GSI TympStar™

Basic Operation and Maximum Efficiency

Introduction
Laura Prigge, AuD

- AuD from ATSU, MA of Audiology from UCONN, BS Communication Disorders from Western Illinois University.
- 15+ years experience include providing manufacturing support as well as managing educational audiology training for an international audiologic equipment company.
- Additional experience: clinician in both ENT offices and a retail hearing center conducting audiologic evaluations and hearing aid fittings on all patient populations including infants, adults, geriatric, and special needs patients.
- Joined GSI in 2010 as application specialist

Overview
- History of Immitance/Typical Use
  - Anatomy and Physiology
  - Diagnostic evaluations
- Customizing Auto Sequence and User Tests
- Maximizing Efficiency: Practical Applications
Middle Ear Testing in Today’s Clinic

Typical Use

• Evaluate integrity of the middle ear and acoustic neural pathway
  – Tympanometry
  – Acoustic Reflexes
  – Acoustic Reflex Decay
  – Eustachian Tube Function

Typical Use

• Objective documentation of reduced eardrum movement (ie: fluid, wax, etc.)
• Monitor chronic middle-ear fluid
• Monitor P.E. tube function
• Confirm tympanic membrane perforation
• Monitor Eustachian tube function
• Correlate with audiogram to develop a more complete picture of hearing
What is being tested??

Anatomy, Physiology and Terminology

Important Review

- In order to understand the mechanics of the ear, it is critical to review the structures and how they contribute to the measurement
- Components fall into categories
  - Compliance Elements
  - Mass Elements
  - Friction Elements
- It is also imperative that the verbiage is clearly defined

Physics of the Middle Ear
Vocabulary

- Impedance
  - Resistance
  - Reactance
- Admittance (Y)
  - Susceptance (B)
  - Conductance (G)

Impedance

- The opposition to the flow of energy
- If energy is introduced to a system (such as the middle ear), how much of the energy is blocked, or impeded
  - Reactance
  - Resistance
- Can not directly measure impedance of the middle ear in humans

Admittance (Y)

- The inverse of Impedance
- The ease at which sound flows through the middle ear system
- Measurement is taken at the plane of the eardrum
- Two components – Susceptance (B) and Conductance (G)
Susceptance (B)

- The relationship between the springy parts of the middle ear and the mass elements of the middle ear
- Referred to as the “Stiffness” of the system
- Springy = muscles, connective tissues, other soft materials
- Mass = ossicles
- Flexibility of movement in the middle ear cavity

Susceptance

Conductance (G)

- Measures the amount of energy that is lost due to the friction in the middle ear
- Measures the effect that resistance has on energy flow
- Tendons, ligaments, air molecules and resistance created when the stapes pushes on the perilymph in the inner ear contribute to loss of energy
Friction Points

Process

Sound Transmission
226 Hz Probe Tone

• Most commonly used stimulus for screening and basic diagnostic evaluation
• 226 Hz elicits the fastest and most accurate “picture” of a normal middle ear

226 Hz Probe tone

• Ear is primarily driven by the springy portion of susceptance at this low frequency
• \( B = Y \)
• \( ml = \) only probe tone that you can measure using \( ml \) because strictly compliance driven
• Compliance = \( ml \) or \( cm^3 \)
Admittance Measurements

• GOAL = To measure the admittance of the middle ear – ease at which sound travels.
• PROBLEM = probe sits in the ear canal – measurement is taken from the probe.
• QUESTION = How do we isolate the admittance of the middle ear?

Tymp Process

Baseline Tympanogram

• Baseline means that the outer ear admittance has been automatically subtracted from total admittance
• The Ear Canal Volume will be estimated and displayed
• Ear Canal Volume can give valuable information about abnormal 226Hz Tympanometry
Interesting Questions….

• Why do we use 226 Hz?
• What happens if there is an abnormality?
• Why are the other probe tones available?

Why Use 226 Hz?

