Wideband Energy Reflectance Measurements and Non-Pathological Variables: Posture and Probe Insertion Depth

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**Introduction:**

What is wideband energy reflectance (ER)?

The ratio of reflected sound energy (power) versus incident energy (power).
Introduction: ER Technique (Cont.)

- ER ratio varies in between 0 and 1 (or, 0% and 100%).
  - 0 means all of the incident sound energy is absorbed (transmitted) into the middle ear;
  - 1 means all of the energy is reflected back.

- ER can be measured for a broad frequency range simultaneously if a wideband signal is used.
  e.g., clicks, tone chirps

- Wideband tympanometry can be measured with varied ear canal pressure, similar to our old friend—conventional tympanometry.
Introduction: ER Technique (Cont.)

- It can be used to acquire tympanograms for any frequency

Introduction: Literature Review

What is the relevance to us as Clinicians?

- Good potential in evaluating the middle ear function for a wide frequency range (in seconds!).

- Usefulness in distinguishing normal from pathological middle ears...
**Introduction:**

**Literature Review (Cont.)**

**Normative Data:**

![Normative Data Diagram]

FIG. 4. Third-octave average energy reflection versus center frequency (Hz) for adult group and infants of ages 1, 3, 6, 12, and 24 months.

(Keefe et al., 1993)

**Negative Middle Ear Pressure:**

![Negative Middle Ear Pressure Diagram]

**Otosclerosis:**

![Otosclerosis Diagram]

**Negative Middle Ear Pressure:**

Fig. 3. Mean ER for ambient pressure measurement as a function of frequency for ears with normal and negative MEP obtained from infants (A). Each panel shows data for a different frequency on the lower horizontal. Squares and circles indicate the frequencies where a parent t-test was conducted and an asterisk indicates significant difference (p < 0.05).

(Gilmore & Tan, 2013)

**Otosclerosis:**

Fig. 3. Mean energy reflection (ER) in 12 Hz intervals from 21-4000 Hz is shown for preoperative and postoperative conditions. Vertical bars indicate 95% confidence intervals (CI).

(Skudder et al., 2009)
There has only been one study (Voss et al., 2010) that looked into the effects of posture on ER, but their aim was different. They looked at a smaller frequency range, and they also were looking into intra-cranial pressure changes—not taking into account the affect the middle ear may have on the outcomes.

There has also only been one known study (Voss et al., 2008) that examined probe insertion depth on ER measures. This study was accomplished in cadavers.
Purpose:

- Objectives:
  - Determine if body position effects ER measures
  - Determine if different probe insertion depths, or in essence probe-tip size, effects ER measures

Why?
  - various clinical populations
  - aid in determining correct probe-tip size

Methods: Subjects & Instrumentation

Subjects:
- Thirty-six subjects (18–35 years)

Instrumentation:
- GSI TympStar
- Wideband Tympanometry System (Interacoustics);
  - Computer;
  - CardDelux sound card;
  - AT235 tympanometer;
  - Titan probe assembly.

**this is a research system
Methods: Instrumentation

- Calibration

Methods: Procedure

TPP and ER were repeatedly measured in the following positions:
1. Upright (90° (1))
2. Supine (0° (1))
3. Supine after 3 minutes (0° (3mins))
4. Supine after swallowing five times (0° (sw))
5. Upright (90° (2))
6. Upright after swallowing five sips of water (90° (sw))
   **Nine subjects were retested at 0° for test-retest comparisons**
7. Nineteen subjects had probe insertion measures taken after postural data — four probe sizes, 2 mm decrease in size
Results:

Wideband ER Measurements in Normal Adult Ears (Baseline)

Supine Position Causes Significant, Small Changes in ER & TPP
Results: (Cont.)

Effects of Other Test Conditions & Test-Retest Comparison

Postural Effects vs. Inter- and Intra-subject Variation
Results: (Cont.)

Effects of Probe-tip Insertion Depth

Discussion:

1. ER normative data from this study is similar to those from previous studies (e.g., Rosowski et al., 2012). ER ratio was lowest in the frequency range of 1–4 kHz.

2. The supine position results in ER altering in a frequency-specific pattern: increase for mid frequencies (greatest at 1 kHz) and decrease in high frequencies (greatest at 4 kHz).
3. The postural effect on ER measurements is statistically significant at some frequencies, but changes of ER ratio are small (0.03).

The postural effect is much smaller than inter-subject variation; therefore, the observed small amount of changes in ER at the supine position is not clinically significant.

4. Postural effects on ER under other test conditions are small and test-retest reliability is good.

5. ER measured with the probe tips of the two largest sizes is similar. ER decreases with smaller probe tips. This may be due to a decreased ear canal volume, which resulted in an “acoustical leak” in the low frequencies.

Clinically, it is better to err on the side of a larger probe size in order to obtain a more valid ER measurement in the low-to-mid frequencies.
References:


References:  (Cont.)

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