Practical Tympanometry for Providers of Pediatric Heath Care

Wendy D. Hanks, Ph.D.
Samantha Kleindienst, Au.D.
EHDI Conference
March 2, 2010
AAP Clinical Report on Hearing Assessment in Infants and Children

Key Point #4:

All providers of pediatric health care should be proficient with pneumatic otoscopy and tympanometry. However it is important to remember these methods do not assess hearing.

Key Point #7:

Any abnormal objective screening result requires audiology referral and definitive testing.
Objectives

- Definition/Function of Tympanometry
- Diagnostics & Interpretation
  - Tympanometric parameters
- Tympanometry: Infant vs. Child vs. Adult
- Etiologies commonly seen in practice
- Pros/cons of clinically available equipment
Basics

- Tympanometry assesses the overall condition of the outer ear, middle ear, and Eustachian tube
- Involves measurement of acoustic immittance in the ear canal as air pressure is varied above and below the atmospheric level
- Immittance is a general term that indicates either acoustic impedance or admittance
- Graphical representation is a tympanogram
- Acoustic admittance as a function of ear canal pressure

Wiley & Fowler, 1997
Tympanogram – 226 Hz

Campbell & Mullin, 2009
How it works

Ear diagram
©Vestibular Disorders Association

1. external auditory canal
2. tympanic membrane (eardrum)
3. malleus
4. incus
5. stapes
6. ligament
7. Eustachian tube
8. oval window
9. round window
10. cochlea
11. cochlear nerve
12. semicircular canals
13. utricle
14. saccule
15. endolymphatic sac
16. vestibular nerve
17. facial nerve
18. temporal bone
19. muscle
20. cartilage
21. internal auditory canal to brain
Tympanometric Parameters

- Equivalent Ear Canal Volume (ECV)
- Tympanometric Peak Pressure (TPP)
- Static Acoustic Admittance (SA, Peak)
  - Peak Compliance
  - Static Compliance
- Tympanometric Width (TW)
  - Gradient (GR)
Ear Canal Volume

- Estimate of the volume between the probe tip and the tympanic membrane
- Use to assess tympanic membrane and ear canal status
  - No perforations, foreign bodies, tumors
  - Effects of surgeries/infections on ear canal and tympanic membrane

- Normative data

<table>
<thead>
<tr>
<th>Adults</th>
<th>Children (6 wk-7 yr)</th>
<th>Children (post-tube)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.63-1.46 cm³</td>
<td>.3-1.0 cm³</td>
<td>1.0-5.5 cm³</td>
</tr>
</tbody>
</table>

Margolis & Heller, 1987; Shanks et al., 1992
ECV 0.5 cm³  PEAK 0.8 cm³

GR 125 daPa  -5 daPa

Admittance (mmhos, ml, or cm³)

Air Pressure (daPa)
Tympanometric Peak Pressure
(TPP)

Admittance (mmhos, ml, or cm3)

Tympanometric Peak Pressure

Air Pressure (daPa)

-400
0
+200

1.5 cm³
Static Acoustic Admittance (SA)

1.5 cm³

Compliance Peak

-400  0  +200

daPa
Etiologies

Type A  →  Normal
Type $A_d$  →  Ossicular Discontinuity (scaling)
Type $A_s$  →  TM Scarring
                           Otosclerosis

Type B “Flat”
                           Otitis Media w/ Effusion
                           Occluded Cerumen
                           Probe against canal (ECV)
                           Perforation/Patient PE tube
                           Head Trauma
                           Otosclerosis
                           Cholesteatoma

Type C
                           ETD
                           Pre/Post OM
                           Barometric pressure changes

Figure 2. Tympanograms

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Harlor & Bower, 2009
## Normative Data for 226 Hz