• Ear is Compliance driven
  ▪ Y = B
• Fastest way to evaluate a normal ear
  ▪ Tons of data on normal
• Certain that we are measuring the mechanical properties of the middle ear

226 Hz Probe Tone

• In order to isolate the process of energy transfer, the 226 Hz standard probe tone meets the following criteria:
  – Much lower than “normal” resonance frequency
  – Consistent, predictable results
  – At 226Hz, the ear is stiffness dominated (springy elements are “running the show”)
  – Does not elicit Reflex Thresholds at higher intensity level
What do we do with the other probe tones??
When do we use them??

Limitation of 226 Hz
- Great for confirming normal.
- Only as good as the eardrum.
- When more critical look at middle ear components is required, higher frequency probe tones can provide detailed information.

Other Probe Tones
- Y is not measured with 678 or 1000 Hz—need the individual B/G components to be measured independently.
- Not compensated. No baseline. No ECV. Admittance measured in mmho.
- As the frequency increases, the mass component of B contributes more and changes the shape of the tympanogram.
Resonance Frequency

- The frequency at which the middle ear system is the most efficient for energy transfer
- The frequency at which the springy and mass components have equal contribution
- Normal Ranges for Resonance Frequency
  - 600Hz to 1340 Hz (Colletti 1977)
  - 800Hz to 1200 Hz (Shanks 1984)

Resonance Frequency

- Low Frequency Probe Tone (226Hz)
  - Tymp will be \(^{\wedge}\)
- Mid Frequency Probe Tone (678Hz & 1000Hz)
  - All tymps will have multiple peaks - \(^{\wedge\wedge}\), inverted W
- High Frequency Probe Tone (above resonance frequency)
  - Tymps will continue to evolve to a V shape – opposite of the 226Hz

678 Hz Probe Tone
678 Hz Probe Tone

- 678 Hz Tympanograms are interpreted based on shape and configuration (morphology)
- 4 configurations are considered normal for 678 Hz Probe Tone
  - 1B1G
  - 3B1G
  - 3B3G
  - 5B3G

678 Hz Probe Tone

- Considered abnormal if the following occurs:
  1. Too many peaks
  2. Too wide
- Often help distinguish between ossicular discontinuities and other disorders – even when no abnormality is present on the 226Hz tymp.

Normal 678 Hz B/G
678 Hz Disarticulation

Broad peaks and wide inter-peak intervals

1000 Hz Probe Tone

- The infant ear is mass dominated.
- The infant ear has a lower resonance frequency, therefore lower probe tones create complex patterns and more notching.
- Classification scheme not consistent with pathology
  - Example, Type A recorded with effusion
- Using a 1000Hz probe tone is optimal.
Acoustic Reflexes and Decay

Anatomy & Physiology Terms

- There are 2 muscles in the middle ear:
  - Tensor tympani
    - Role is uncertain in the response to sound, but is involved in the opening and closing of the Eustachian Tube
  - Stapedius
    - Is the muscle that contracts reflexively in response to intense sound
- Acoustic Reflex Arc
  - The pathway of the auditory periphery and brainstem through which acoustic reflex passes through to stiffen the tympanic membranes

Ipsilateral Acoustic Reflex
The Pathway of the ARC

- Sound is presented to one ear
- Passes through the middle ear to the cochlea
- Moves along the VIIIth CN to the brainstem
- As an electrical impulse, it travels to the cochlear nucleus
- From the cochlear nucleus 3 separate pathways emerge:
  1. Ipsilateral superior olivary complex (SOC)
  2. Ipsilateral facial nerve (CN VII)
  3. Contralateral superior olivary complex (SOC)

The Pathway of the ARC cont’d

- SOC sends projections to the ipsilateral and contralateral facial nerve
- The facial nerve innervates the stapedius muscle
- The impulses from the facial nerve cause the stapedius muscle to contract
- Bilateral contraction of the stapedius muscle to monaural stimulation

ART Response
Interpretation of ART

- Response may be described as:
  - Present
  - Absent
  - Elevated
  - Abnormal Adaptation
- Reflexes occur at 85 dB HL in normal hearing individuals
- Analyze results from ipsilateral and contralateral ART to identify site of lesion

