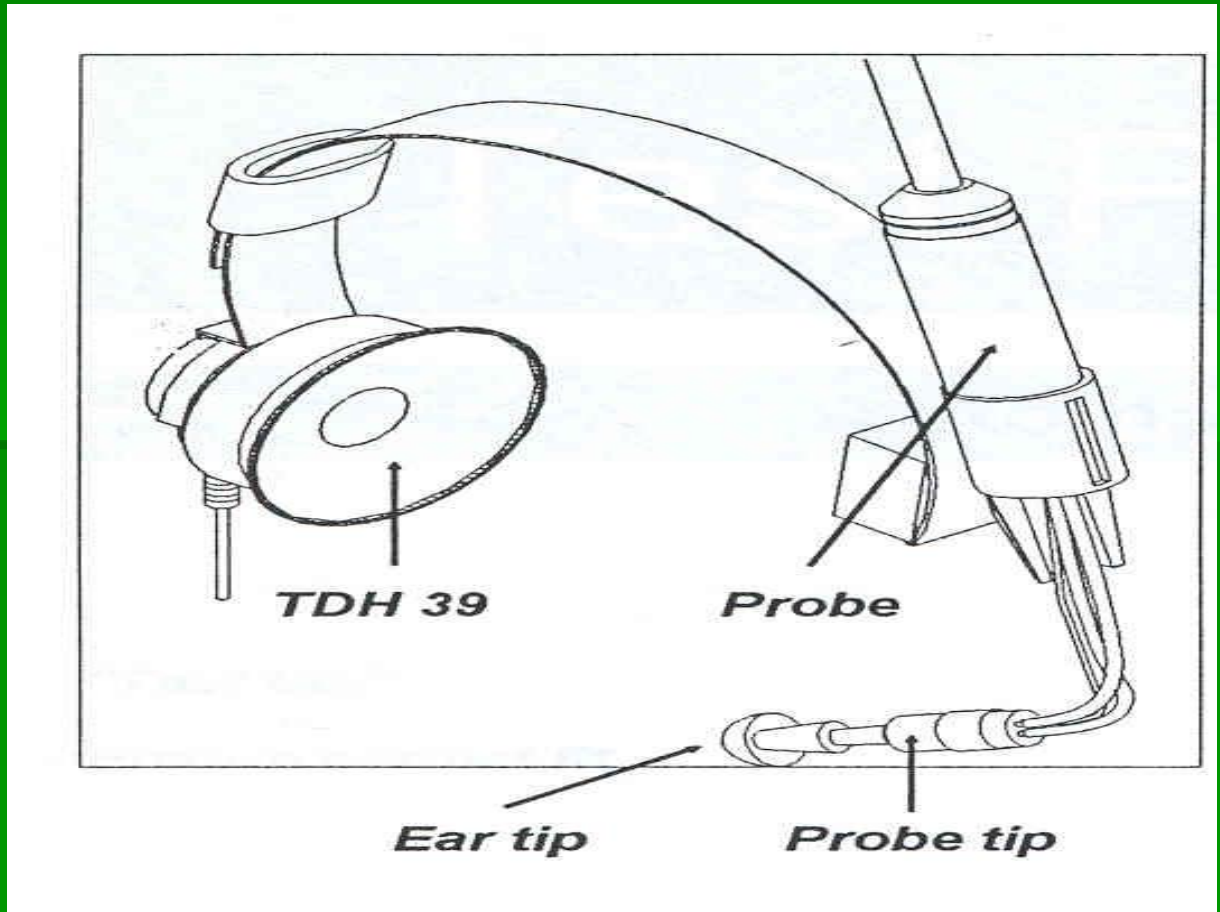
TYMPANOMETRY

Tympanometry is a measure of the Ya in the ear canal as a function of changing ear canal pressure.

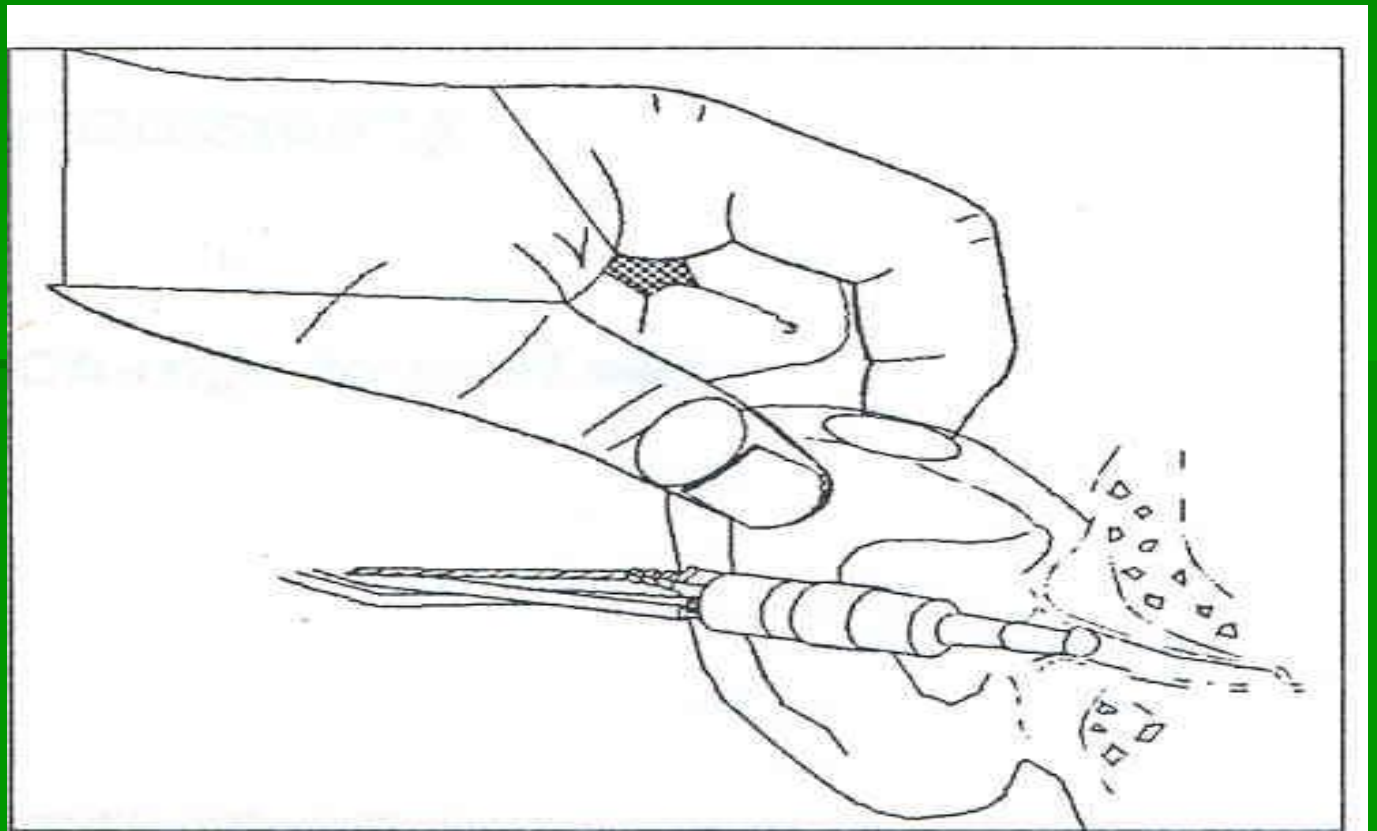
The graphic display of these measures is called a TYMPANOGRAM.

Tympanometry

- Fitting the Headset



- Making a good probe
  Seal



TYMPANOMETRY

- Single component or single frequency tympanometry
- Multiple component or multiple frequency tympanometry

SINGLE-COMPONENT (Y-226) TYMPANOMETRY

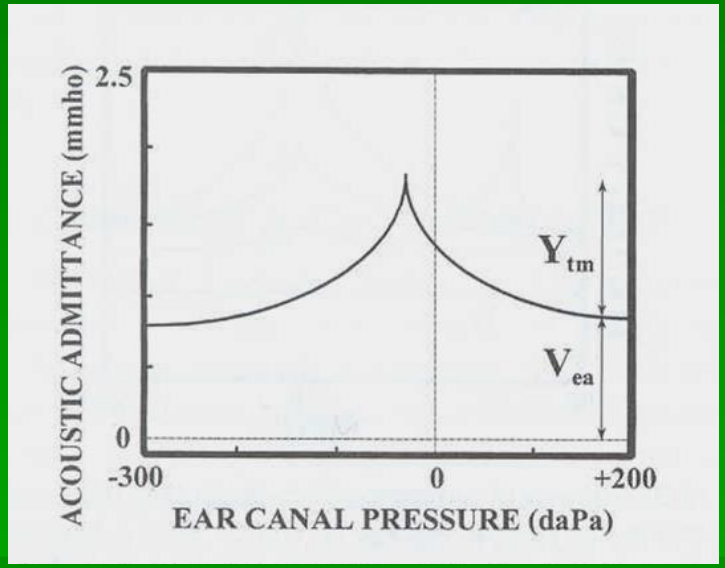
- The simplest and most commonly used tympanometric procedure involves the recording of a single immittance component, acoustic admittance (Ya), with a single probe-tone frequency, typically 220/226 Hz.

