Current Strategies for Assessment of Infant Hearing Plus an Update on Diagnostic Audiometry in Adults

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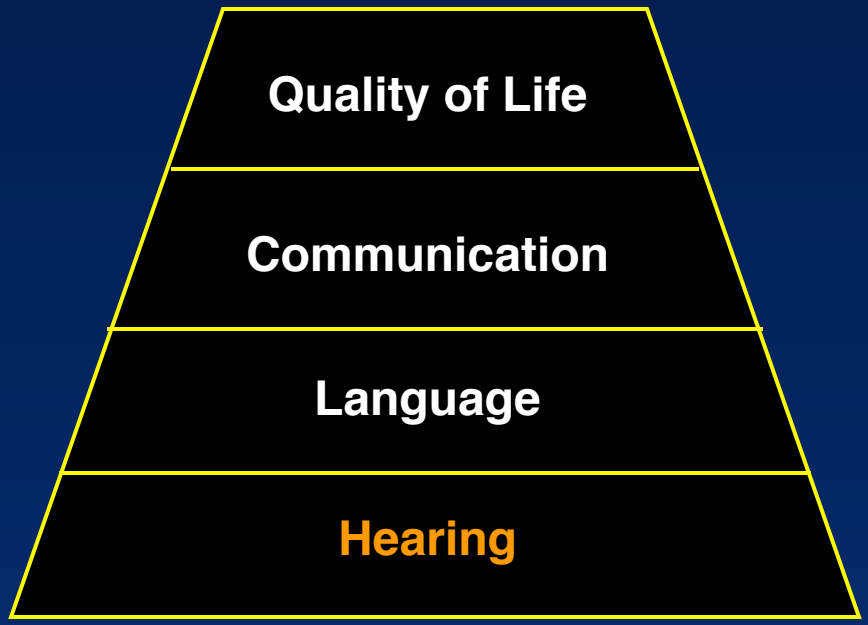
Current Strategies for Assessment of Infant Hearing Plus an Update on Diagnostic Audiometry in Adults

- Overview of Objective Infant Hearing Assessment
- Electro-Acoustic Procedures
  - Acoustic Immittance Measures
  - Otoacoustic Emissions
- ABR and ASSR Measurement with Frequency Specific, Chirp, and Bone Conduction Stimulation
- Live Demonstration
- Update on Diagnostic Audiometry and Speech Audiometry in Children and Adults

Overview of Infant Hearing Assessment

- Early diagnosis and intervention improves communication
- Accurate assessment of infant hearing is standard of care
- Efficient screening for identification of hearing loss
- The cross-check principle still rules
- An objective auditory test battery
  - Acoustic immittance measures
  - OAEs
  - ABR
  - ASSR
  - ECochG

Hearing: An Important Building Block in the Foundation for Communication and Quality of Life



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A Common Evidence Grading System: *Four Categories*

- Grade 1
  - 1a: Well-designed meta-analysis of randomized controlled trials
  - 1b: Well-designed randomized controlled trials
- Grade 2
  - 2a: Well-designed controlled studies without randomization
  - 2b: Well-designed quasi-experimental studies
- Grade 3: Well-designed non-experimental studies, i.e.,
  - Correlational studies
  - Case studies
- Grade 4:
  - Expert committee reports, consensus conferences and clinical experience

Overview of Infant Hearing Assessment: *Clinical Guidelines*

- Joint Committee on Infant Hearing Year 2007 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs. *Pediatrics, 120*, 2007-2333, 2007
- 2008 Guidelines on Identification, Diagnosis, and Management of Auditory Neuropathy Spectrum Disorder in Infants and Young Children
- 2012 American Academy of Audiology: Audiologic Guidelines for the Assessment of Hearing in Infants and Young Children
- 2013 American Academy of Audiology Clinical Practice Guidelines: Pediatric Amplification
- Guidance for Auditory Brainstem Response Testing in Babies (Version 2.1) March 2013. NHSP Clinical Group

Example of A Practice Guideline in Audiology: Year 2007 JCIH Position Statement Protocol for Evaluation for Hearing Loss In Infants and Toddlers from Birth to 6 months

- Child and family history
- Evaluation of risk factors for congenital hearing loss
- Parental report of infant's responses to sound
- Audiological assessment
  - Auditory brainstem response (ABR)
    - ✓ Click-evoked ABR with rarefaction and condensation single-polarity stimulation if there are risk factors for auditory neuropathy
    - ✓ Frequency-specific ABR with air-conduction tone bursts
    - ✓ Bone-conduction stimulation (as indicated)
    - ✓ Auditory steady state response (ASSR) is optional
  - Otoacoustic emissions (distortion product or transient OAEs)
  - Tympanometry with 1000 Hz probe tone
  - "Clinical observation of infant's auditory behavior. *Behavioral observation alone is not adequate for determining whether hearing loss is present in this age group, and is not adequate for the fitting of amplification devices."*

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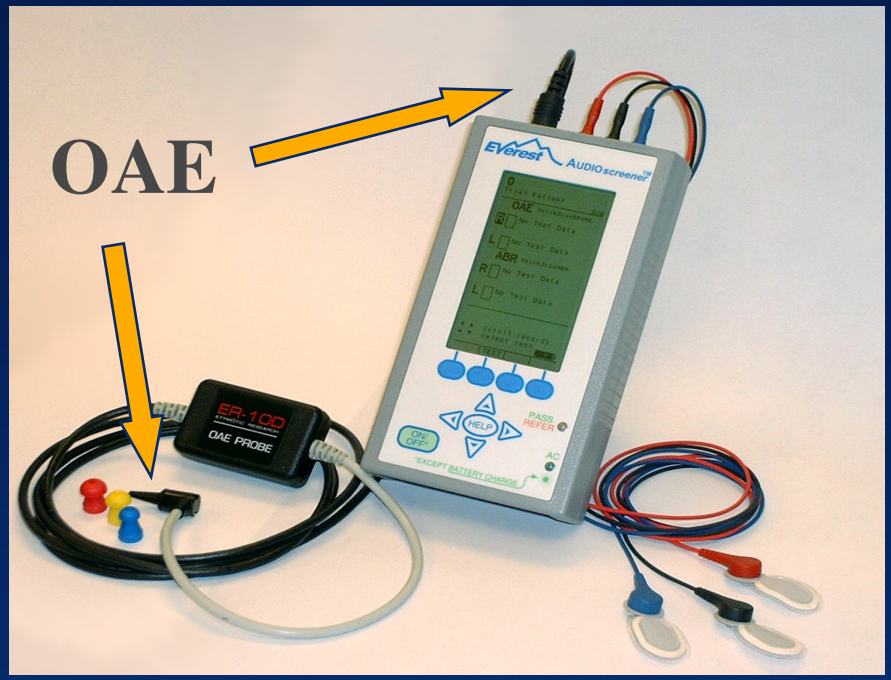
Combined Automated OAE and ABR Technique

AUDIOscreener (GSI)



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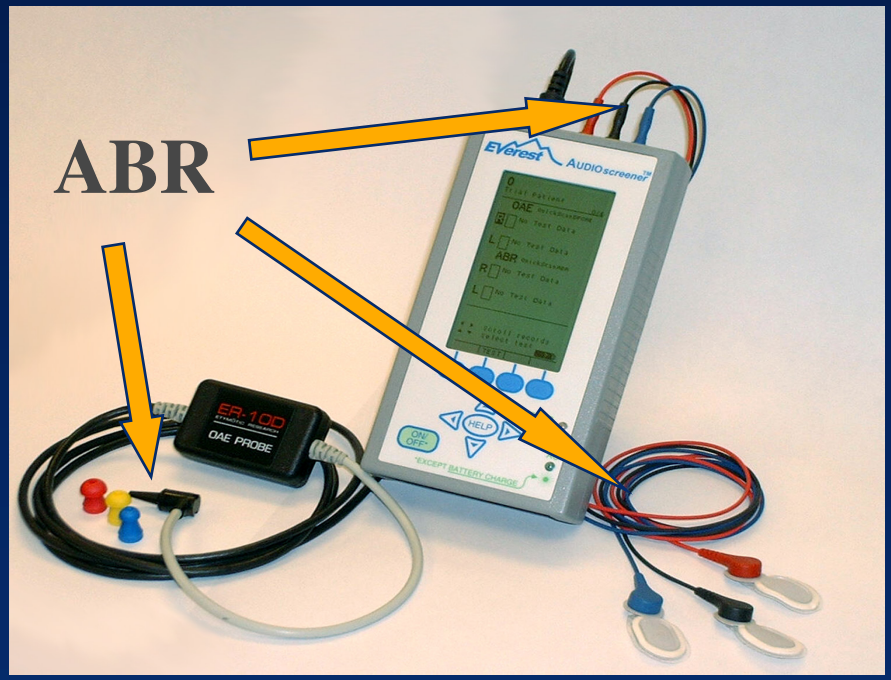

