Cochlear Implants

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Background and Introduction

• Djourno and Eyries (1953) - direct stimulation
• House and Doyle (1961) - scala tympani approach
• Simmons (1964) - modiolar stimulation
• House and Michelson - implantation of electrodes
• House (1972) - first available device
• 1984 - multiple channel devices
• 1997 - 20,000 people with cochlear implants
Basic Science - Technology

- Implantable circuitry and processing system
- Restore activity in the central auditory pathway
- Receive, process, and transmit via electrical stim.
- Directly depolarize auditory nerve fibers
- Internal and external component
- Receiver-stim. - accepts, decodes, transmits
- Speech processor - amplifies and compresses
Amplification

- Occurs within the processor
- Amplifiers used to increase the signal levels
- Gain of amplifier determines the amount of increase
  - Gain = ratio of output signal level to input signal level
- Can increase or decrease signal level
Compression

- Impaired hearing has decreased acoustical dynamic range - 10 to 25dB
- Linear and non-linear compression
- Gain of amplifier changed so output to input ratio changes - automatic gain control
- Automatic gain control - keep output voltage in a certain range
- Wide range of compressor types in use
Filtering

- Filter on the basis of frequency - 100 to 4000Hz
- Three types: low pass, high pass, and bandpass
- Two reasons for filtering:
  - 1) remove unwanted information
  - 2) separate bands for independent processing
- Extract frequency dependent features
- Divide acoustic frequency spectrum into channels
- Feature extraction systems - filter F0, F1, and F2
- Multichannel processing refers to multiple filtered bands
Encoding

• Encoded to transmit to the receiver
• Preserves information and enables information to get to the auditory nerve
• Analog signal first enters the processor
• One type - changes analog to radio-frequency
• Another - converts from analog to digital
General Design

• Two configurations of electrodes
• Monopolar and bipolar
• Speech processing strategies
  – Nucleus 22-channel implant - SPEAK
  – Clarion multichannel implant - CA and CIS
  – MED-EL Combi 40-Cochlear implant - CIS
Patient Selection

- Originally for postlingually deafened adults
- Adult: postlingual, bilateral profound SNHL >95dB
  - little or no benefit from hearing aids - 6 months
  - psychological and motivational suitability
  - aided word discrim. scores no better than 30%
  - no upper age limit
- Child: bilateral severe to profound SNHL >90dB
  - age 2 or greater, no benefit from hearing aids
  - no medical contraindication
Pediatric Implants

- Intensive auditory training to make sure the hearing aid would not give the same benefit as an implant
- Family highly motivated
- Appropriate expectations
- Enrolled in a program for development of auditory skills
Audiological Evaluation

• Primary means of determining suitability
• Aided and unaided thresholds obtained
• Hearing aid performance compared to normative cochlear implant performance
• Not all patients are candidates
• Not candidate if have speech recognition skills with conventional hearing aids
Medical Evaluation

- Complete history and physical
- Lab studies as needed to rule out medical disorder
- Evaluate for external or middle ear disease
- CT scan to evaluate cochlea
- Congenital malformations are not contraindications - except Michel and small IAC
- Psychologic testing
Surgical Implantation

- Decide which side to place implant
- Facial nerve monitoring
- Mark position of internal component - 1cm behind
- Design a skin flap - c-shaped or postauricular
- Internal device depression created
- Complete mastoidectomy with facial recess
- Cochleostomy anteroinferior to round window
- Quit using monopolar electrocautery
- Place electrodes carefully into scala tympani and secure internal component
Surgery - continued

• New bone growth - drill 4-5 mm along basal coil
• Complete obliteration of tympani - use vestibuli
• Complete ossification - drill out tympani
• Cochlear dysplasia - CSF gusher
• Fit external device and antenna 3 weeks postop
• Overall complication rate - 5%
• Most commonly associated with skin and flap
• Unwanted stimulation-eliminate during mapping
Rehabilitation

- Needs differ depending on auditory experience before deafness
- Prelingual - auditory and speech training
- Postlingual - auditory for complex skills
- Team approach for pediatric patients
- Develop receptive and expressive language skills
Results

• No cochlear implant can restore normal hearing
• Variability in outcomes primarily due to patient factors
• Primary goal is improved speech perception
• Postlingual- achieve open-set discrimination earlier
• Prelingual children continue to improve over 2-5 years
• Miyamoto et al.-55 prelingual children, 63% discrim.
• Gantz et al.-54 children, 4 years, 82% open-set discrim.
• Waltzmann et al.-14 children implanted prior to age 3, followed for 2-5 years, all aspects of hearing improved, oral language, attended regular school, open-set discrim.
Conclusion

- Cochlear implants are not experimental
- Cost effective
- Provide high quality of sensation of hearing
- Further research improves implant components and implant results
- Further expansion of criteria to include patients with less severe hearing loss, but poor discrimination
Case Presentation

• 66 year old female
• Progressive SNHL over several years
• Failed to respond to steroids
• Hearing loss of unknown etiology
• Physical examination: normal except for hearing loss
Case Presentation

- Audio shows severe to profound SNHL bilaterally
- PTA: AD = 93, AS = 90
Case Presentation

- Hearing aid evaluation was done
- Patient wore AS BTE hearing aid with minimal benefit
- Needs visual cues to communicate
- Interested in cochlear implants
Case Presentation - Result

- Preimplant:
  - CNC word list
    - aid- 8%
    - aid w/ visual- 64%
  - Phonemes
    - aid- 26%
    - aid w/ visual- 81%
  - HINT sentences
    - aid- 11%
    - aid w/ visual- 72%

- Post-implant:
  - CNC word list
    - proc.- 50%
    - proc. w/ aid- 58%
    - proc. w/ visual- 82%
  - Phonemes
    - proc.- 69%
    - proc. w/ aid- 77%
    - proc. w/ visual- 91%
  - HINT sentences
    - proc.- 90%
    - proc. w/ visual- 94%