TYMPANOGRAM CLASSIFICATION

- Static Immittance
- Tympanometric peak pressure
- Shape

Peak Compensated Statlc Acoustlc Admlttance

The peak compensated static acoustic admittance (Ytrn) describes the height of the tympanogram measured at the plane of the tympanic membrane.



This measure is useful because certain disease processes can increase or decrease the normal height of the tympanogram.

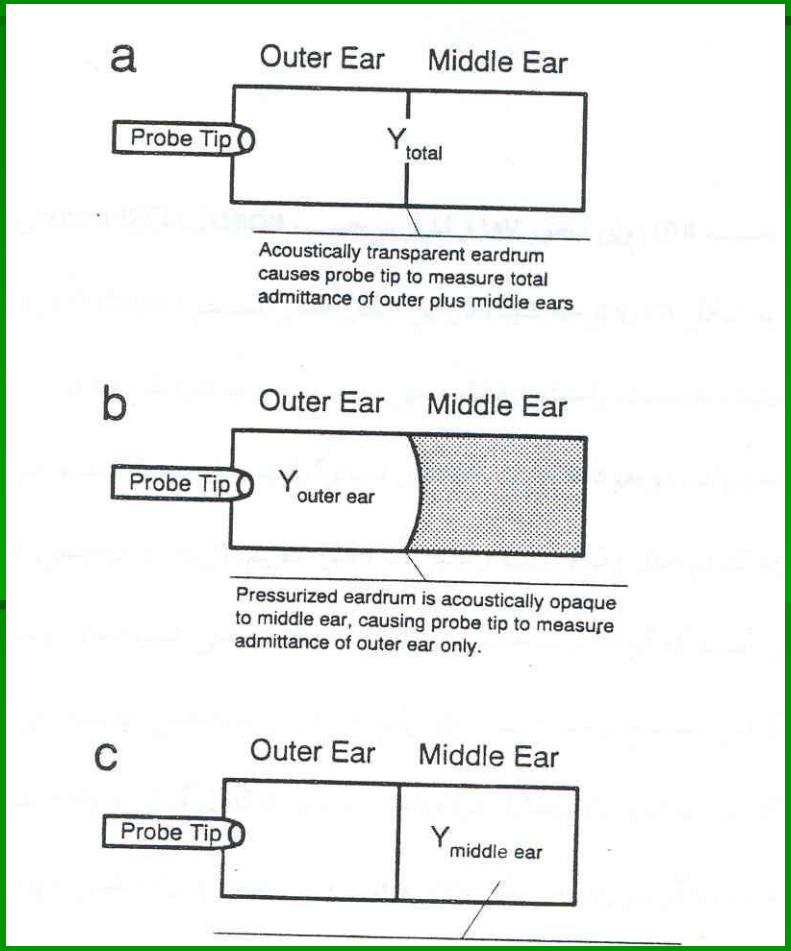
Peak Compensated Static Acoustic Admittance

- Peak measures are reliable

  because they are unaffected by small normal fluctuations in peak pressure that are caused by swallowing and breathing.

Peak Compensated Statlc Acoustlc Admlttance

- normal values :
  for peak Ytrn
  Encompass
  large range.
  0.3 – 1.60 cc
  0.28 – 2.5 cc



Peak Compensated Static Acoustic Admittance

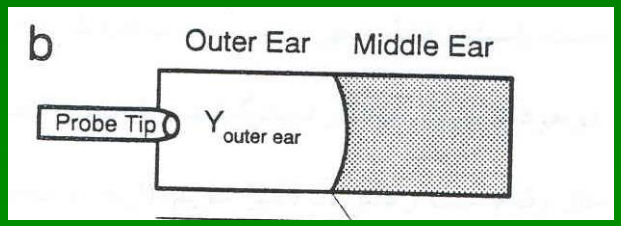
(static Admittance & Immittance)

- Effective variables on Ytm:
  - AGE
  - SEX
  - Pathologic conditions

Procedural variables:

- Pump speeds
- Direction of the pressure
- Number of tympanograms recorded

Equivalent Ear Canal Volume

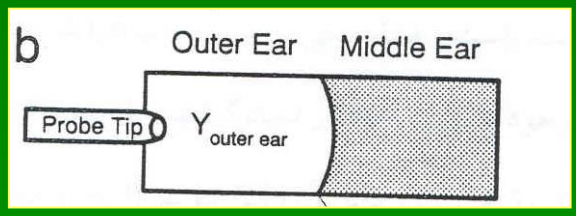


(Ear Canal Volume)

The equivalent ear canal volume (Vea or Vec) is an estimate of the volume of air medial to the probe, which includes the volume between the probe tip and the tympanic membrane if the tympanic membrane is intact, or the volume of the ear canal and middle ear space if the tympanic membrane is perforated

Vec : equivalent ear canal volume Vea : acoustic equivalent volume

Equivalent Ear Canal Volume



(Ear Canal Volume)

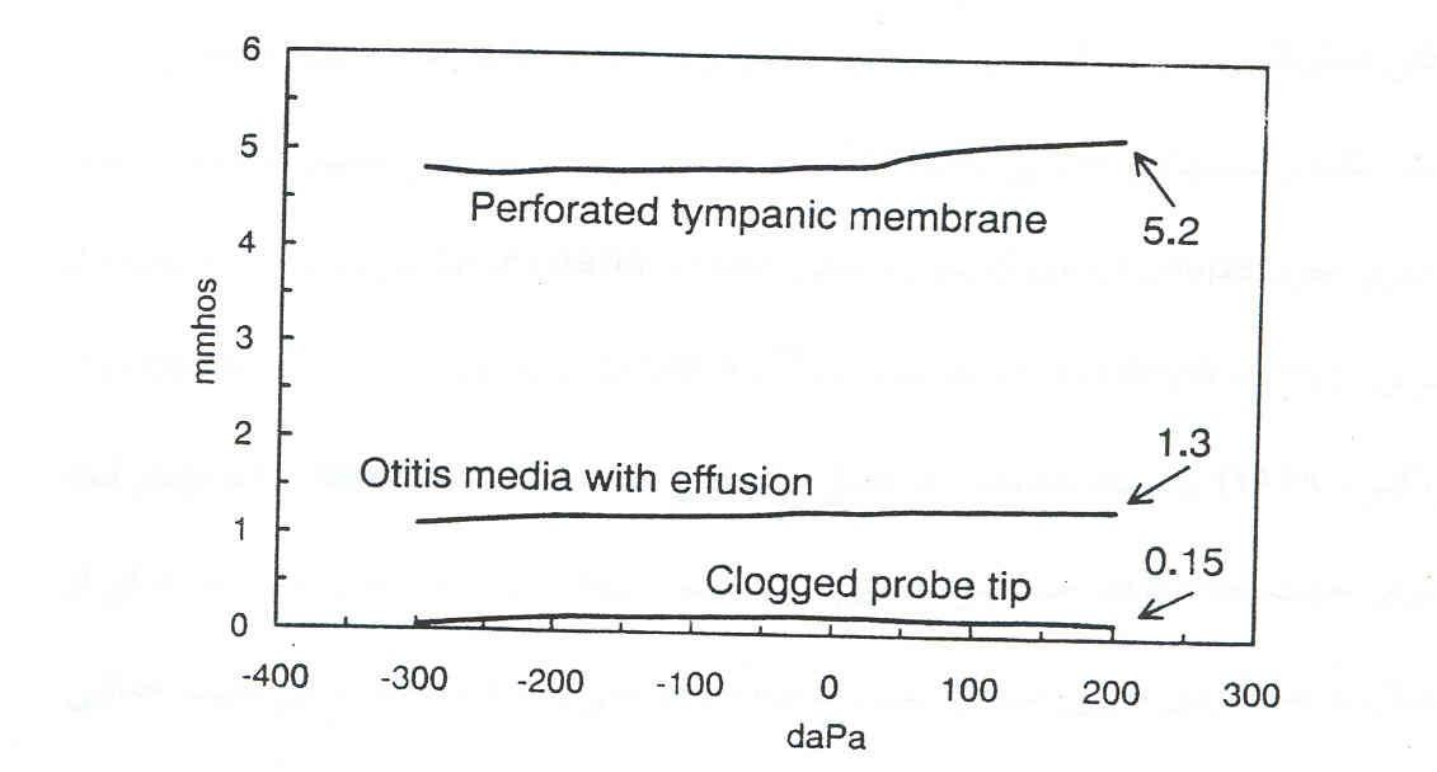
volume estimates are useful for two reasons :