Combination OAE/ABR Screening: Differentiation of Peripheral Auditory Dysfunction

(Hall, Smith & Popelka. Journal of the American Academy of Audiology, August 2004)

Type of dysfunction	OAE	ABR
None	Normal	Normal
External/middle ear *	Abnormal	Normal
Sensory (OHC)	Abnormal	Abnormal
Neural	Normal	Abnormal

** Minor dysfunction in most cases*

Combined OAE and AABR Study: Results (N = 600)

Diagnostic Outcome	Screening Outcome: Pass	Refer	N
Normal	590	2	592
Hearing Impaired	0	8	8
N	590	10	

Sensitivity = 100.0%
Specificity = 99.7%
Refer Rate = 1.7%
Positive Predictive Value = 80.0%

OAE and AABR Screening Techniques: 2007 Joint Committee on Infant Hearing Recommendations

- Well baby nursery (WBN)
  - Screening with OAEs or AABR
  - Refer outcome for AABR
    - ✓ Schedule for diagnostic follow up assessment < 3 months
  - Refer outcome for OAEs?
    - ✓ Immediate follow up screening with AABR
  - Refer outcome for OAEs and AABR?
    - ✓ Schedule for diagnostic follow up assessment < 3 months
- Neonatal intensive care unit (NICU) or intensive care nursery (ICN)
  - Screening AABR (to detect auditory neuropathy)
  - Pass outcome for AABR?
    - ✓ Follow as indicated by risk factors for progressive/delayed onset hearing loss
  - Refer outcome for AABR?
    - ✓ Perform OAEs to identify possible auditory neuropathy
    - ✓ Schedule for diagnostic follow up assessment < 3 months

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The Cross-Check Principle in Pediatric Audiology

(Jerger J & Hayes D. Arch Otolaryngol 102: 1976)

The Cross-Check Principle in Pediatric Audiology

(Jerger J & Hayes D. Arch Otolaryngol 102: 1976)

"We have found that simply observing the auditory behavior of children does not always yield an accurate description of hearing loss"…

"The basic operation of this principle is that no result be accepted until it is confirmed by an independent measure."

Test Battery:

- Behavioral audiometry
- Immittance (impedance) measurements
  - ✓ Tympanometry
  - ✓ Acoustic reflexes (contralateral only with SPAR)
- Auditory brainstem response (brainstem-evoked response audiometry or BSER)
  - ✓ Click stimulus air conduction
  - ✓ Click stimulus bone conduction

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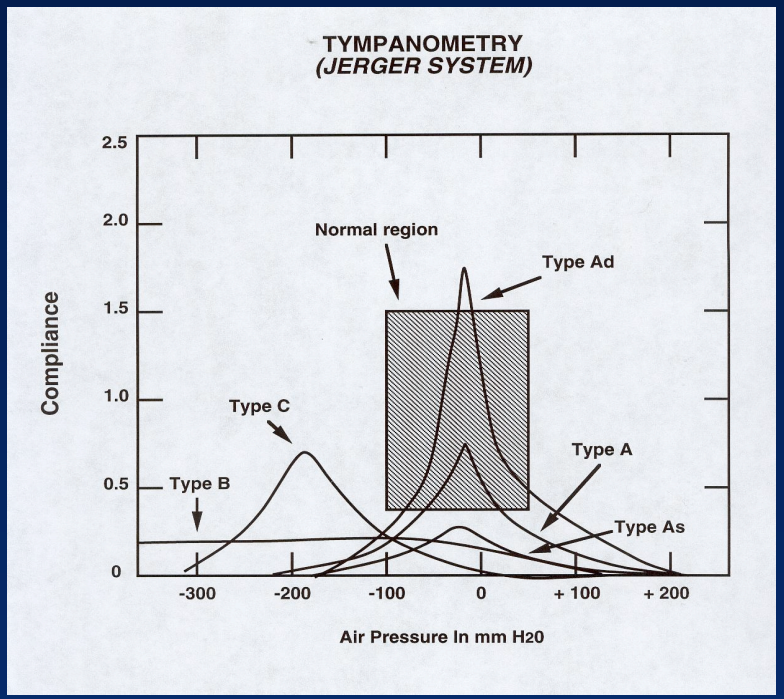
British Society of Audiology Recommended Procedure: Tympanometry (August 2013)

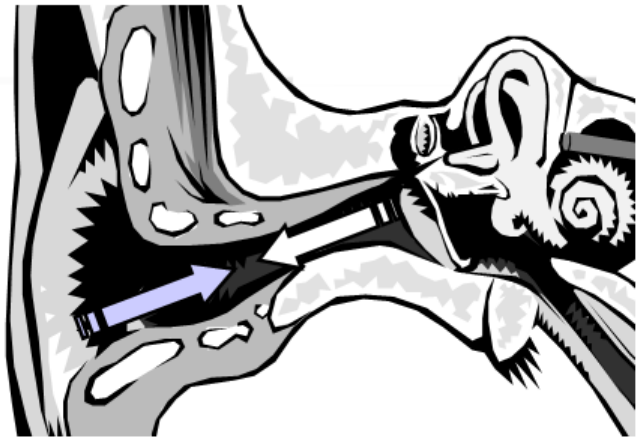
- Introduction
- General considerations
- Equipment
- Calibration
- Subject preparation
- Test procedure
- Results and recording
- References
- Appendices

Acoustic Immittance Measures:
Tympanometry with 226 and 1000 Hz Probe Tones



Wideband Reflectance/Absorbance

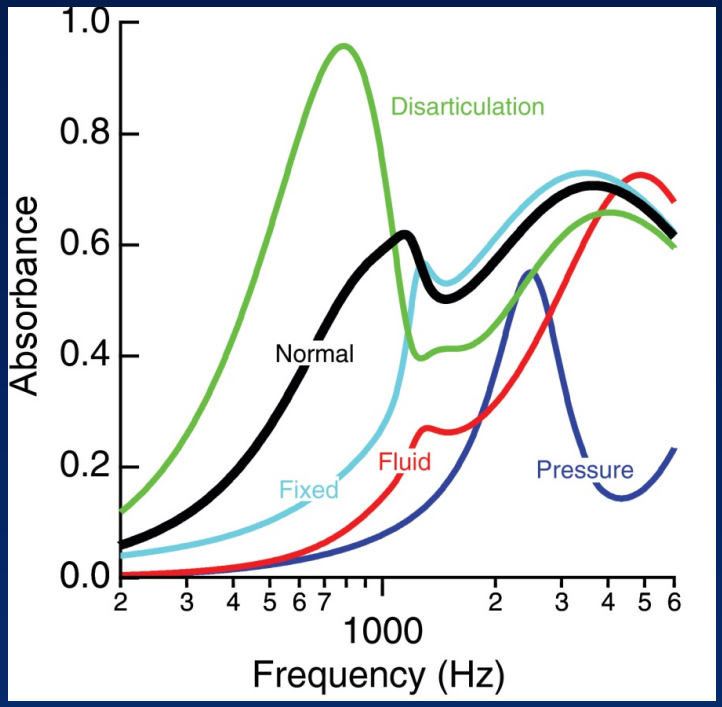
(Figure courtesy of Bue Kristensen, Interacoustics, 2013)



$$\text{Energy Absorbance} = \frac{\text{Absorbed Power}}{\text{Incident Power}} = 0$$