ART Result Pattern

<table>
<thead>
<tr>
<th></th>
<th>Ipsilateral</th>
<th>Contralateral</th>
<th>Ipsilateral</th>
<th>Contralateral</th>
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</thead>
<tbody>
<tr>
<td>Malleolar right</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Malleolar left</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
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<tr>
<td>Chorda tympani</td>
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<tr>
<td>Labyrinthine left</td>
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<td>N</td>
<td>N</td>
<td>N</td>
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<tr>
<td>Inferior vestibular</td>
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<td>N</td>
<td>N</td>
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<tr>
<td>Superior vestibular</td>
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<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Percussion left</td>
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<td>N</td>
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<tr>
<td>Percussion right</td>
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<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Tympanic membrane</td>
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<td>N</td>
<td>N</td>
<td>N</td>
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Hearing Sensitivity & ART

<table>
<thead>
<tr>
<th>Hearing sensitivity (dB HL)</th>
<th>Acoustic Reflex Thresholds (dB HL)</th>
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<tbody>
<tr>
<td>10-25</td>
<td>90</td>
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<tr>
<td>20-45</td>
<td>95</td>
</tr>
<tr>
<td>40-65</td>
<td>105</td>
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<tr>
<td>60-85</td>
<td>115</td>
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<tr>
<td>80-100</td>
<td>125</td>
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<tr>
<td>100+</td>
<td>130</td>
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Reflex Decay

Acoustic Reflex Decay

- Important test to identify CN VIII pathologies and acoustic tumors on CN VIII
- When a stimulus is presented above the reflex threshold, it will induce a constant and steady decrease in compliance
  - 500 or 1000 Hz for 10 seconds
- Patients with CN VIII pathologies will exhibit abnormal decay of this response
  - CN VIII pathologies – decay occurs by 6.2 seconds
  - CN VIII tumor – decay occurs by 1.5 seconds

Reflex Decay

- Stimulus is presented for 10 seconds, 10dB above contralateral reflex threshold at 500 or 1000Hz.
- Does the contraction hold for the entire 10 seconds, or does it fatigue?
- Indicates retrocochlear pathology or pressure on hearing nerve.
- Needs to decay 50% or more to be considered “positive for decay.”
  - Less than 50% decay is reported as a “negative result”
Eustachian Tube Function

- The normal opening and closing of the Eustachian tube maintains equal air pressure between the middle ear and the outside world
- Abnormal ETF can cause the peak of the tympanogram to have significant negative pressure
- Abnormal ETF can be a precursor to middle ear disease such as Otitis Media

Intact Tympanic Membrane

- Perform 3 tympanograms:
  - Normal conditions
  - Swallow with nose & mouth closed
  - Blow with nose & mouth closed (Valsalva’s Maneuver)
- Tymp shows shift in pressure if Eustachian tube is functioning properly
- Total shift should be at least 15-20 daPa
Perforated Tympanic Membrane

- Introduce +/-400daPa of pressure
  - If ET opens due to pressure, the reading will equalize to 0 daPa... ET most likely functioning properly.
  - If pressure does not change, have patient swallow several times. If pressure does not equalize as a result... ET dysfunction.

Customizing the TympStar

User Tests
Auto Sequence

Button/Function Refresher
Programming User Tests

- Press a Test Type Hard Key
- Press Return on the display
- Press Program Mode
- Select a User
- Use soft keys to select parameters for this “test”
- Press Return
- Press Store!
User Tests – Program Mode

• Tympanometry
  – Screening, Diagnostic, User 1, User 2, User 3
• Reflex Threshold
  – Diagnostic, User 1, User 2, User 3, User 4
• ETF
  – Perforated TM, Intact TM
• Special Tests
  – Reflex Decay, ARLT, AR Sensi, Multiple Hz

Reflex Thresholds

• “Semi-Manual”
  – Examiner selects stimulus, intensity and presents manually. Thresholds are marked manually
• Threshold Seek
  – TympStar automatically presents stimulus at increasing intensity and interprets compliance change. Marks threshold automatically.
• Fully Manual
  – Examiner watches the VU meter for a change in compliance – no tracings

