Auditory Brainstem Implant: Array Position and Auditory Outcomes in Pediatric Patients

Isabeau van Beurden Bsc, Dana Egra-Dagan Msc, Barbara S. Herrmann PhD, Samuel R. Barber MSc, Mary E. Cunnane MD, Christine Carter ScD, M Christian Brown PhD, Daniel J. Lee MD

July 13th 2019
16th Symposium on Cochlear Implants in Children – CI2019
Auditory brainstem implant (ABI)

- ABI is a modified CI
- ABI candidates\(^1\)
  - NF2 – FDA approved
  - Cochlear or cochlear nerve anomalies
- Cochlear nucleus is the target of the surface array\(^1\)

ABI challenges and limitations

- ABI array is placed **blindly** during surgery with **no image-guidance**
  - Indirect surgical landmarks and electrophysiology guide final position of ABI array \(^1,2\)

- **ABI outcomes are modest** compared to the CI and vary widely \(^3\)
  - Sound awareness
  - Poor word understanding

---

1. Vincent C. et al., 2012
2. Herrmann BS et al., 2015
3. Noij KS. et al., 2015
What is known about ABI array position and perception?

(Barber et al., 2017)

- Large variations in ABI array position are observed (on post-op CT) 4
- ABI position is moderately correlated to perception in adults 5
- In children, the ABI array position and perception is not well understood

4. Barber et al., 2017
5. Egra-Dagan et al., Poster presentation ARO, 2019
Hypotheses

- ABI array position varies among pediatric patients
- ABI array position may influence
  - Perceptual outcomes
  - Distribution of active and disabled electrodes
  - T-level of individual electrodes
- Change in ABI array position associated with change in perception
Subjects

- Retrospective study of 8 pediatric ABI subjects
- All subjects had cochlear nerve abnormalities
- Retrosigmoid craniotomy approach
- All subjects underwent routine post-op CT

Table 1. Patient characteristics and ABI information

<table>
<thead>
<tr>
<th>Subject</th>
<th>Comorbidities</th>
<th>Imaging</th>
<th>Age at implantation</th>
<th>Side</th>
<th>Duration of ABI use</th>
</tr>
</thead>
<tbody>
<tr>
<td>P01</td>
<td>Autism</td>
<td>Nerve aplasia, malformation cochlea</td>
<td>1y 4mo</td>
<td>Right</td>
<td>7mo</td>
</tr>
<tr>
<td>P01-R</td>
<td></td>
<td></td>
<td>2y 1mo</td>
<td>Right</td>
<td>1y 2mo</td>
</tr>
<tr>
<td>P02</td>
<td>CHARGE syndrome</td>
<td>Nerve aplasia, malformation cochlea</td>
<td>0y 11mo</td>
<td>Right</td>
<td>1y 5mo</td>
</tr>
<tr>
<td>P02-R</td>
<td></td>
<td></td>
<td>2y 7mo</td>
<td>Right</td>
<td>3y</td>
</tr>
<tr>
<td>P03</td>
<td>None</td>
<td>Nerve aplasia, hypoplasia cochlea</td>
<td>1y 3mo</td>
<td>Right</td>
<td>3y 9mo</td>
</tr>
<tr>
<td>P04</td>
<td>None</td>
<td>Nerve aplasia, hypoplasia cochlea</td>
<td>2y 5mo</td>
<td>Right</td>
<td>3y 10mo</td>
</tr>
<tr>
<td>P05</td>
<td>Autism suspected</td>
<td>Nerve hypoplasia (Left &gt; right)</td>
<td>1y 8mo</td>
<td>Right</td>
<td>1y 5mo</td>
</tr>
<tr>
<td>P05-R</td>
<td></td>
<td></td>
<td>2y 7mo</td>
<td>Right</td>
<td>Not activated</td>
</tr>
<tr>
<td>P06</td>
<td>CHARGE syndrome</td>
<td>Nerve aplasia, hypoplasia cerebellar vermis</td>
<td>2y 9mo</td>
<td>Left</td>
<td>10mo</td>
</tr>
<tr>
<td>P07</td>
<td>CHARGE syndrome</td>
<td>Nerve aplasia, malformation cochlea</td>
<td>3y 11mo</td>
<td>Right</td>
<td>6mo</td>
</tr>
<tr>
<td>P08</td>
<td>None</td>
<td>Nerve aplasia, malformation cochlea</td>
<td>2y 0mo</td>
<td>Right</td>
<td>3mo</td>
</tr>
</tbody>
</table>
3D CT reconstruction can resolve detailed ABI array position (Barber et al., 2017)

- Reformatted images to true axial series with McRae line
- Marked coordinates: Basion, proximal and distal array tip
- Measured angles and linear distances
- Measurements were done twice by two investigators

a. OsiriX, b. ImageJ
Variability in ABI array position

- There is subject to subject variability in the position of the arrays
- Most arrays are tilted medially (8/11 subjects) and posteriorly (10/11 subjects)
- The linear distances from the arrays to the basion lie within 2SD for almost all arrays
- The position of electrode array of P06 is an outlier (red stars)
Wide range in perceptual outcomes (no perception to sound discrimination with live voice)
The subject without auditory perception is the outlier (red stars)
Unclear relationship between degree of perception and ABI array position
Overlapping area of disabled electrodes

Overlapping area of low T-level electrodes

Posterior view

Legend:
- Low (< 9.1 nC)
- Low to medium (9.2 to 48.5 nC)
- Medium to high (48.6 to 75.5 nC)
- High (> 75.5 nC)
- Active electrode
- Disabled electrode

D1 (cm) Vertical distance from basion
D2 (cm) Horizontal distance from basion
Change in array position associated with change in perception

- Change in perception, no history of head trauma
- Considerable change in position after change in perception
Change in array position associated with change in perception

Subject P01

- Internal receiver device failure after head trauma → no perception
- Minimal change in position
Summary and Discussion

• Variability in ABI array position was observed, although the variability for these pediatric subjects is less than found in our group’s studies of adult subjects.

• Variability of perceptual outcomes were observed. It was not clear how array position influenced degree of perception.

• We observed overlapping areas of disabled electrodes and low thresholds.

• We observed changes in array position after changes in perception.
Discussion

• 3D-CT reconstructions can resolve position of ABI array

• Limitations of our study include:
  – Small sample size
  – Possible confounding effect of duration of ABI use and comorbidities
  – Anatomy and age at implantation may influence measurements
    → No significant correlation (p > 0.05)

• Prospective studies on larger numbers of patients are needed to determine predictive value of ABI array position on perceptual outcomes and the role of image-guidance during ABI surgery in the future

3. Noij KS et al. 2015
5. Nelhaus G et al. 1968
ABI research team at MEEI

Daniel J. Lee, MD
Barbara S. Herrmann, PhD
M. Christian Brown, PhD
Sam Barber MD

Elliott D. Kozin, MD
Vivek Kanumuri, MD
Fadhel el May, Msc
Osama Tarabichi, MD
Dana Egra-Dagan MA
Stephen P. McInturff
Ahad A. Qureshi, MD

- Christine Carter, Sc.D and Mary E. Cunnane, MD

Funding: NIH, DoD, Foundation Bertarelli
References