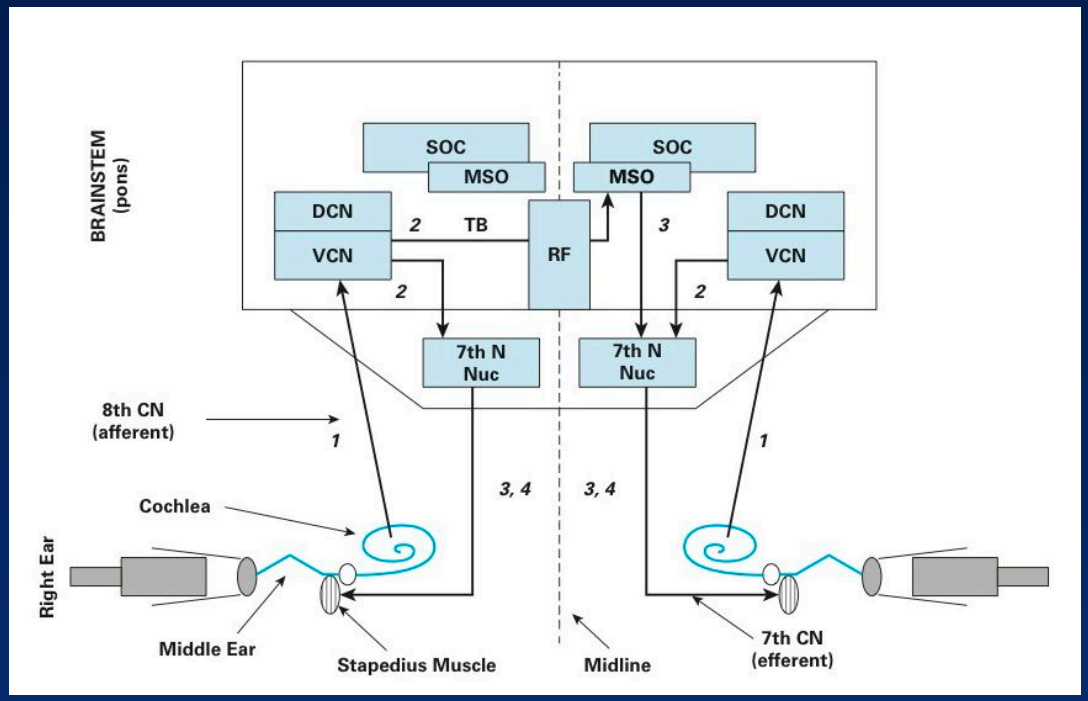
$$= 1 - \text{Energy Reflectance}$$

Wideband Reflectance/Absorbance (Voss et al. Ear & Hearing, 2008)

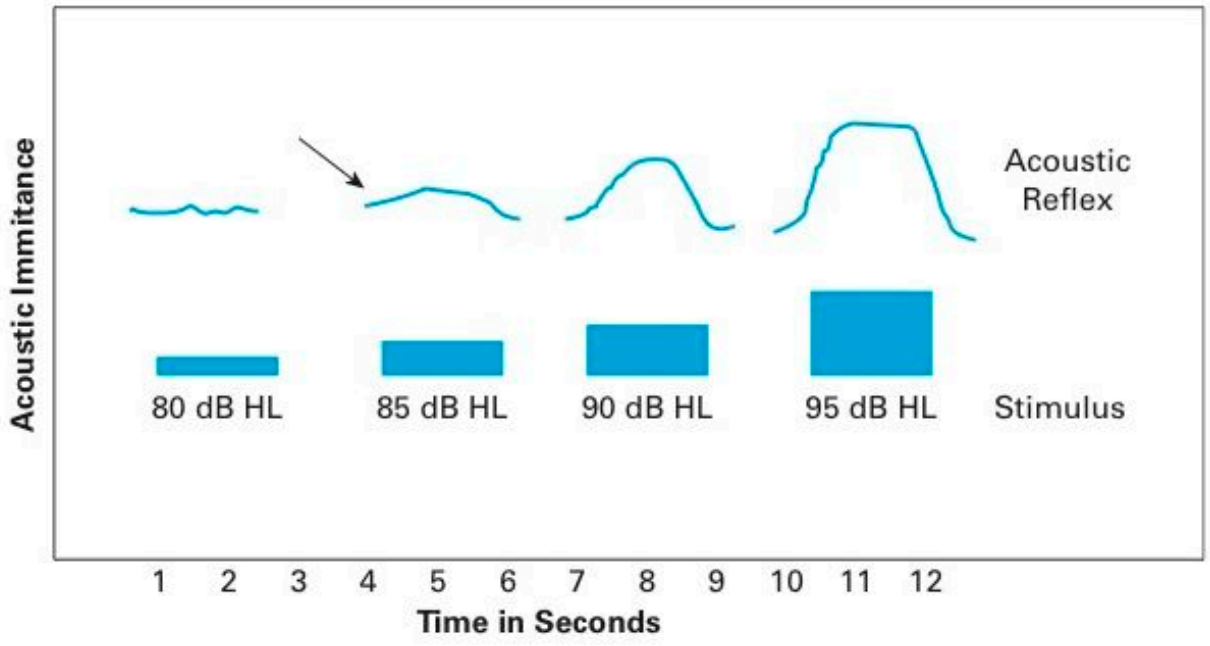


Acoustic Stapedial Reflex Pathways According to Erick Borg

(From Hall JW III (2014). *Introduction to Audiology Today*. Boston: Pearson)



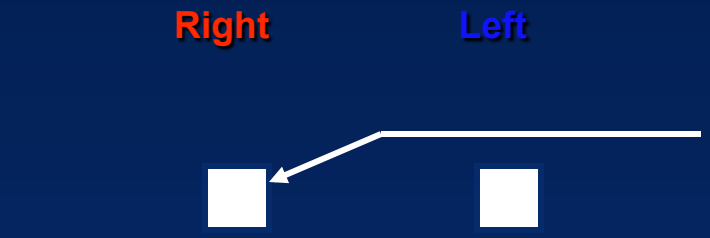
Making Acoustic Reflex Measurements
Acoustic Reflex Threshold



Plotting the Results of Acoustic Reflex Measurements:
Objective Differentiation Among Types of Auditory Dysfunction

Abnormal Acoustic Reflex

Diagnosis Based on Pattern of Abnormalities
Middle ear, Cochlea, 8th CN, Brainstem, 7th CN



Contralateral (Crossed) Sound Right Probe Left

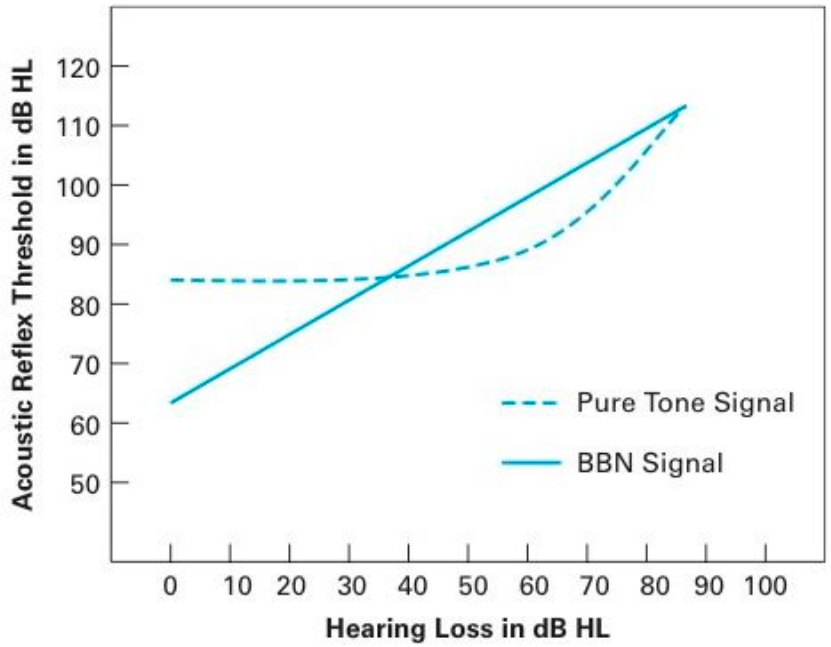
Contralateral (Crossed) Sound Left Probe Right

