, 10 SRS, 2 obsv)
  • Open set
  • Surgery 65%
  • SRS 80%
  • Obsv 100%
Summary

• ABI can restore some hearing in the majority of patients
• The indications are expanding to include patients without tumors
• Penetrating ABI did not lead to improved performance
• Pediatric implantation is being explored

Thank you
Intraoperative Monitoring During Auditory Brainstem Implant Surgery

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Indications

US FDA Approved Package Insert: The Nucleus 24 ABI is intended to restore useful hearing via electrical stimulation of the cochlear nucleus.

The Nucleus 24 ABI is intended for use in individuals 12 years of age or older who have been diagnosed with Neurofibromatosis Type 2 (NF2). Implantation may occur during first or second side tumor removal or in patients with previously removed acoustic tumors bilaterally. Because the surgical procedure for tumor excision and electrode placement eliminates residual hearing, preoperative audiological criteria are not relevant.

Prospective implant recipients and their families should have appropriate expectations regarding the potential benefits of an auditory brainstem implant, and should be highly motivated to participate in the post-operative rehabilitation process.
Why Do We Need EABR?

- Reassures surgeon that placement of the array is correct
- Can help surgeon find CN in cases of a highly distorted brainstem (caused by large tumour, e.g. > 3cm)
- Can be used to find optimal placement for the ABI over the CN

Generators of the ABR

- Auditory Cortex
- Medial Geniculate
- Inferior Colliculus
- Lateral Lemniscus
- Superior Olivary Complex
- Cochlear Nucleus
- Auditory Nerve
The ABI & CI Compared

Diagram showing relative positions of a cochlear implant (CI) and an auditory brainstem implant (ABI)

Position of ABI in the Brainstem
Position of ABI relative to CN

Depth and orientation variable

Lateral

Medial

ABI Surgical Procedure

Patient Preparation (30m)

Prepares site (15m)

Nerve Monitoring (60m)

Preparing site (15m)

Tumor removal (0-6h) + ABI placement (1-2h)

EABR recording (15m-45m)

Approach + implant bed (1h)

Total = 5 - 12 hours
Cranial Nerve Monitoring

- VII - Obicularis Oris (Upper & Lower)
- VII - Mandibular (Upper & Lower)
- IX - Glossopharyngeal (soft palate)
- V - Trigeminal
- X - Vagus
- VIII - Auditory nerve (for EABR)

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Generators of the ABI-EABR Response

- The first wave (0.7ms if present) has its origin in the **cochlear nuclei**
- The second wave (1.2 – 1.8ms) probably represents the axonal discharge of the **direct pathway** via the **superior olive**
- The third wave (2.2 – 2.8ms) may be due to the discharge of the **indirect pathway** through the **lateral lemniscus** to the **inferior colliculus**
- The fourth wave (3.0 – 3.8ms) most probably has its origin in the **medial geniculate body**

EABR Electrode Combinations

- **First**: 2 - 21 or 3 - 20
- **Second**: 14 - 21 or 15 – 20
- **Third**: 2 - 9 or 3 - 8
- **Fourth**: 8 - 15 or 9 - 14
Intraoperative Equipment - ABI24M

Trigger Characteristics Using PCI / PPS

If the ERA machine time window starts at the beginning of the TRIGGER signal (this is normal) then:

NO ADJUSTMENT NEEDS TO BE MADE TO ON-SCREEN LATENCIES
Results in Practice: 1-peak Responses

Results in Practice: 2-peak Responses

* Stimuli reverse phase but NOT responses

Stimulus removed by ‘blanker’
and then, recovery and initial programming which must take place with appropriate medical personnel monitoring the patient.

Subsequent follow-up programming can be done in a typical CI programming room.