Normal Internal Auditory Canal (IAC)

Facial Nerve
Standard ABR
Acoustic Nerve
Sup. Vest. Nerve
Inf. Vest. Nerve

High-frequency
Cross Section: Human Auditory Meatus

I. Background: Limitations of Standard ABRs

Spoendlin and Schrott (1989)
Medium or Large Tumor in IAC

Abnormal
Standard
ABR

Facial Nerve

Acoustic Nerve

Sup. Vest. Nerve

Inf. Vest. Nerve

Tumor
Small Tumor in IAC

Facial Nerve

Abnormal Standard ABR

Acoustic Nerve

Sup. Vest. Nerve

Inf. Vest. Nerve
Small Tumor in IAC

Facial Nerve

Normal Standard ABR

Acoustic Nerve

Sup. Vest. Nerve

Inf. Vest. Nerve

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Normal IAC

Facial Nerve

Acoustic Nerve

Sup. Vest. Nerve

Inf. Vest. Nerve

Stacked ABR
**Diagnostic Test:** If you add the activity from each of the five areas, is the amplitude normal?

Activity from area 1
+ Activity from area 2
+ Activity from area 3
+ Activity from area 4
+ Activity from area 5

Normal Amplitude
Medium or Large Tumor in IAC

Abnormal Stacked ABR

Normal

Tumor

Acoustic Nerve
Small Tumor in IAC

Abnormal Stacked ABR

1
2
3
4
5

Normal Tumor

Acoustic Nerve
Small Tumor in IAC Missed by Standard ABR

Facial Nerve

Normal
Standard ABR

Acoustic Nerve

Sup. Vest. Nerve

Inf. Vest. Nerve
Small Tumor in IAC

Abnormal Stacked ABR

Normal Tumor

Acoustic Nerve
## Stacked ABR Measure

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Proposed Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. An auditory signal that stimulates essentially <strong>all frequency regions</strong> of the cochlea</td>
<td>=&gt; Wide-band Click</td>
</tr>
<tr>
<td>2. A method for <strong>separating</strong> the responses from different frequency regions of the cochlea</td>
<td>=&gt; The Derived-band ABR Technique</td>
</tr>
<tr>
<td>3. A procedure for <strong>summing</strong> the responses to approximate total neural activity</td>
<td>=&gt; The Stacking Technique</td>
</tr>
</tbody>
</table>
Click

High-pass Masking Noise
(8.0, 4.0, 2.0, 1.0, and 0.5 kHz)
Click Alone and High Pass Noise Responses

- Click Alone
- 8.0 kHz
- 4.0 kHz
- 2.0 kHz
- 1.0 kHz
- 0.5 kHz
The derived-band technique uses subtraction of the click alone response and the five different high pass responses to obtain five derived-band ABRs that reflect the neural contributions from five different octave-wide frequency regions of the cochlea.
The Stacking Technique

- The Stacked ABR is formed by first temporally aligning wave V of the derived-band ABRs, then summing the responses.
- Aligning the derived-band ABRs eliminates phase cancellation of lower frequency activity. Thus, the Stacked ABR amplitude reflects activity from all frequency regions of the cochlea, not just the high frequencies.
- Reduction of any neural activity due to a tumor, even a small tumor, will result in a reduction of the Stacked ABR amplitude.
For 95% sensitivity (that is, for correct identification of 95 out of every 100 small tumors):

The IT5 and I-V Delay measures have less than 5% specificity (that is, the IT5 and I-V Delay correctly identify less than 5 out of every 100 non-tumor patients),

But the Stacked ABR has 83% specificity (that is, the Stacked ABR correctly identifies 83 out of every 100 non-tumor patients)!
The Stacked ABR appears to have better sensitivity and specificity than the standard ABR for small (≤ 1 cm) tumors.

In other words, the Stacked ABR is better at:

1. detecting small tumors, and
2. decreasing the number of misdiagnosed non-tumor patients (i.e., decreasing the number of false-positives referred for MRI).
ABR SCREENING PROTOCOL FOR ACOUSTIC TUMORS

Perform Standard ABR Analyses (IT5, I-V, etc.)

- Normal? (Yes = Evaluate for auditory neuropathy and/or refer for neurological evaluation)
  - No = Send For An MRI

Send For An MRI

- Tumor? (Yes = Prescribe Treatment (e.g., surgery))
  - No = Normal?

Perform Stacked ABR Analyses

- Normal? (Yes = Observe? Follow?)
  - No = Send For An MRI

Tumor?

- Yes = Prescribe Treatment (e.g., surgery)
  - No = No
Breaking News: Meniere’s Disease

- Symptoms of early Meniere’s disease and small acoustic tumors are similar.
- There’s a pattern in the high pass responses of patients with Meniere’s disease that may be used to help with the differential diagnosis.
Endolymphatic Hydrops

Alters Basilar Membrane Parameters (e.g., stiffness, fluid column height, etc.)

Changes how cochlea processes auditory stimuli
In Meniere’s disease, we think that:

- Cochlear hydrops alters the response properties of the basilar membrane.
- Low frequency masking noise is less effective for masking activity in higher frequency regions.
- Thus, we observe undermasking in the high pass responses.
Click Alone (Unmasked) and High Pass Noise (HPN) Responses

ABR to Click Alone (unmasked)
ABR to Click + 8 kHz HPN
ABR to Click + 4 kHz HPN
ABR to Click + 2 kHz HPN
ABR to Click + 1 kHz HPN
ABR to Click + 0.5 kHz HPN
Undermasking in Meniere’s Disease

Meniere’s disease

non-Meniere’s disease

Unmasked
8.0 kHz
4.0 kHz
2.0 kHz
1.0 kHz
0.5 kHz

Undermasking in Meniere’s Disease

Meniere’s disease

non-Meniere’s disease

Unmasked
8.0 kHz
4.0 kHz
2.0 kHz
1.0 kHz
0.5 kHz
Wave V Latency Delay (500 Hz HP – Click Alone)

Meniere’s disease

non-Meniere’s disease

Unmasked

8.0 kHz

4.0 kHz

2.0 kHz

1.0 kHz

0.5 kHz

0 - 2 - 4 - 6 - 8 - 10 - 12 - 14 ms

8 - 10 - 12 - 14 ms
Wave V Latency Delay (500 Hz HP – Click Alone)

- Normal - typical wave V (N = 35)
- Normal - undermasked wave V (N = 3)
- Meniere’s (N = 20)
In addition to the wave V latency delay, we are investigating other measures of this undermasking phenomenon.

We are also analyzing data from non-Meniere’s disease subjects with hearing loss and patients diagnosed with cochlear hydrops, not Meniere’s disease.

Preliminary results show very good separation of Meniere’s disease/cochlear hydrops patients and non-Meniere’s disease subjects.
IMPORTANT!

- Do not confuse the Stacked ABR method with this method for evaluating Meniere’s disease.
- The Stacked ABR is for small tumor detection and is not used for Meniere’s disease assessment.
- Stacked ABR uses the sum of the aligned derived-band (subtracted) ABRs while the Meniere’s test uses only the high-passed noise masked responses to clicks.
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References


Don M, Kwong B, Tanaka C (2005) A Diagnostic Test for Meniere’s Disease and cochlear Hydrops: Impaired High-pass Noise Masking ABRs. (Otology & Neurotology 26: 711-722.)