Ipsilateral (Uncrossed) Sound Right Probe Right

Ipsilateral (Uncrossed) Sound Left Probe Left

Differentiation of Normal Hearing Sensitivity versus Hearing Loss Using BBN Stimulus for Acoustic Reflex Threshold

(Figure from Hall JW III. Introduction to Audiology Today. Boston: Pearson, 2014)



Contribution of Aural Immittance Measurement to Diagnosis and Intervention of Infant Hearing Loss

- Diagnostic information
  - Differentiation of middle ear versus sensory auditory dysfunction
  - Objective confirmation of sensory hearing loss (acoustic reflexes)
  - Objective evidence of retrocochlear auditory dysfunction and of auditory neuropathy spectrum disorder (acoustic reflexes)
  - Objective evidence of central auditory nervous system dysfunction (acoustic reflexes)
- Impact on Intervention Outcome
  - Prompt medical management of middle ear disorder
  - Cost effective and lower risk decisions regarding further diagnostic test procedures (e.g., ABR under anesthesia)
  - Timely referral for multi-disciplinary referrals for prompt and accurate diagnosis of ANSD

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  - ABR
  - ASSR
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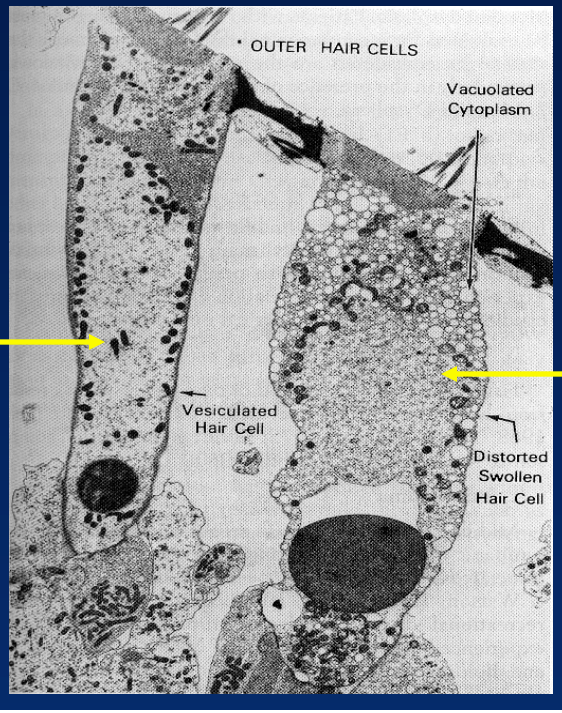
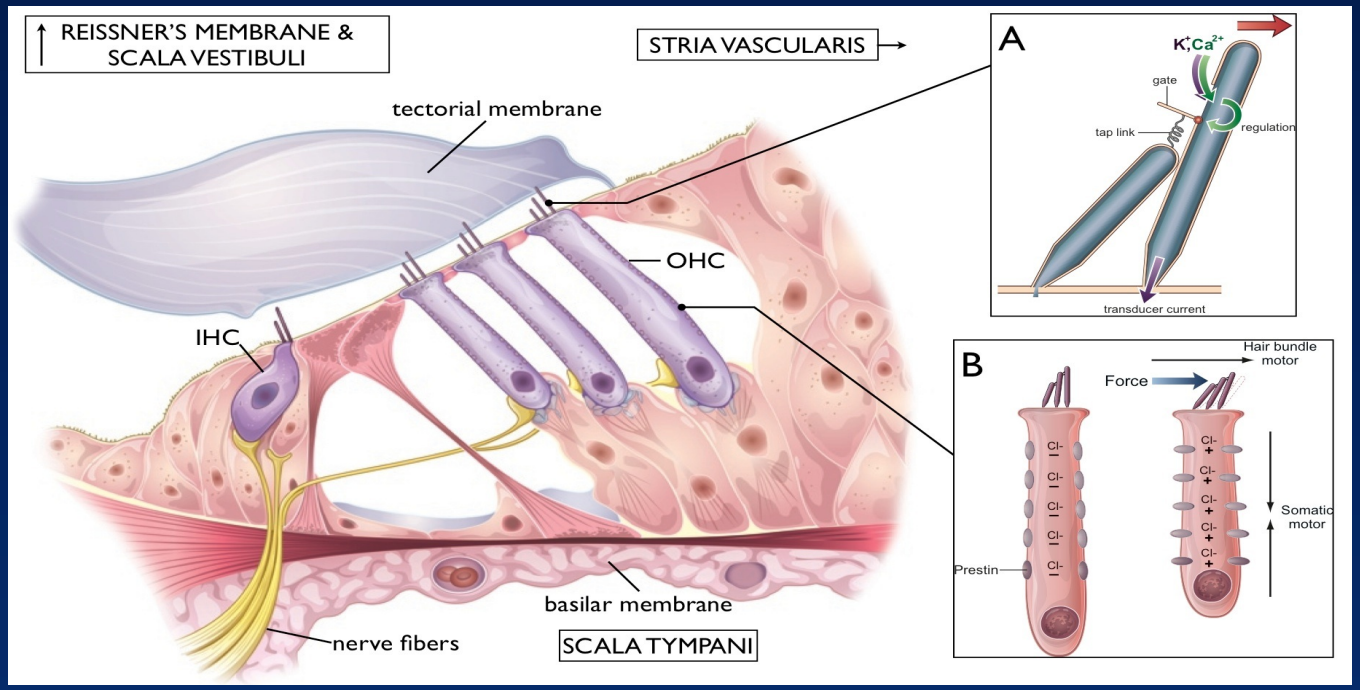
Otoacoustic Emissions (OAEs) in Early Detection of Outer Hair Cell Dysfunction

Normal OHC (OAEs)



Abnormal OHC (OAEs)

OAEs Originate in the Cochlea …
But That's Not the Entire Story



Auditory Anatomy Involved in the Generation of OAEs

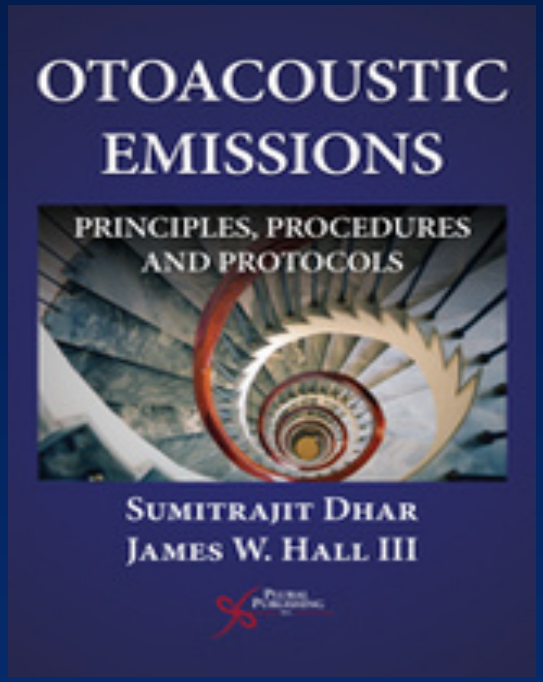
- Outer hair cell motility
  - Prestin motor protein
- Stereocilia
  - Motion
  - Stiffness
- Tectorial membrane
- Basilar membrane mechanics
  - Dynamic interaction with outer hair cells
- Stria vascularis
- Middle ear (inward and outward propogation)
- External ear canal
  - Stimulus presentation
  - OAE detection

Contribution of Otoacoustic Emissions to Diagnosis and Intervention of Infant Hearing Loss

