Detection of middle ear dysfunction using wideband acoustic tests in newborn hearing screening and diagnostic follow-up

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Disclosure Statements

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Learning Outcomes

• Define how transient middle ear problems affect newborn screening.
• Explain how middle ear problems affect OAE and ABR screening.
• Discuss effectiveness of wideband immittance for diagnosis of newborn hearing referrals.
Newborn Screening 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.

• Sensitivity: Screening Auditory Brainstem Response (ABR) misses approximately 23% of infants with mild permanent hearing loss (Johnson et al., 2005).
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 Screening and Diagnostic Tests

- 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 Research System (Keefe et al.)
Produced by Interacoustics, Inc.

http://www.interacoustics.com/News_and_events/Newsmain.asp
Wideband Power Reflectance:
Measures amount of energy reflected back and time delay of travel across frequencies
Wideband Reflectance Probe and Response

Microphone
Chirp/Click

ER = \frac{\text{Reflected Power}}{\text{Incident Power}}
Wideband Absorbance in TEOAE Screening

AROC = .87 for absorbance versus .75 for 1-kHz tympanometry
Early Diagnosis of Ears in Newborns

- **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
Two-Stage NHS

Screened 1325 ears

742 passed TEOAE
583 failed TEOAE

225 passed AABR
123 failed AABR

30 CHL or MHL
20 CHL or MHL

Air and bone ABR
Research Instrumentation

• Wideband Research System with Titan probe and tympanometer
• Custom software, CardDeluxe sound card
  – 22.05 kHz sample rate
• Ambient and wideband tympanograms
• Acoustic absorbance and group delay to clicks
  – Inter-click interval of 46 ms; half-octave frequencies from 0.25 to 8 kHz
Research Instrumentation: Wideband Acoustic Reflex Reflex Thresholds

- Ipsilateral ART
  - 5 click stimuli alternating with 4 broadband noise (BBN) activator pulses
- Click difference to each of 4 post-activator clicks with respect to the first "baseline" click
- AR shift spectra averaged
  - low (0.8-2.8 kHz) and high frequencies (2.8-8 kHz).
- 10 activator levels in 5 dB increments
- Presence of ART based on criteria including:
  - Signal “energy” of AR-shift >=6 dB re: noise
  - Max correlation between click-difference spectra >= 0.7
  - Low-level noise responses excluded
Demographics

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

White: 59%
Risk Factors

- NICU: 17.50%
- Ototoxic Drugs: 13.10%
- High Bili: 12.30%
- Family Hx: 7.30%
- Low Birthweight: 6.30%
Normal Case
Wideband Absorbance & Group Delay

GSW1567\%V1.LTT (tested 02/04/14)
Normal Case
Wideband Tympanometry & Group Delay
Normal Case
Wideband Acoustic Reflex Threshold to Clicks

Threshold = 60 SPL
Measured at +22 daPa
Conductive HL Case
Wideband Absorbance & Group Delay

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

Absorbance

Group delay (μs)

f (kHz)
Conductive HL Case
Wideband Tympanometry & Group Delay
Conductive HL Case
Wideband Acoustic Reflex Threshold

Threshold = No Response
Measured at -300 daPa
Wideband Test Performance

- Ambient absorbance (Aa)
- Tympanometric absorbance (At)
- Group Delay
- Acoustic reflex thresholds
  - Compared to TEOAE and AABR NHS
  - Test Performance in Randomized Split Groups
  - Compared to diagnostic ABR
  - ROC Area Under Curve (AUC) and Symmetry (SYM)
TEOAE Screening Test: Wideband Reflectance Split-Group Test Performance Ambient Absorbance and Group Delay

GROUP 1
Screening Pass, N=450
Screening Refer, N=346
Mean ± SE

GROUP 2
Screening Pass, N=292
Screening Refer, N=237
Mean ± SE
Overall Predictions of Split-Group TEOAE Screening
Brackets indicate Significant Differences
Two-Stage TEOAE and AABR Screening Result
Ambient Absorbance and Group Delay

Screening Pass, N=648
Screening Refer, N=123
Mean ± SE
Two-Stage TEOAE and AABR Screening Result
Tympanometric Absorbance and Group Delay

**Screening Pass, N=648**

**Screening Refer, N=123**

**Mean ± SE**
Overall Predictions of Two-Stage Screening
Brackets indicate Significant Differences
Overall Predictions of Conductive and Mixed Hearing Loss at Diagnostic ABR
Conclusions

- Wideband reflectance is a reliable predictor of NHS refer in randomized study of two independent groups, smart algorithms will be helpful for audiologists.

- Wideband reflectance and acoustic reflexes detect TEOAE and AABR screening refer and Conductive Hearing.

- Multiple tests (ambient or tympanometric reflectance 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.
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• Thank you for attending!
Questions and Discussion