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

- 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
Multichannel auditory brainstem implant: update on performance in 61 patients

Steven R. Otto, M.A., Donald E. Brackmann, M.D., William E. Hitzelberger, M.D., Robert S. Shannon, Ph.D., and Johannes Korbek, M.D.

Horse Ear Institute, Los Angeles, California

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  Vision + sound
Conclusions

- 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

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

*Mario Sanna, Filippo Di Lella, Maurizio Guida, and Paul Markus

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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 an 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

• 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

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

• 48 implants placed with > 1 year f/u
Patients

- Head trauma (7)
- Auditory neuropathy (4)
- Cochlear malformations (6)
- Altered cochlear patency (31)

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

% correct resp.

FIG. 1. Average performance (% correct on open-set speech) over time (yr) for different groups (auditory neuropathy, altered cochlear patency, cochlear malformation, and head trauma) and NF2 groups.
Outcomes

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

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

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

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

ABI in Children - Results

1 log's six sound detection

Word identification

FIG. 5. Closed-set word identification across 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
Cochlear Implantation in NF2

- 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
ABI Surgical Procedure

- Patient Preparation (30m)
- Nerve Monitoring (60m)
- Preparing site (15m)
- Tumor removal (0-6h) + ABI placement (1-2h)
- EABR recording (15m-45m)
- Close approach & flap (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)

Conventional ABR
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

Results in Practice: 3-peak 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.