- Diagnostic information
  - Confirmation of outer hair cell integrity versus dysfunction
  - Early detection of cochlear (outer hair cell) dysfunction, e.g., in
    - ✓ Ototoxicity
  - Differentiation of outer versus inner hair cell dysfunction
  - Objective confirmation of sensory hearing loss
  - Identification and diagnosis of auditory neuropathy spectrum disorder
- Impact on Intervention Outcome
  - Earlier and more accurate diagnosis leads to more effective intervention
  - Cost effective and lower risk decisions regarding further diagnostic test procedures (e.g., ABR under anesthesia)
  - Timely referral for multi-disciplinary referrals for prompt and accurate diagnosis of ANSD

Otoacoustic Emissions:
Principles, Procedures, and Protocols

Plural Publishing
(www.pluralpublishing.com)
150 pages, Softcover, 5 x 7.5"
ISBN10: 1-50756-342-0
ISBN13: 978-1-59756-342-0
$45.00



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  - ABR
    - ✓Click
    - ✓Tone burst
    - ✓Chirp
  - ASSR
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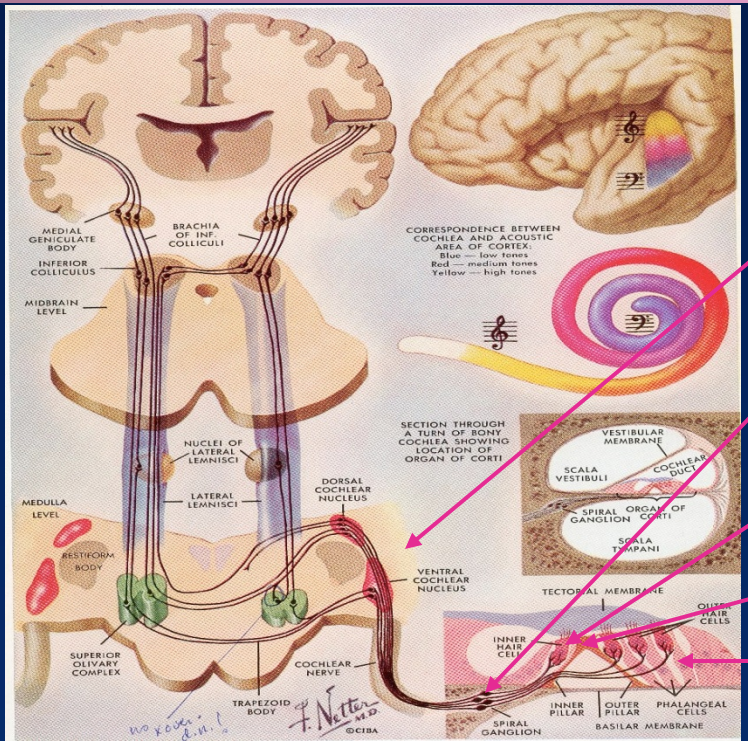
- Pulling it all together

Guidance for Auditory Brainstem Response Testing in Babies (Version 2.1) March 2013. NHSP Clinical Group

- Introduction
- Scope
- Patient Preparation
- Stimulus
- Data Collection and Analysis
- Calibration
- Artefacts
- Glossary
- Appendices

Overview of Infant Hearing Assessment
Sensory and Neural Asssessment



Brainstem
(ABR, ASSR, ARs)

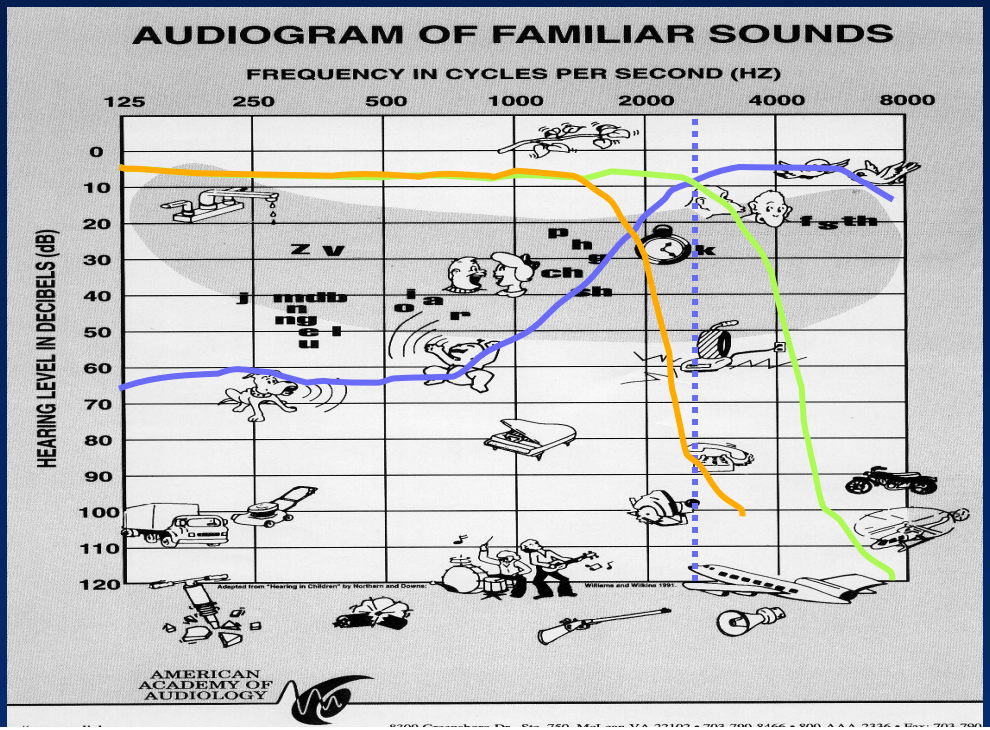
Spiral ganglion cells
(ABR, ECochG)

IHC - 8th CN Synapse
(ABR)

Inner hair cells
(ECochG, ABR, ASSR, ARs)

Outer hair cells
(OAE, ECochG, ARs)

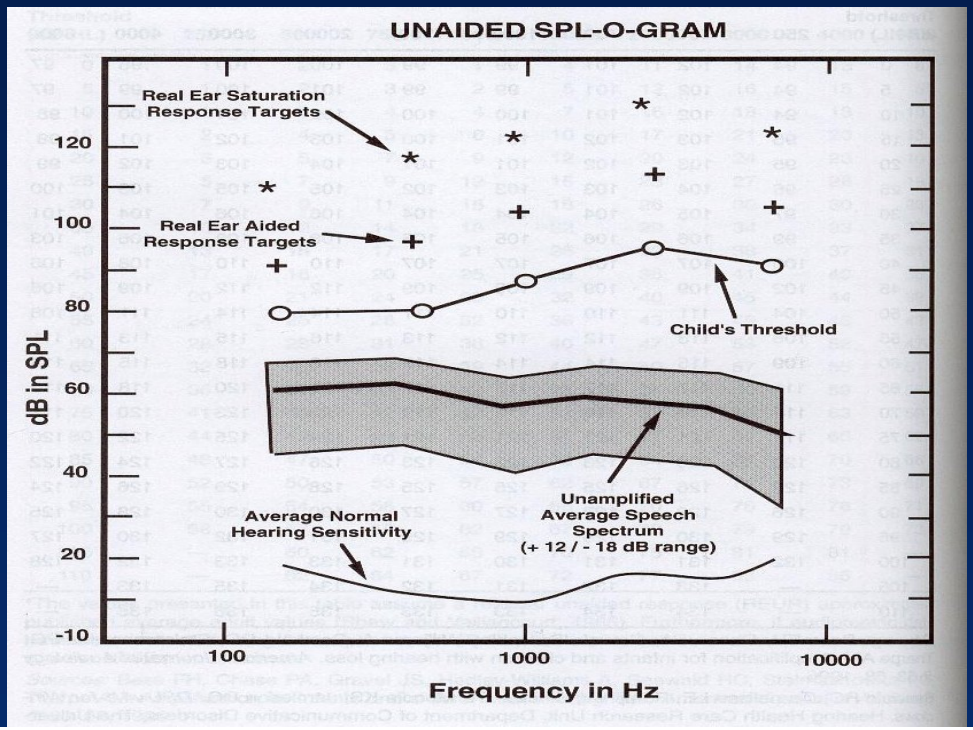
Frequency-Specific Estimation of Auditory Thresholds: An Essential Step in Diagnosis of Infant Hearing



