Conductive hearing loss in NHS follow-up using wideband immittance

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Objectives

- List middle ear problems that may affect newborn screening.

- Define wideband immittance testing and how it differs from traditional tympanometry.

- Discuss wideband immittance results in transient and permanent conductive hearing loss.
NHS and Middle Ear Problems

• Refer rate for Newborn Hearing Screening (NHS) averages 8% at Stage I screening but improves to about 2% at re-screening.

• 80-90% of NHS referrals are due to temporary middle-ear dysfunction (Sanford et al., 2009; Hunter et al, 2010)

• Maturational differences in ear canal and middle ear acoustic transfer affect screening and diagnosis.

• Positive Predictive Value of NHS ≅ 10% since incidence of mild or greater congenital permanent hearing loss is approx. 2/1000.
Newborn Conductive Hearing Loss

- Infants failing NHS due to conductive hearing loss are at high risk for persistent or fluctuant hearing loss.
- Average hearing for infants with CHL approximately 30 dB with range of 15-45 dB. (Maxon et al., 1993).
- Conductive hearing loss may sometimes be permanent due to congenital defects.
Baby Leah

- Female, full-term, born by C-section
- Referred on OAE and AABR newborn screen in both ears
- Seen for follow-up, Mom is unconcerned, was told its “just fluid due to c-section”.
• Repeat OAEs are absent in both ears
• ABR shows thresholds of 60 dBnHL in both ears for clicks, 1 and 4 kHz tonebursts
• Bone conduction thresholds are absent except for stimulus artifact
• Wideband immittance is normal in both ears
• **Diagnosis = SNHL**
• Difficult counseling session
• Mom in shock, denial
Newborn transient outer and middle ear conditions

- Vernix in ear canal
- Residual amniotic fluid
- Mesenchyme or meconium
- Similar to otitis media, these conditions alter the sound-conducting efficiency of the middle ear.
- These conditions affect both OAEs and AABR
Limitations of Hearing Screening Tests in Newborns

• OAE and ABR screening does not distinguish between temporary hearing loss due to middle ear fluid and permanent congenital hearing loss.
• Standard tympanometry cannot detect middle ear effusion in newborns.
• Standard tympanometry tests only one frequency at a time, missing important frequency regions for pathology detection.
Wideband Immittance Tests

Use clicks instead of pure tones

Wideband Acoustic Reflexes

- Middle ear, cochlear and efferent middle ear muscle reflex tests
- Same probe/tip & instrumentation for 3 tests; total time ranges from 10 sec to 1 min per test.

Wideband Tympanometry

Chirp evoked OAEs
Wideband Tympanometry Research System (Keefe et al.)
Produced by Interacoustics, Inc.

http://www.interacoustics.com/News_and_events/Newsmain.asp
Wideband Absorbance Principle

Absorbance = \frac{Absorbed Power}{Incident Power}
Wideband Absorbance Method

Microphone

Chirp/Click

Absorbed Power
Incident Power

\[ WA = \frac{\text{Absorbed Power}}{\text{Incident Power}} \]
• **Study design**: Longitudinal, infants screened in normal nurseries and NICUs, funded by NIH/NIDCD

• **Overall goal**: To improve accuracy of Newborn Hearing Screening (NHS) to identify SNHL and CHL

• **Clinical performance**: Wideband acoustic absorbance and acoustic reflexes in newborn and infants

• **Clinical validation**: Diagnostic air and bone conduction ABR at about 1 month
Study Questions

• Can NHS failure due to middle ear problems be predicted by wideband immittance measures?
  – Two stage TEOAE and AABR

• Can wideband immittance help diagnose CHL at diagnostic ABR?
  – Air and bone conduction tone burst threshold ABR at 0.5, 1, 2, 4 kHz
Study Questions

Two-Stage NHS

Air and bone ABR

Screened 1423 ears

840 passed TEOAE

225 passed AABR

30 CHL or MHL

583 failed TEOAE

153 failed AABR

20 CHL or MHL
Demographics

- White: 59%
- Black or African American: 31%
- Asian: 1%
- Other: 9%
- Unknown: 0%
Risk Factors

- NICU: 17.50%
- Ototoxic Drugs: 13.10%
- High Bili: 12.30%
- Family Hx: 7.30%
- Low Birthweight: 6.30%
Normal Case Wideband Tympanometry
Conductive HL Case
Wideband Tympanometry

0.7-1.4 kHz band tympanogram
Peak: 0.67  TPP: -300

1.4-2.8 kHz band tympanogram
TWN: 0  TWp: 130

Absorbance vs. Frequency
Normal Case
Wideband Reflectance

GSW1567%V1.LTT (tested 02/04/14)

Absorbance

Group delay (μs)

f (kHz)
Conductive HL Case
Wideband Reflectance

GSN2022%V1.RTT (tested 05/20/11)

Absorbance

Group delay (µs)

f (kHz)
Normal Case
Wideband Acoustic Reflex

Threshold = 60 SPL
Measured at +22 daPa
Conductive HL Case
Wideband Acoustic Reflex Threshold

Threshold = No Response
Measured at -300 daPa
Two-Stage TEOAE and AABR Screening Ambient Absorbance

Screening: Ambient Absorbance and Group Delay

- Screening Pass, N=648
- Screening Refer, N=123
- Mean ± SE

Cincinnati Children’s
Overall Predictions of Conductive and Mixed Hearing Loss at Diagnostic ABR
Baby Jacob

- Referred on newborn screen in both ears
- Seen for follow-up, referred on DPOAEs for both ears
- Toneburst ABR showed mild hearing loss in RE
- Mom is concerned, what do we know?
Jacob 3D Tympanograms
Wideband Absorbance Left and Right
Conclusions

- Wideband absorbance and acoustic reflexes are reliable predictors of transient and persistent conductive hearing loss.

- Multiple tests (ambient or tympanometric absorbance plus ART) perform better than single tests.

- Wideband tests are fast and useful tests that can detect screening refer due to transient middle ear conditions at birth and conductive hearing loss at diagnostic follow-up.

- Ideally, these tests could be done at re-screening, or diagnostic testing.
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Questions and Discussion