1- An accurate determination of the compensated static admittance

2- In the case of a flat tympanogram

Equivalent Ear Canal Volume

- flat tympanogram



Equivalent Ear Canal Volume

- Normal range

Effective variables on Vec

1-AGE

2- SEX

children	0.3 – 1.00
adults	0.65 – 1.75

3- Admittance component

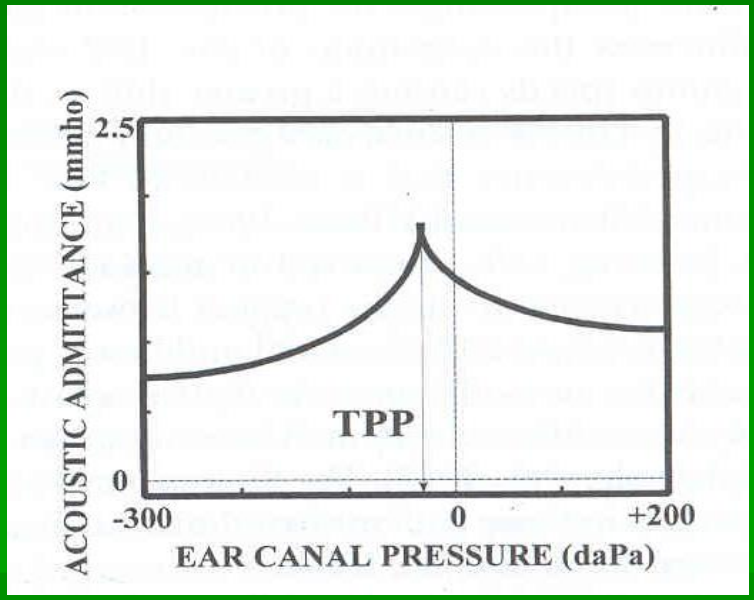
4- pressure values

Middle Ear Pressure

One of the earliest uses of tympanometry was to estimate middle ear pressure and, indirectly, to measure eustachian tube function because normal eustachian tube function is necessary for maintaining normal middle ear pressure

Middle Ear Pressure

tympanogram peak pressure (TPP) indicated as the location of the peak of the tympanogram along the pressure axis.



Tympanogram Gradient/Width

- Tympanogram gradient is an objective measure that desribes the steepness of the slope of the tympanogram near the peak.
- Tympanogram width (TW) is another measure used to quantity tympanogram shape in the vicinity of the peak and is sometimes also called the tympanogram gradient.

Normal Range

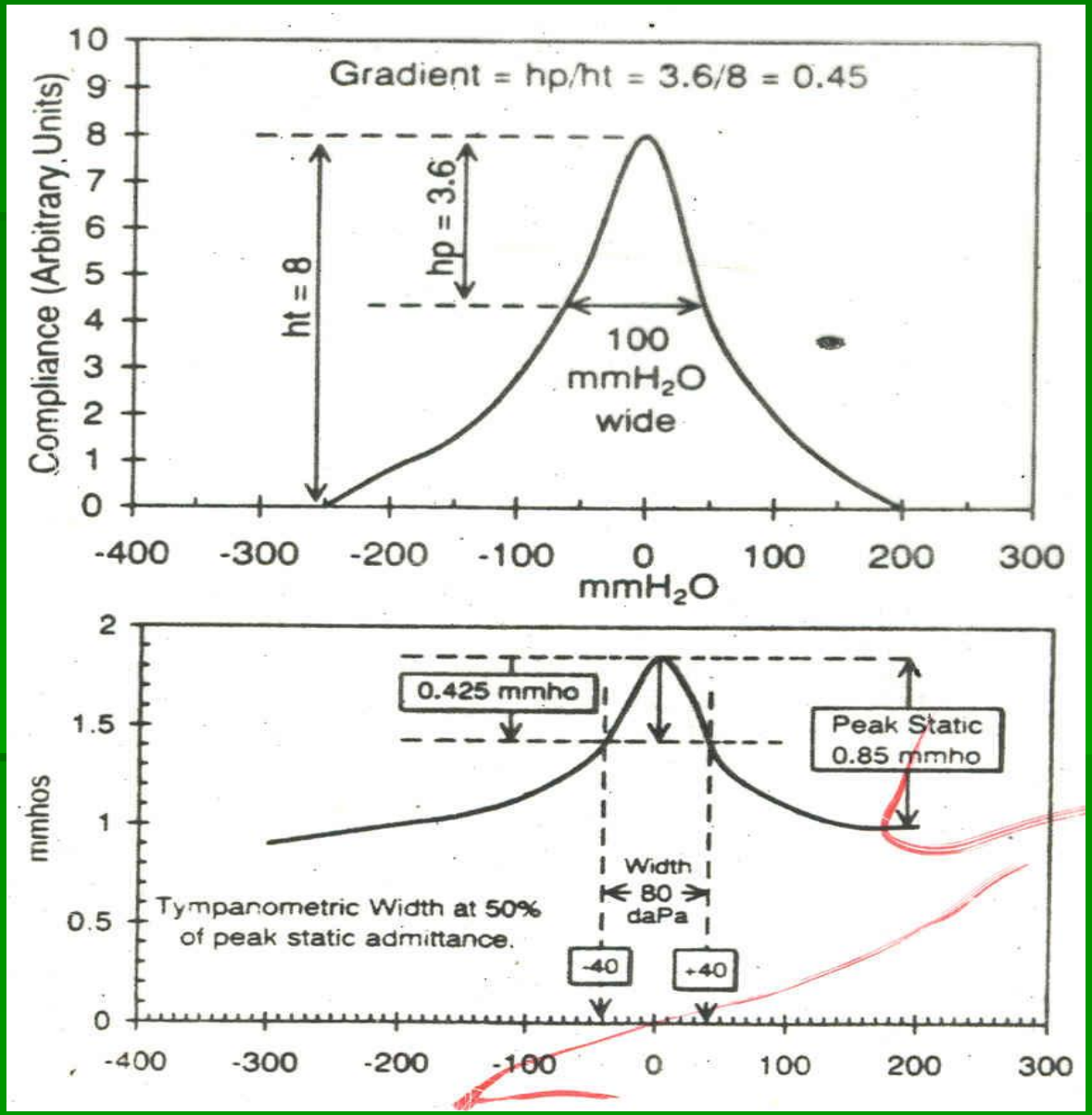
- >.1 & >.2

- Children

60-150 dapa

Adults

50 – 110 dapa



Tympanogram Types

- Jerger (1970), Jerger et al and liden (1972)
- Paradise et al (1976)
- Feldman (1975)

Jerger (1970), Jerger et al and liden (1972)

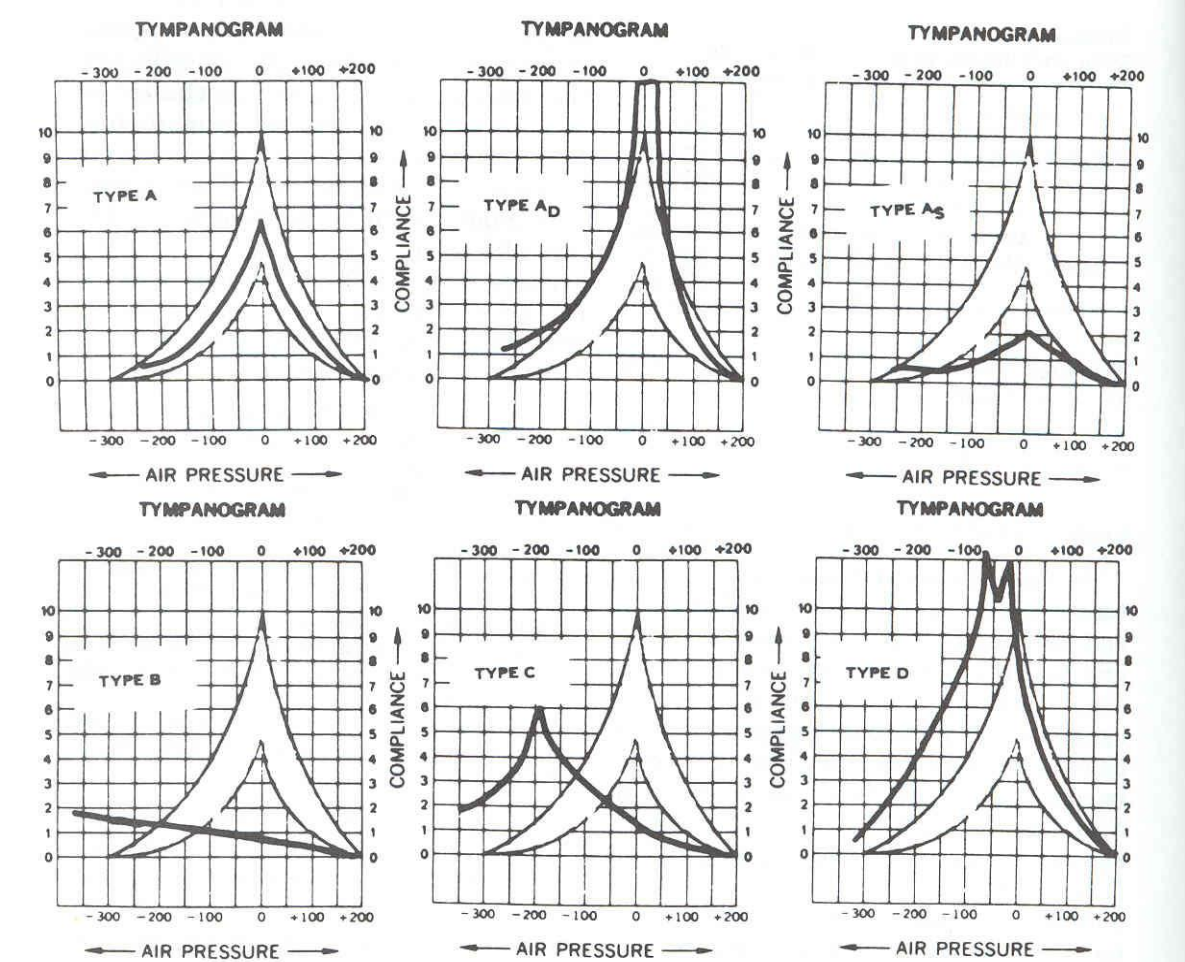
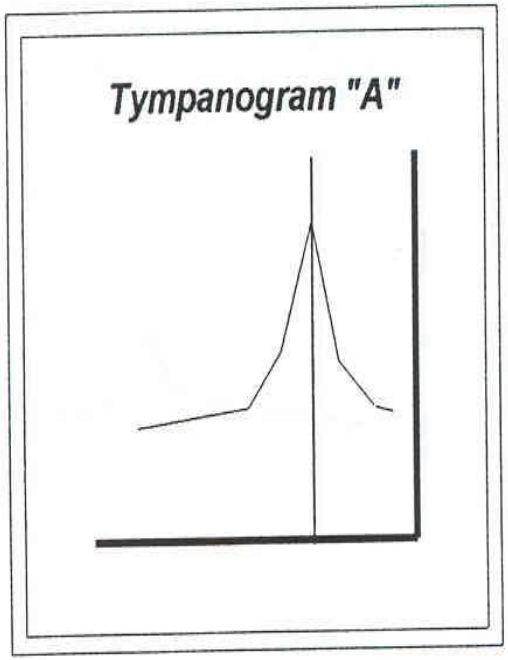