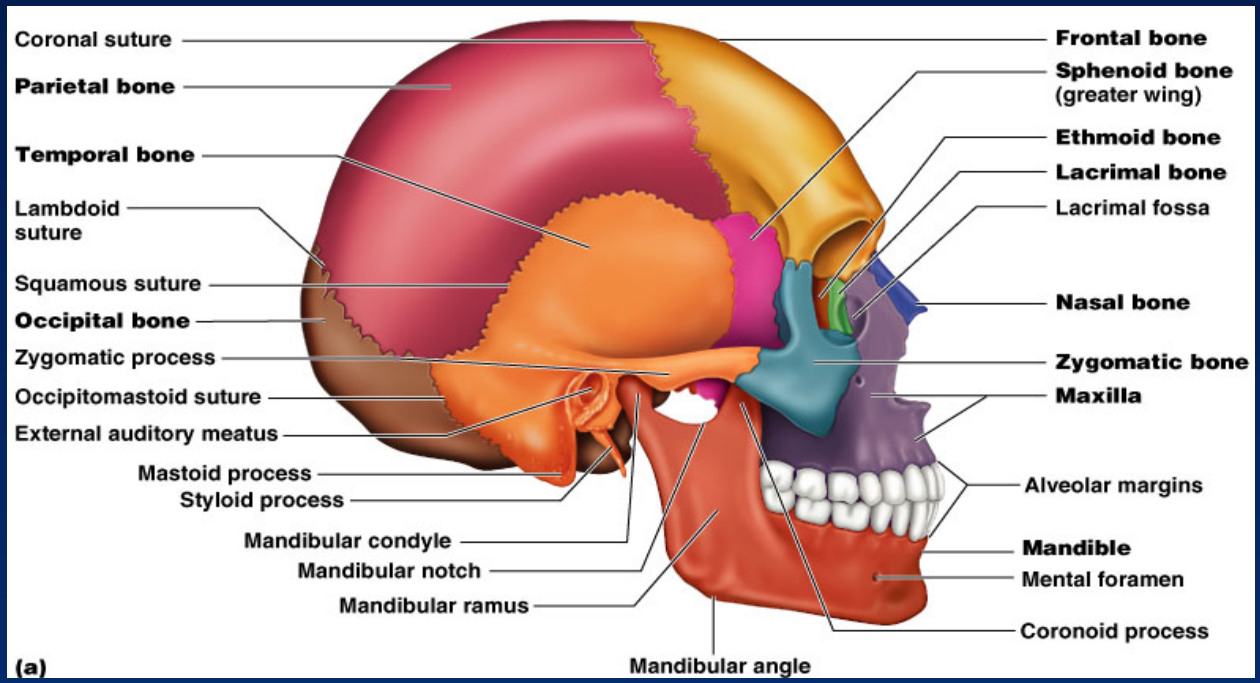
Normal click ABR

Abnormal or no click ABR

Estimation of Frequency-Specific Auditory Thresholds with Tone Burst ABRs: Initial Data Points for Hearing Aid Fitting

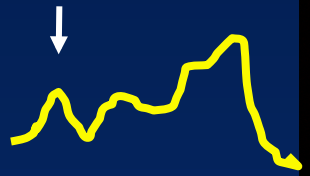


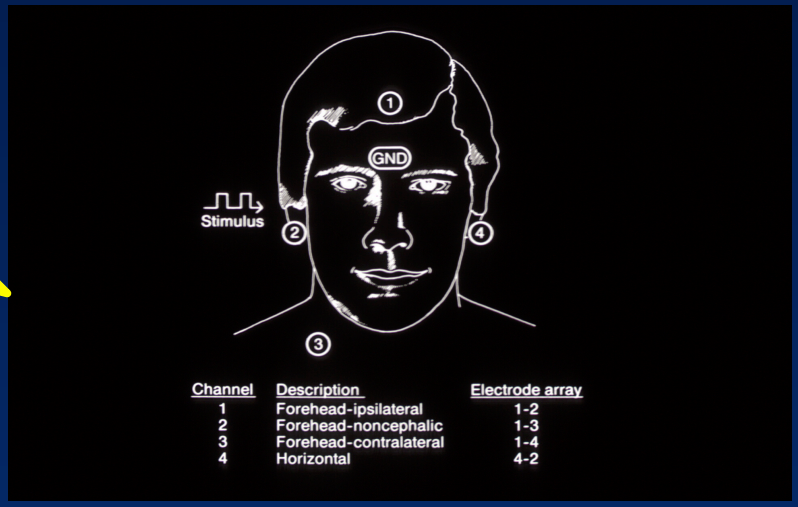
Ear Specific Bone Conduction ABR Assessment: Clinically Feasible and Essential



Two-Channel Bone Conduction ABR Recording: Applying ECochG Principles to Verify the Test Ear

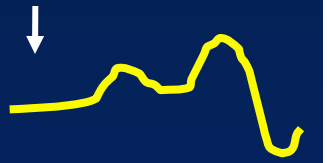
Ipsi Channel
Wave I





Channel	Description	Electrode array
1	Forehead-ipsilateral	1-2
2	Forehead-noncephalic	1-3
3	Forehead-contralateral	1-4
4	Horizontal	4-2