Threshold Seek Setup

• Must set up parameters in program mode
• Define start and stop intensity
• Define required change in compliance
• Manually select stimulus
Auto Sequence
- One button press performs pre-defined test sequence
- Sequence always starts with a 226 Hz Tympanogram
- Reflex thresholds, ipsilateral and/or contralateral, and stimuli defined by the examiner
- Reflex Decay, ipsilateral and/or contralateral, and stimuli defined by the examiner

Auto Sequence Setup
-ETF Hard Key
-Return Key on Display
-Instrument Options
-Test Sequence

Practical Applications
Maximizing Efficiency with Middle Ear Evaluations
Tympanometry – Tip #1

• Pressure Sweep Rates
  – Use 600/200 daPa/s or 200 daPa/s for screening purposes where need speed and snapshot of amplitude and pressure
  – Use 50 daPa/s for diagnostic purposes where accuracy is needed and patient is co-operating
  – Why? Higher speeds artificially increase tympanic amplitude
    - Example: In pre-school kids, a pump speed of 200 daPa/s yields a tym amplitude that is 22% higher than at 50 daPa/s (similar impact on adult ears)

Tympanometry – Tip #2

• Ear tip selection
  – Use screening tips when hand holding the probe tip
  – Use diagnostic tips when positioning probe within the ear canal
  – Clearly observe the ear canal entrance while positioning the probe

Tympanometry – Tip #3

• Use 226 Hz probe tone with Y
  – First measure of middle ear admittance on 6 month to adults
  – Provides information on ECV
    - If abnormally high: indicative of TM perforation
    - If abnormally low: indicative of occluded ear canal
  – Provides information on type of hearing loss
Reflex Thresholds – Tip #4

- Use Threshold Seek when the patient is able to sit quietly for the evaluation.
- Do not use Threshold Seek if reflex growth functions are required.
- For reflex growth, it is possible to expand the timebase to fit more tracings on one line.

Ipsilateral Reflex Threshold

- Why use multiplexing on TympStar?
  - Avoid artifact caused by interaction of probe tone with activating stimulus; greater accuracy
    - Probe tone on throughout measurement
    - Activating stimulus is turned on and off at a rate of approximately 10 times per second
    - During time when stimulus is turned off, microphone is turned on to measure changes in probe tone

Tympanometry – Tip #5

- 678 Hz Probe Tone should be the “GO TO” test when things just don’t add up
  - A/B Gap with normal 226
  - Abnormally steep gradient
  - Patient reports (hollow voice)
Tympanometry – Tip #6

- Use 678 Hz B/G simultaneously
  - Need diagnostic information on degree of middle ear pathology to allow MD to determine best treatment
  - Suspected disarticulation; Suspected otosclerosis

<table>
<thead>
<tr>
<th>B</th>
<th>G</th>
<th>Y</th>
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<tbody>
<tr>
<td>0.98</td>
<td>0.75</td>
<td>1.50</td>
</tr>
<tr>
<td>Median: 1.53</td>
<td>2.29</td>
<td>3.00</td>
</tr>
<tr>
<td>Upper Limit: 2.22</td>
<td>3.94</td>
<td>5.80</td>
</tr>
</tbody>
</table>

*Margolis, R., and Shanks, J. (Katz, J. 1995)*

**Susceptance**

**Pathologies**

- Fixation - Otosclerosis
  - Decrease in susceptance (lower than normal) with an increase in conductance (higher than normal)
- Disarticulation
  - Increase in mass (if at junction of incus and stapes, the impact of mass is much greater that if break is at junction of malleus and incus)
678 Hz Disarticulation

- Broad peaks and wide inter-peak intervals

1000 Hz

- Infants 6 months and under
- Look for any discernable peak
- Utilize normal ranges

Summary

- Understanding the mechanics of the middle ear is important
- Gives more confidence in typical testing
- Gives understanding and insight if there is an abnormal response
- Gives more tools to add to our battery for the best possible care of our patients
Questions?

To ask a question, please type your question into the chat box in the lower left corner of the screen and click on the “Send” button located right below the box.

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