Figure 23.1. Liden-Jerger classification of tympanometric shapes. (From Feldman, A. S. 1976. Tympanometry—procedures, interpretation and variables. pp. 103–155. *in* A. S. Feldman and L. A. Wilber, eds. *Acoustic Impedance and Admittance—The Measurement of Middle Ear Function*. Williams & Wilkins, Baltimore.)

Jerger (1970), Jerger et al and liden (1972)

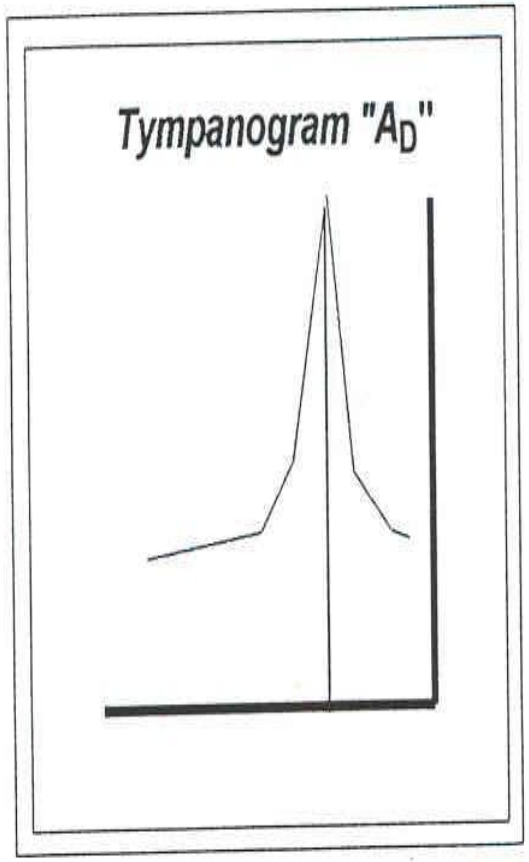


Type "A" characteristics:

The tymp curve shows a clear compliance peak within the the pressure range of ± 50 daPa for adults. For children the middle ear pressure may be considered normal down to -150 daPa negative pressure.

Note: Normal ears can show type "A" tympanograms.

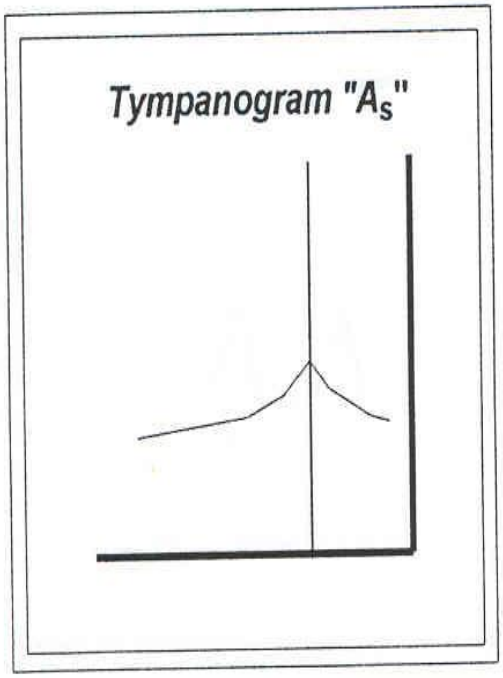
Jerger (1970), Jerger et al and liden (1972)



Type "A_D" characteristics:

The type A_D tympanogram is essentially a type A tympanogram in which the curve is very high and may be outside the range of the instrument / recording chart. Peak is within the pressure range of type A of $\pm$ 50 daPa.
The very mobile eardrum can reproduce various curves. It can represent ossicular discontinuity, flaccid eardrum or a combination of both. Peaking and notching outside the instrument is possible.
Note: The type A_D curve may reveal itself as being a type D curve, if a higher probe tone, e.g. 800 Hz is used.

Jerger (1970), Jerger et al and liden (1972)



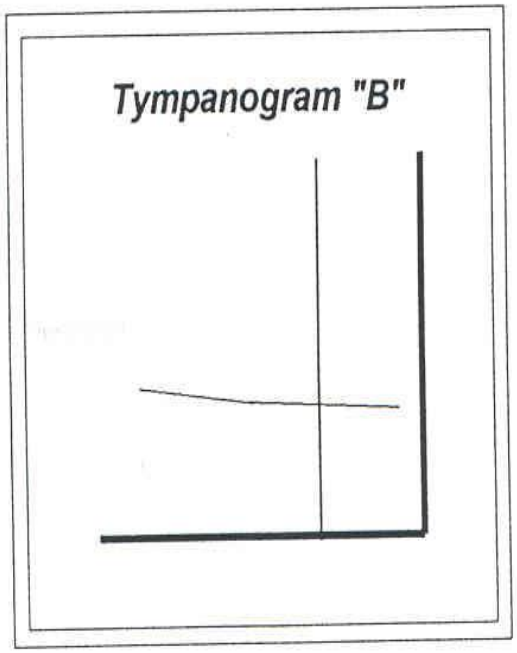
Type "A_S" characteristics:

The type A_S tympanogram is essentially a type A tympanogram in which the curve is much shallower than usual. Peak is within the pressure range of type A of ± 50 daPa. For children the middle ear pressure may be acceptable down to -150 daPa negative pressure.

The pathology could be immobile stapes due to otosclerosis (no reflexes), some form of otitis media, thick or scarred eardrum or just a normal variant.

Infant's ears may show this small compliance.

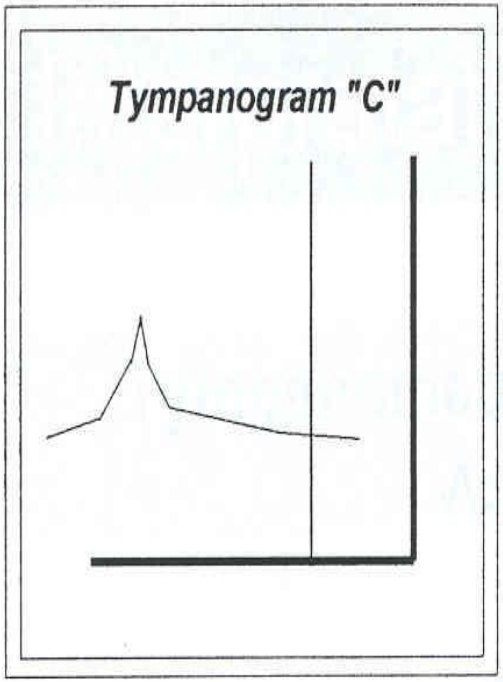
Jerger (1970), Jerger et al and liden (1972)



Type "B" characteristics:

Low compliance without peak identification. Middle ear pressure is unknown, probably negative. The type "B" is flat going slightly upwards by negative pressure.
May be associated with ears having extremely stiffened middle ear systems. Indication of fluid (serous or adhesive otitis media), retracted eardrum, blockage of the external ear canal, or perforated eardrum e.g. with drainage tube.
Note: Ears with type B tympanograms should be tested for peak identification down to -600 daPa.