Contra Channel
No Wave I



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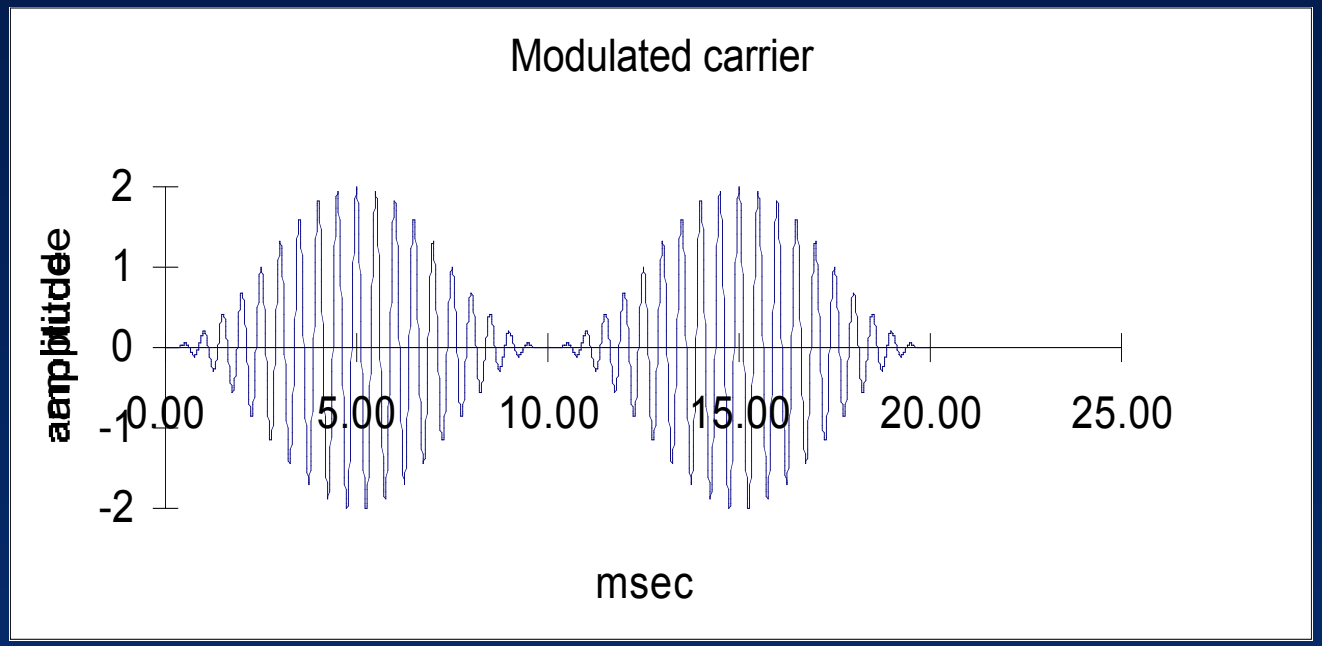
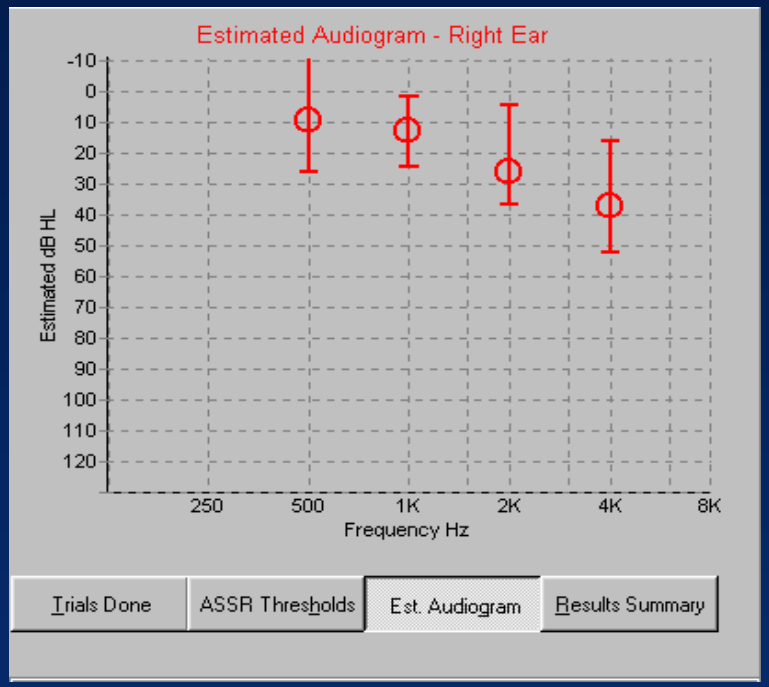
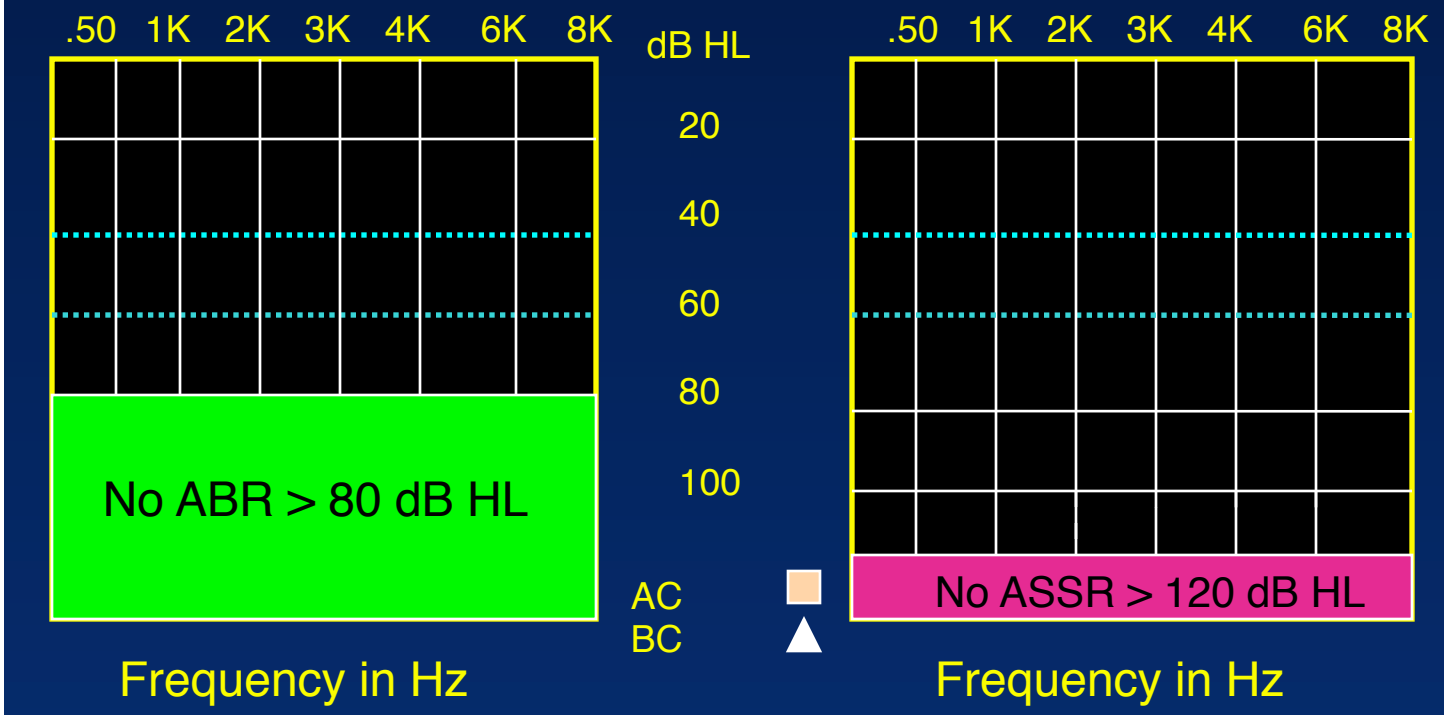
Auditory Steady State Response (ASSR): 2000 Hz tone modulated at rate of 100 Hz



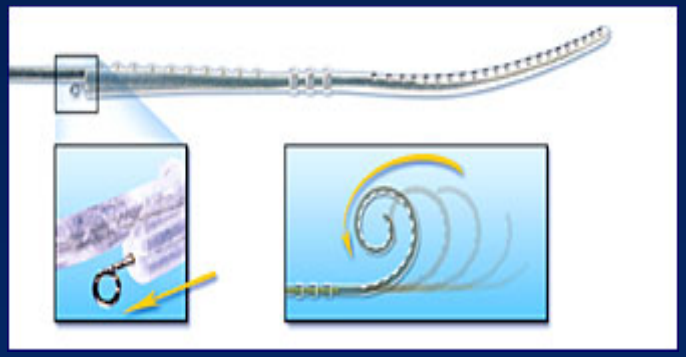
Estimating the Audiogram with ASSR



Limitation of Tone Burst ABR and Advantage of ASSR in Severe-to-Profound Hearing Loss



ASSR Contributes to Timely Management of Infant Hearing Loss: Determining the Need for Cochlear Implants and Confirmation of 8th Nerve Integrity in ANSD



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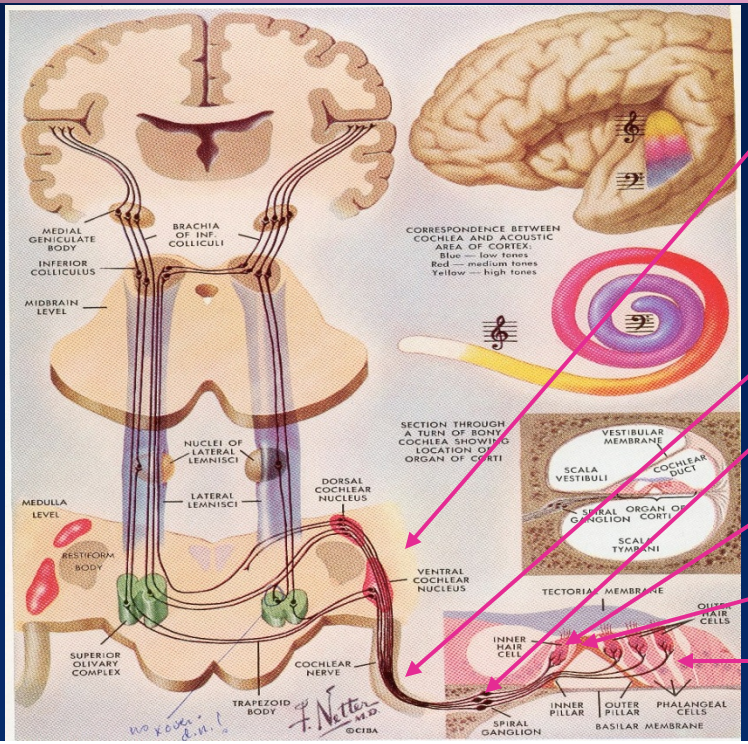
ECochG in the Diagnosis and Management of Auditory Neuropathy Spectrum Disorder (ANSD)