<table>
<thead>
<tr>
<th>Measure</th>
<th>Infants &amp; Toddlers</th>
<th>School Children</th>
<th>Young Adults</th>
<th>Older Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Acoustic Admittance</td>
<td>.2 to .7</td>
<td>.4 to 1.4</td>
<td>.3 to 1.5</td>
<td>.2 to 1.5</td>
</tr>
<tr>
<td>Ear Canal Volume</td>
<td>.3 to 1.0</td>
<td>.6 to 1.4</td>
<td>.9 to 1.8</td>
<td>.9 to 2.0</td>
</tr>
<tr>
<td>Tympanometric Width</td>
<td>102 to 204</td>
<td>60 to 168</td>
<td>36 to 95</td>
<td>35 to 125</td>
</tr>
<tr>
<td>Tympanometric Peak Pressure</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Roush et al., 1995 (6-30mo); Nozza et al., 1992 (3-16y/o); Roup et al., (20-30y/o); Wiley et al., 1996 (48-92y/o)
Tympanometric Width (TW) or Gradient (GR)

Tympanometric Width at 50% of peak static admittance.

Peak Static 0.85 mmho

0.425 mmho

-40  +40

Width 80 daPa
What Type is This???

12 year old female

\[ /75 / + / -375/ = 450 \text{ daPa!} \]
Infant vs. Child vs. Adult Testing

- Mature ears = 226 Hz; Infants (< 7 mo) = 1000 Hz
- Anatomical differences between ears
- Ear Canal/Middle Ear Characteristics
  - Infant ear canals are cartilaginous and do not ossify until at least 4 months of age
  - The middle ear space is smaller in volume and may contain mucus and mesenchyme
  - These differences make the mass and resistive components more prominent in infants than adults
  - Vibratory motion of the external ear may add to the resistive component

Holte et al., 1991
How does these factors effect 226 Hz Tympanogram?

- Usually results in a normal or notched tympanogram, **even if there is middle ear effusion** in infants under 6 months of age
Example: 2 month old
## 1000 Hz Norms

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Kei et al., 2003</th>
<th>Margolis et al., 2003</th>
<th>Kleindienst et al., 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear Canal Volume (cm³)</td>
<td>N/A</td>
<td>N/A</td>
<td>0.16 to 0.36</td>
</tr>
<tr>
<td>Static Acoustic Admittance (mmho)</td>
<td>0.39 to 2.12 (±200)</td>
<td>0.6 to 4.3 (-400)</td>
<td>0.73 to 2.25 (-400)</td>
</tr>
<tr>
<td>Tympanometric Peak Pressure (daPa)</td>
<td>-58.0 to 86.6</td>
<td>-133 to 113</td>
<td>-86.5 to 77</td>
</tr>
</tbody>
</table>

Kei et al., 2003 (1-6 d/o); Margolis et al., 2003 (2-4 wks CA); Kleindienst et al., 2009 (12-60 h/o)
Equipment

Manufacturers

- GSI/Welsh Allyn (4 models)
- Madsen (3 models)
- Maico (6 models)
- Interacoustics (3 models)
- Ear Check
Grason Stadler (GSI)/Welsh Allyn

MicroTymp 3

TympStar

GSI 38

GSI 39
Madsen

OtoFlex 100

Zodiac

Capella
Maico

Otowave

MI 24

MI 44

MI 34

MI 26

Race car audiotymp
Interacoustics

Titan

MT10

AT235H
Ear Check
Conclusions

Take Home Messages

- Tympanometry is an essential tool in combination with otoscopy for diagnosing middle ear pathology
- Tympanometry is quick, easy, and affordable
- Audiological management is recommended for pediatrics with middle ear pathology
- Obtain definitive hearing evaluation
- Monitor for speech-language delay
- The equipment you buy will depend on your practice needs….work with your local audiologist!
References


References


Questions/Comments
Contact Information

- Wendy D. Hanks, PhD
  - Wendy.hanks@gallaudet.edu
- Samantha J. Kleindienst, AuD
  - Samantha.Kleindienst@gallaudet.edu