Jerger (1970), Jerger et al and liden (1972)

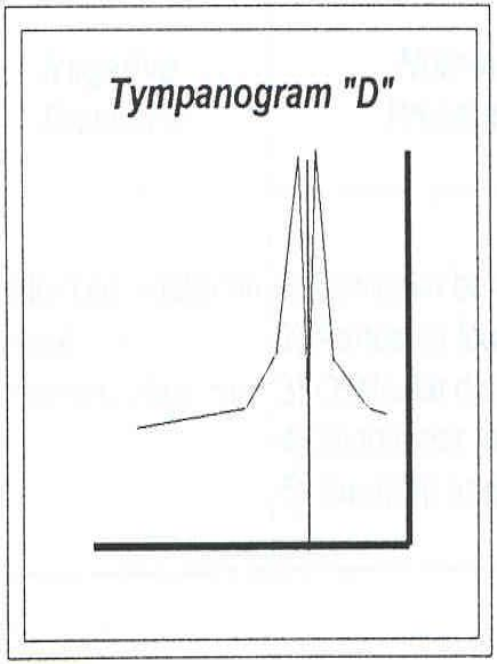


Type "C" characteristics:

Normal compliance peak with peak identification in the negative pressure range, e.g. below -50 daPa for adults (Bluestone), and below -150 daPa for infants (Lidén).
The type C curve shows all the characteristics of normal type A, A_D and A_S curves.

The type C curve indicates poor eustachian tube function with possible developing or resolving middle ear effusion.

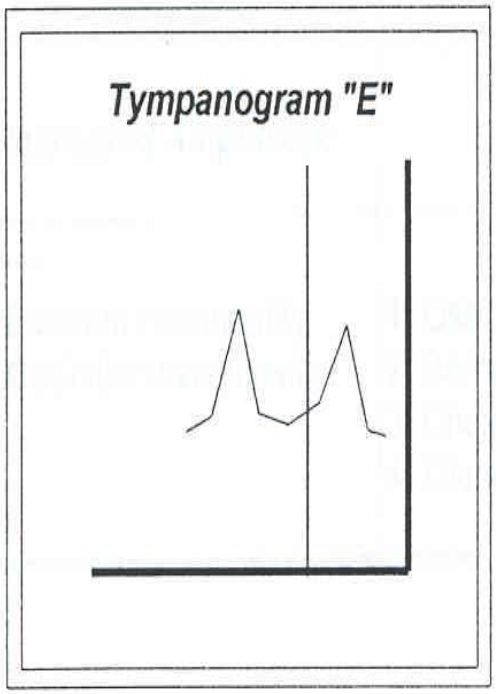
Jerger (1970), Jerger et al and liden (1972)



Type "D" characteristics:

Depicted by a deep curve with a small notch at the peak.
Middle ear pressure ± 100 daPa.
This curve does not necessarily indicate a pathological ear. Healed perforation of tympanic membrane, fixation of parts of the bones after ossicular discontinuity, flaccid eardrum with ear wax, or maybe a ventilation tube blocked with earwax and healed middle ear, can cause peaking and notching resulting in many shapes at the top of the maximum compliance curve. The curve could also be a narrow type E (W shaped) tympanogram.
Note: May be better detected with a 800 Hz probe tone.

Jerger (1970), Jerger et al and liden (1972)



Type "E" characteristics:

Depicted by a broad, deep, often multiple notching. "W" shaped.
This tympanogram is usually caused by ossicular discontinuity, but may also indicate restored ossicular chain one year or more after stapedectomy.

Note: May be better detected with a 800 Hz probe tone.

Paradise et al (1976)

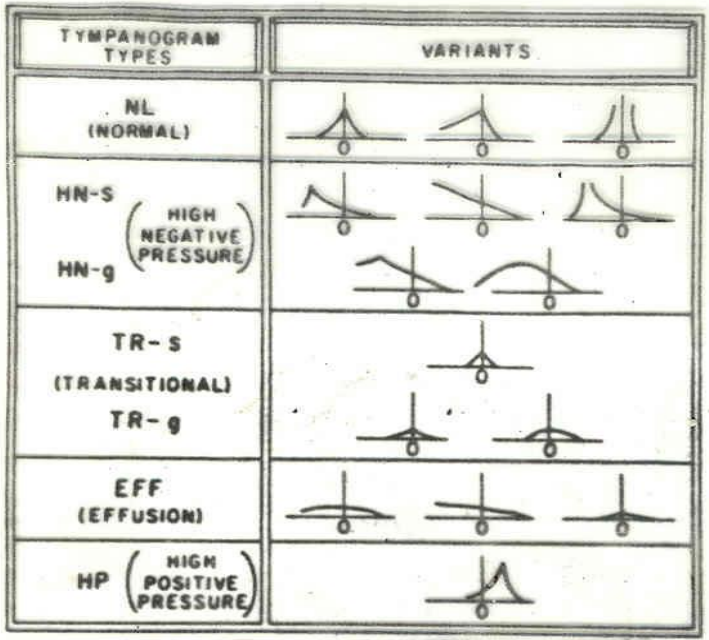


Figure 23.2. Paradise et al's (1976) classification of tympanometric shapes.

Paradise et al (1976) described a classification system for predicting middle ear effusion. Figure 23.2 illustrates their five types of tympanograms:

1. Normal (NL): tympanometric peak pressure between −100 and +50 daPa with normal peak amplitude.
2. High negative pressure (HN): tympanometric peak pressure less than (more negative than) −100 daPa with normal peak amplitude.
3. Transitional (TR): tympanometric peak pressure between −100 daPa and +50 daPa and reduced peak amplitude.
4. Effusion (EFF): tympanometric peak pressure less than +50 daPa and low peak amplitude or flat tympanogram.
5. High positive (HP): tympanometric peak pressure greater than +50 daPa and normal peak amplitude.

The gradient measure, adopted from Brooks (1969) and discussed later in this chapter, was categorized as either steep (s) or gradual (g), and was used for predicting effusion in the HN and TR categories. Low peak amplitude with or without negative tympanometric peak pressure (EFF category) and a gradual gradient were most frequently associated with middle ear effusion.

Feldman (1975)

A. *Pressure peak*. Pressure related pathologies may be categorized as follows:

1. Pathologies with negative pressure
   a) Blocked Eustachian tube
   b) Serous otitis media
2. Pathologies with normal pressure
   a) Ossicular bony fixation
   b) Adhesive fixation
   c) Ossicular discontinuity
   d) Middle ear tumor
   e) Eardrum abnormality
3. Pathologies with positive pressure
   a) Early acute otitis media
4. Absence of pressure peak
   a) Middle ear effusion
   b) Open tympanic membrane
   c) Artifact.

Feldman (1975)

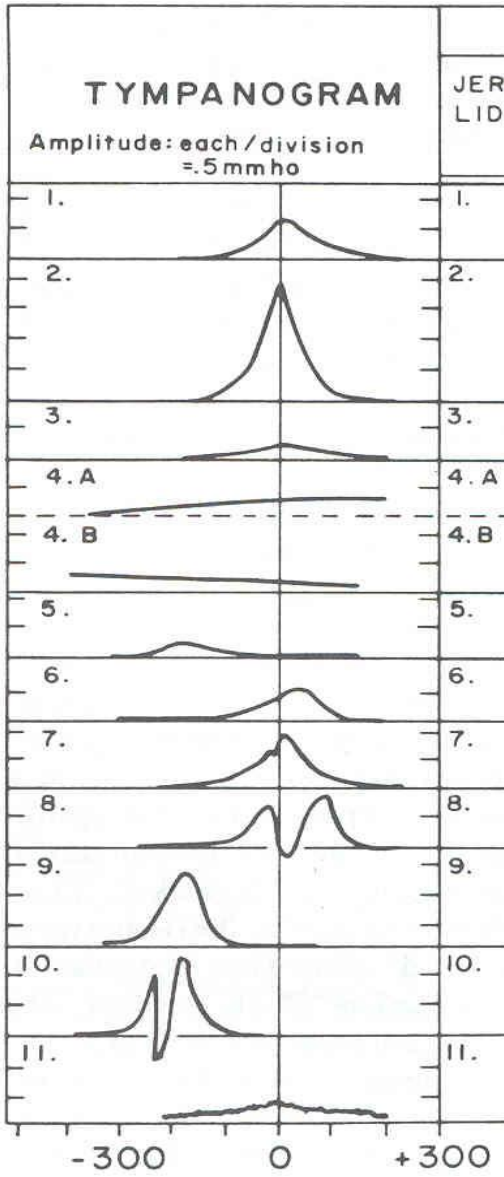
B. *Amplitude*. Pathologies as they influence amplitude may be categorized as follows:

1. Pathologies with increased tympanogram amplitude
   a) Eardrum abnormality
   b) Ossicular discontinuity
2. Pathologies with decreased tympanogram amplitude
   a) Ossicular fixation bony or adhesive
   b) Serous otitis media
   c) Cholesteatoma, polyps, granuloma
   d) Glomus tumors
3. Pathologies not influencing tympanogram amplitude
   a) Blocked Eustachian tube
   b) Early acute otitis media.

Feldman (1975)

C. *Shape*. Pathologies altering tympanogram shape may be categorized as follows:

1. Slope
   a) Pathologies which flatten or decrease tympanogram slope
      1) Serous otitis
      2) Ossicular fixation
      3) Tumors of the middle ear
   b) Pathologies which increase slope
      1) Eardrum abnormality
      2) Ossicular discontinuity
2. Smoothness
   a) Pathologies altering tympanogram smoothness
      1) Eardrum abnormality
      2) Ossicular discontinuity
      2) Vascular tumors
      4) Patulous Eustachian tube.