Cerebello-pontine angle (CPA)

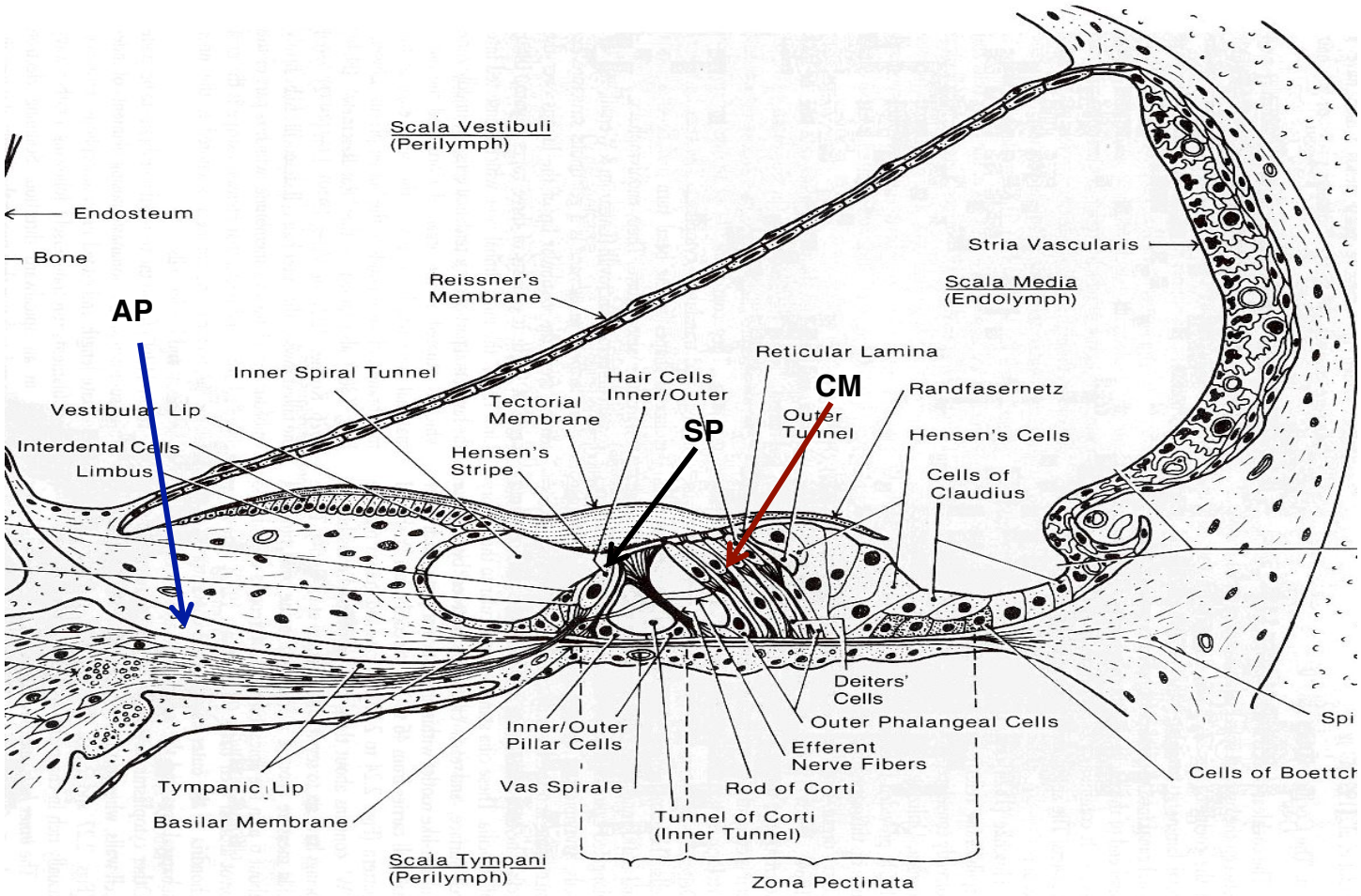
Internal Auditory Canal (Auditory Nerve)

Spiral ganglion cells

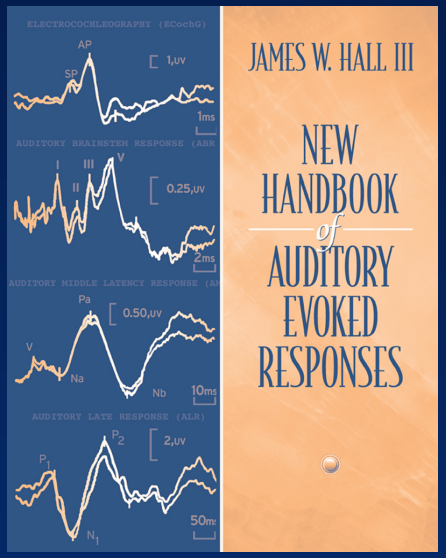
IHC - 8th CN Synapse (glutamate)

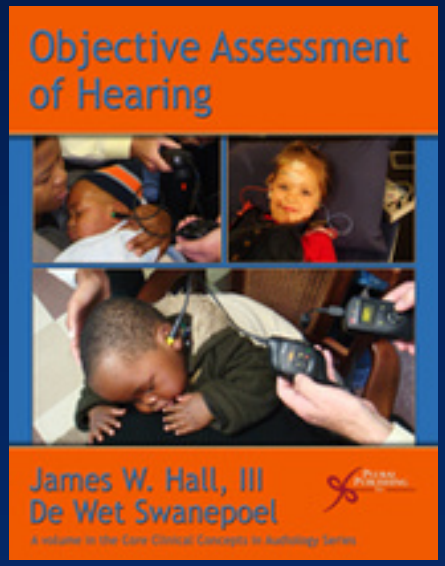
Inner hair cells

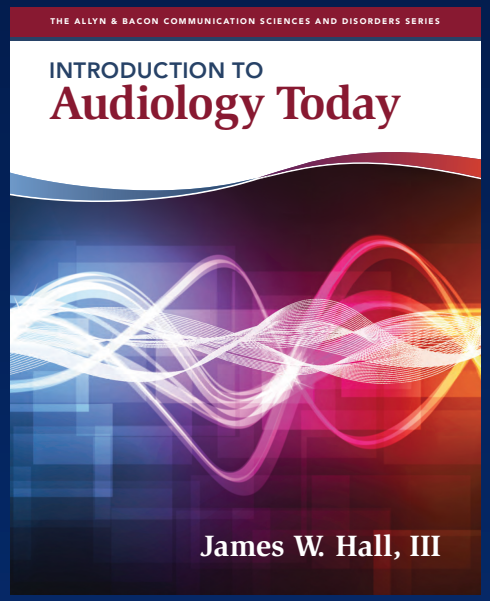
Outer hair cells


Scala Vestibuli
(Perilymph)
Endosteum
Bone
AP
Reissner's
Membrane
Stria Vascularis
Scala Media
(Endolymph)
Reticular Lamina
Inner Spiral Tunnel
Hair Cells
Inner/Outer
CM
Randfasernetz
Vestibular Lip
Tectorial
Membrane
SP
Outer
Tunnel
Hensen's Cells
Interdental Cells
Limbus
Hensen's
Stripe
Cells of
Claudius
Deiters'
Cells
Outer Phalangeal Cells
Inner/Outer
Pillar Cells
Efferent
Nerve Fibers
Cells of Boettch
Tympanic Lip
Vas Spirale
Rod of Corti
Basilar Membrane
Tunnel of Corti
(Inner Tunnel)
Scala Tympani
(Perilymph)
Zona Pectinata

Thank You!
Questions?







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