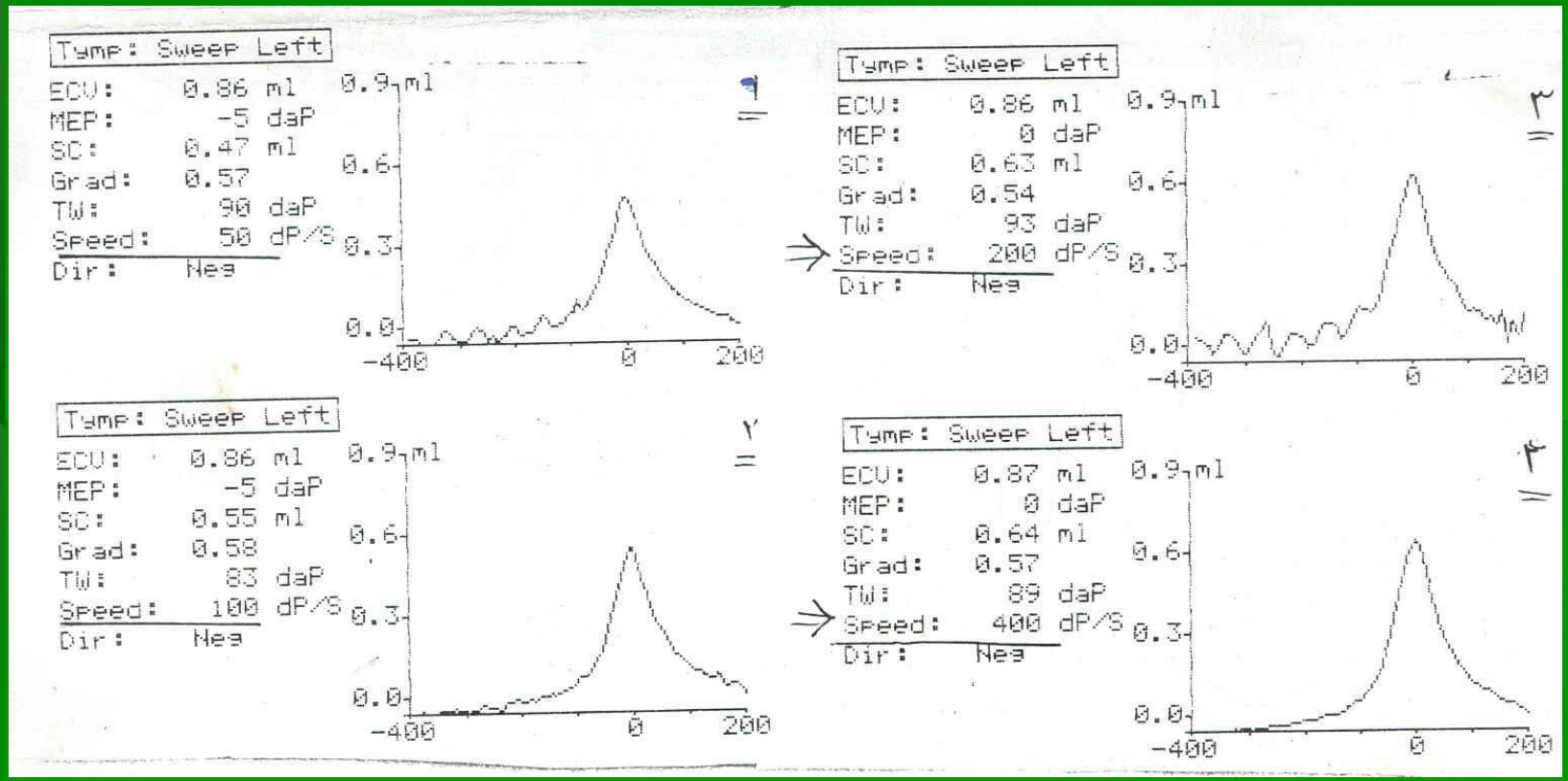


CLASSIFICATION			
JERGER (1970) LIDEN et al (1974)	FELDMAN (1975)		
TYPE	PRESSURE	AMPLITUDE	SHAPE
1. A	NORMAL	NORMAL	NORMAL
2. A_D	NORMAL	FLACCID	PEAKED
3. A_S	NORMAL	STIFF	NORMAL
4.A ? B	ABSENT-NEG.	STIFF	FLAT
4.B ? B	ABSENT-NEG.	STIFF	FLAT A+B CONVERGE
5. C	-125 mm	STIFF	NORMAL
6. ?	+ 90 mm	NORMAL	NORMAL
7. D	NORMAL	FLACCID	NOTCHED
8. E	NORMAL	FLACCID	DEEP, BROAD NOTCHING
9. C	-200 mm	FLACCID	NORMAL
10. ? C/E	-200 mm	FLACCID	DEEP, BROAD NOTCHING
11. A_S	NORMAL	STIFF	VASCULAR PERTURBATION

Figure 23.3. Feldman's (1978) descriptive analysis of tympanometric shapes.

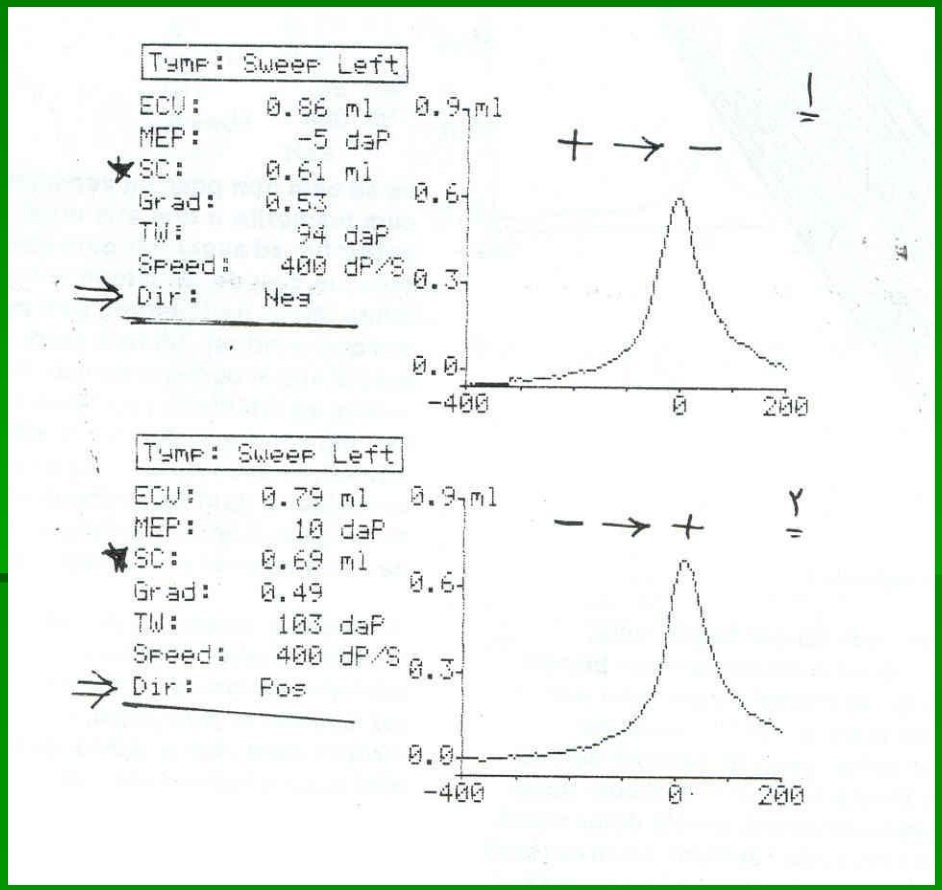
Test Variables Tympanometry

- Pump Speed



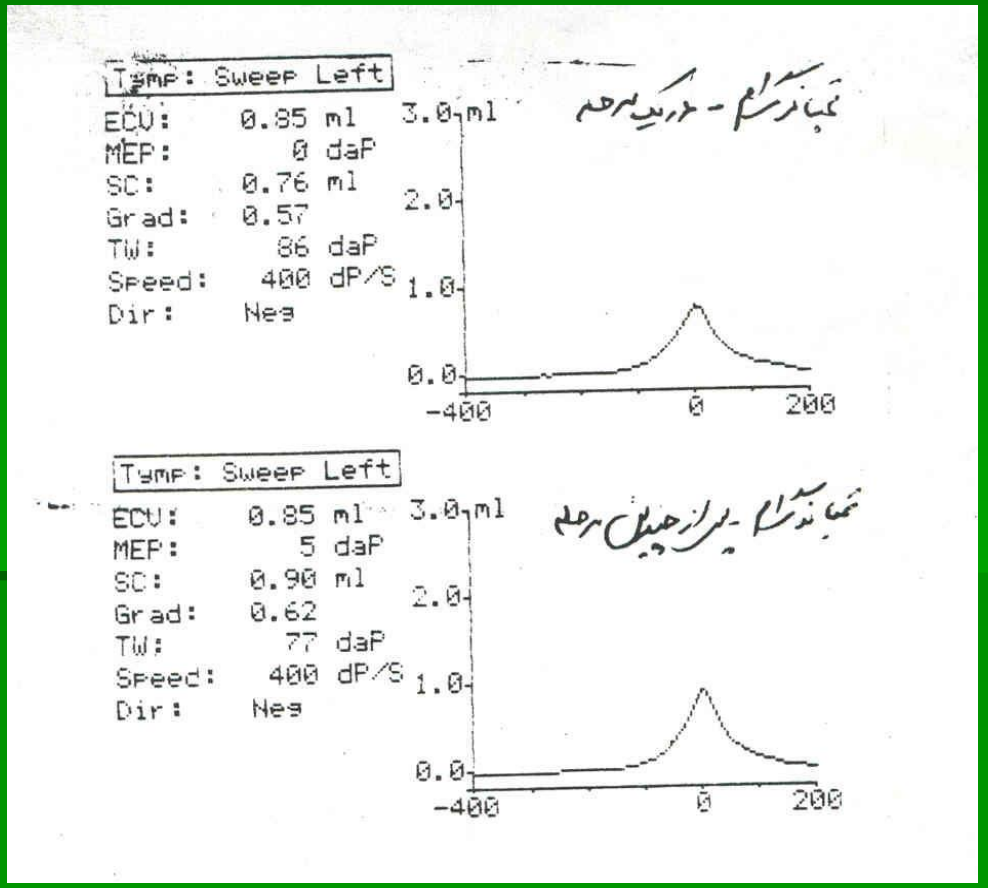
Test Variables Tympanometry

- Direction of air Pressure change In the external Ear canal



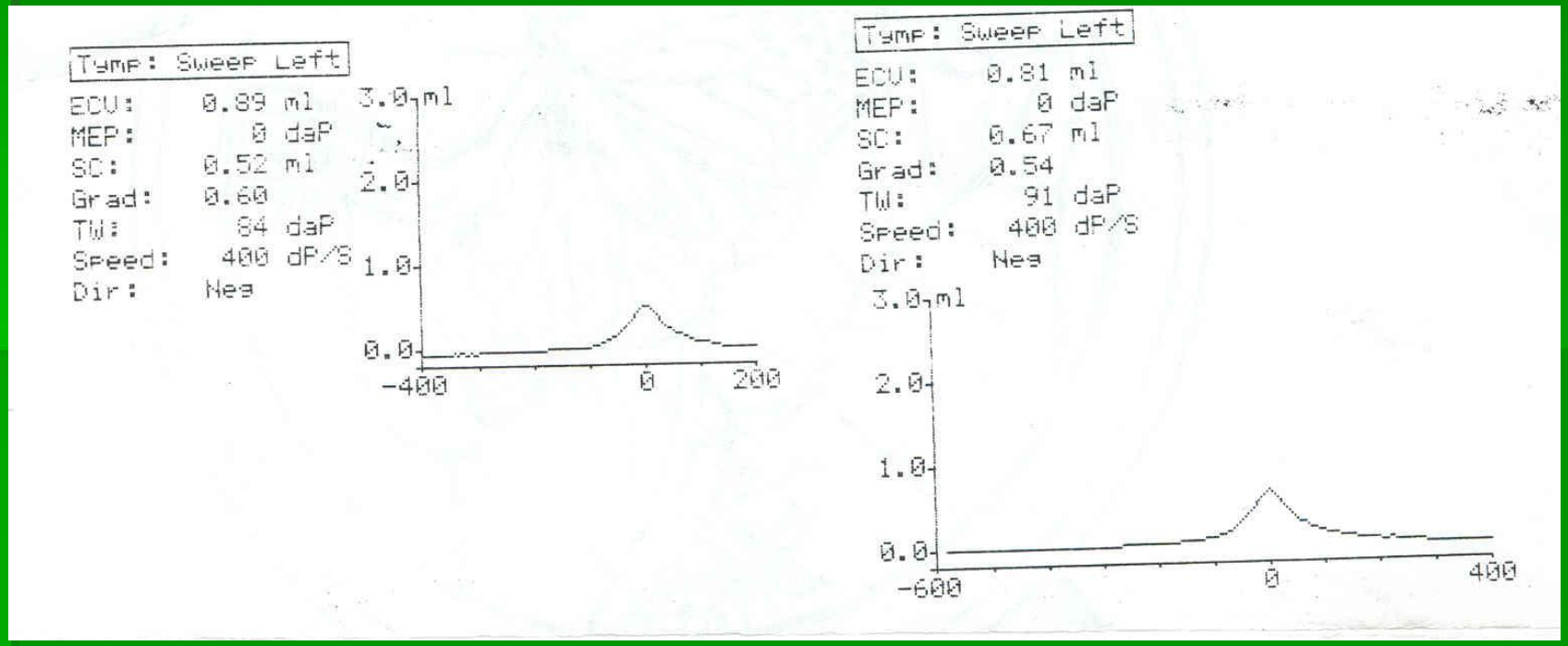
Test Variables Tympanometry

- Rate of tympanometry



Test Variables Tympanometry

- Pressure range



Test Variables Tympanometry

- Probe tone frequency
- Messurement values
- Calibration
- Recorder speed

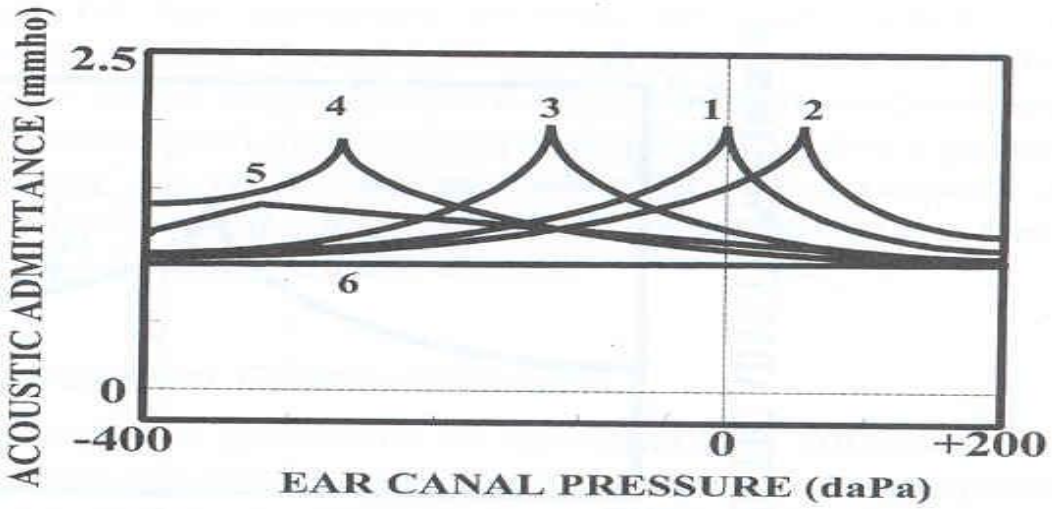


Figure 12.10. A family of tympanograms indicating changes in TPP during the development of otitis media with middle ear effusion. The tympanogram begins within the normal range *(1)*, and then develops slightly positive pressure *(2)*, which is followed by increasingly negative pressure *(3, 4)*. When sufficient fluid develops, the tympanogram becomes flat *(6)*. Resolution of middle ear effusion occurs in the opposite direction.

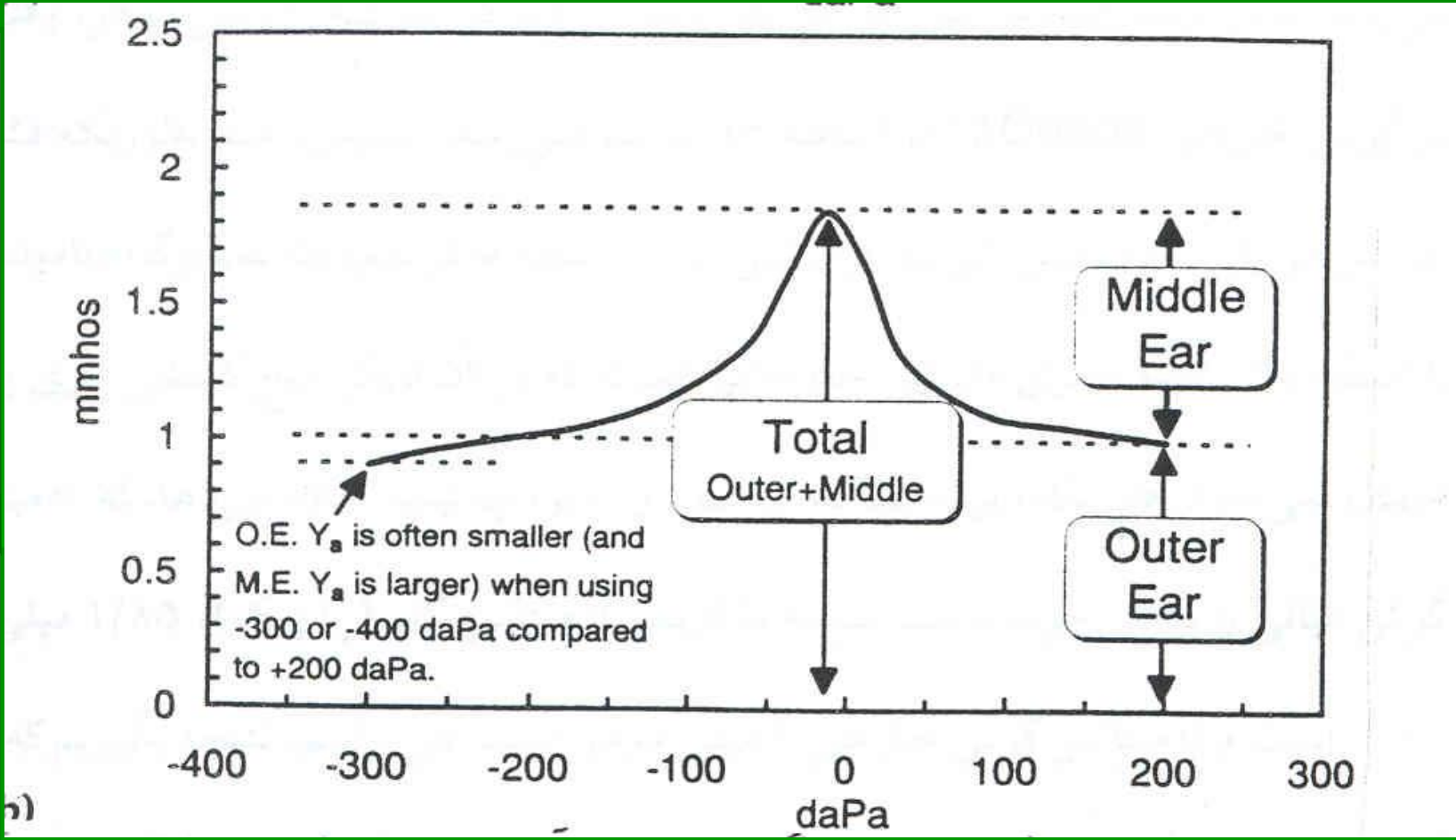

2.5
2
1.5
1
0.5
0
mmhos
-400
-300
-200
-100
0
100
200
300
daPa
Middle Ear
Total
Outer+Middle
Outer Ear
O.E. Y_a is often smaller (and M.E. Y_a is larger) when using -300 or -400 daPa compared to +200 daPa.

Table 12.3.

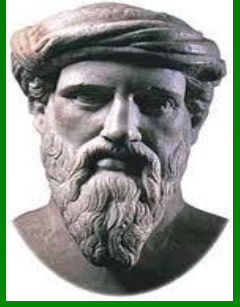
Common Middle Ear Pathology and the Characteristics of Y-226 Tympanograms Frequently Associated With Them[a]

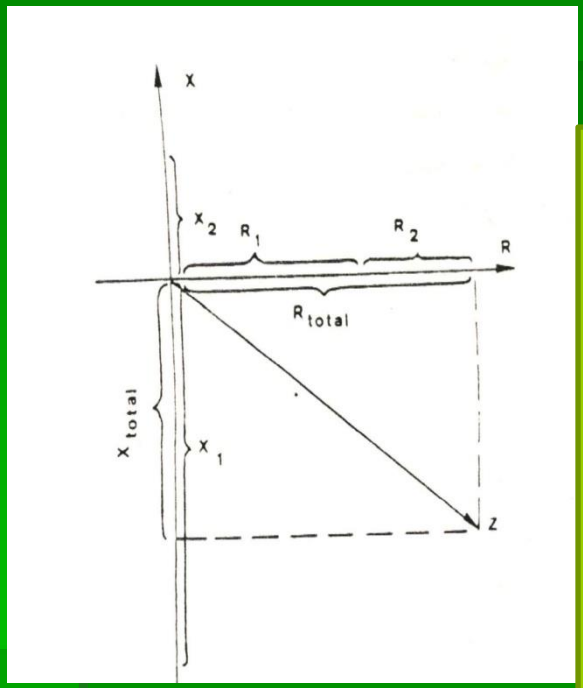
Pathology	V_{ea}	Y_{tm}	TW	TPP
Early ME effusion	Normal	Reduced	Widened	Normal/positive
ME effusion	Normal	Reduced/flat	Widened	Negative/CNT
Ossicular discontinuity	Normal	Increased	Normal	Normal
TM pathology	Normal	Increased	Normal	Normal
Otosclerosis	Normal	Normal/reduced	Normal/reduced	Normal
Malleus fixation	Normal	Reduced/flat	Increased	Normal
ET blockage	Normal	Normal	Normal	Negative
Open PE tubes	Increased	Flat	CNT	CNT
TM perforation	Increased	Flat	CNT	CNT
Cerumen blockage	Decreased	Flat	CNT	CNT

[a] V_{ea}, equivalent ear canal volume; Y_{tm}, peak compensated static acoustic admittance; TW, tympanogram width; TPP, tympanogram peak pressure; ME, middle ear; TM, tympanic membrane; ET, eustachian tube; PE, pressure equalization; CNT, cannot test.

Multiple component or multiple frequency Tympanometry

قضیه فیثاغورث





$$Z^2 = R^2 + X^2$$

$$Z = \sqrt{R^2 + X^2}$$

$$Z = \sqrt{R^2 + \left\{2\pi f.m + \left(-\frac{S^2}{2\pi f}\right)\right\}}$$

Multiple component or multiple frequency tympanometry

- Vanhuyse et al.(1975)

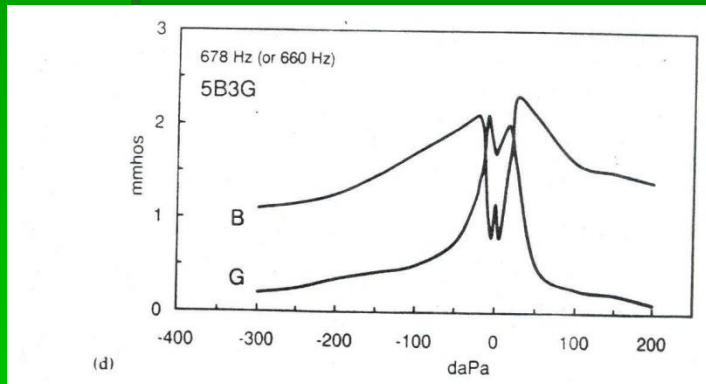
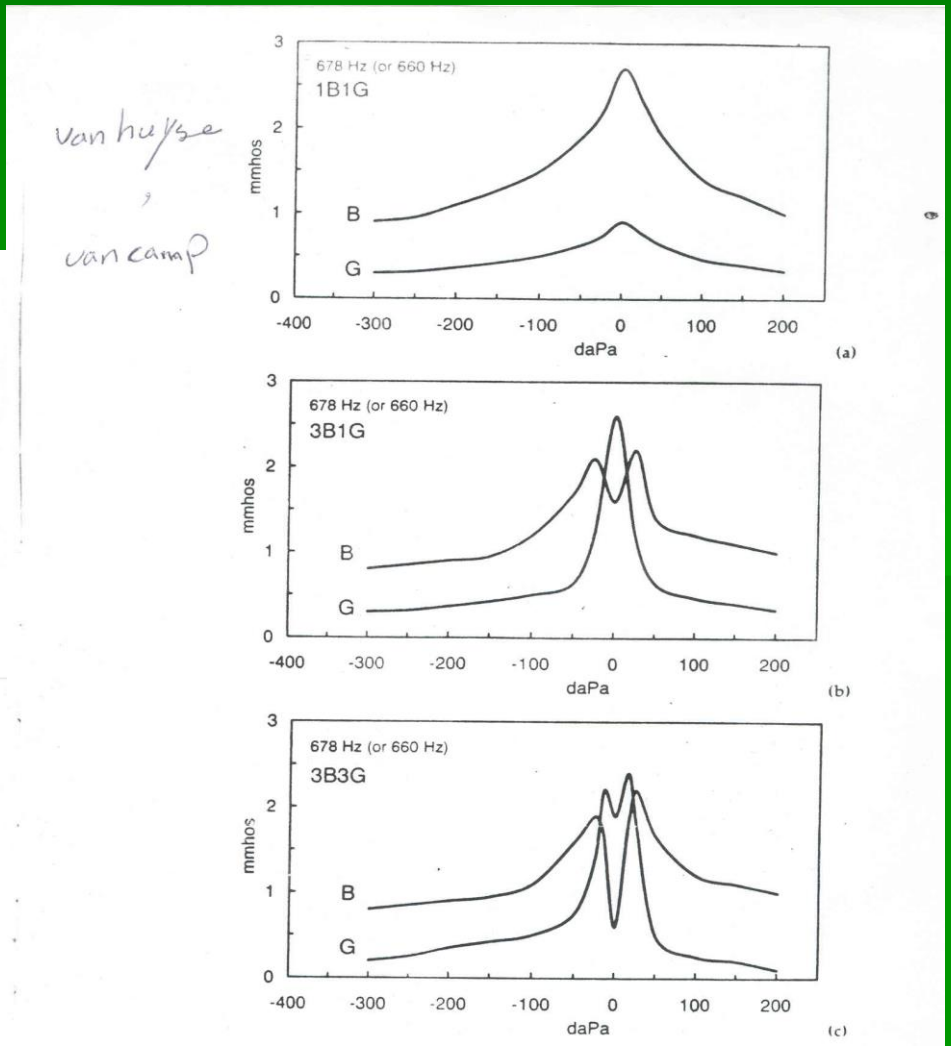
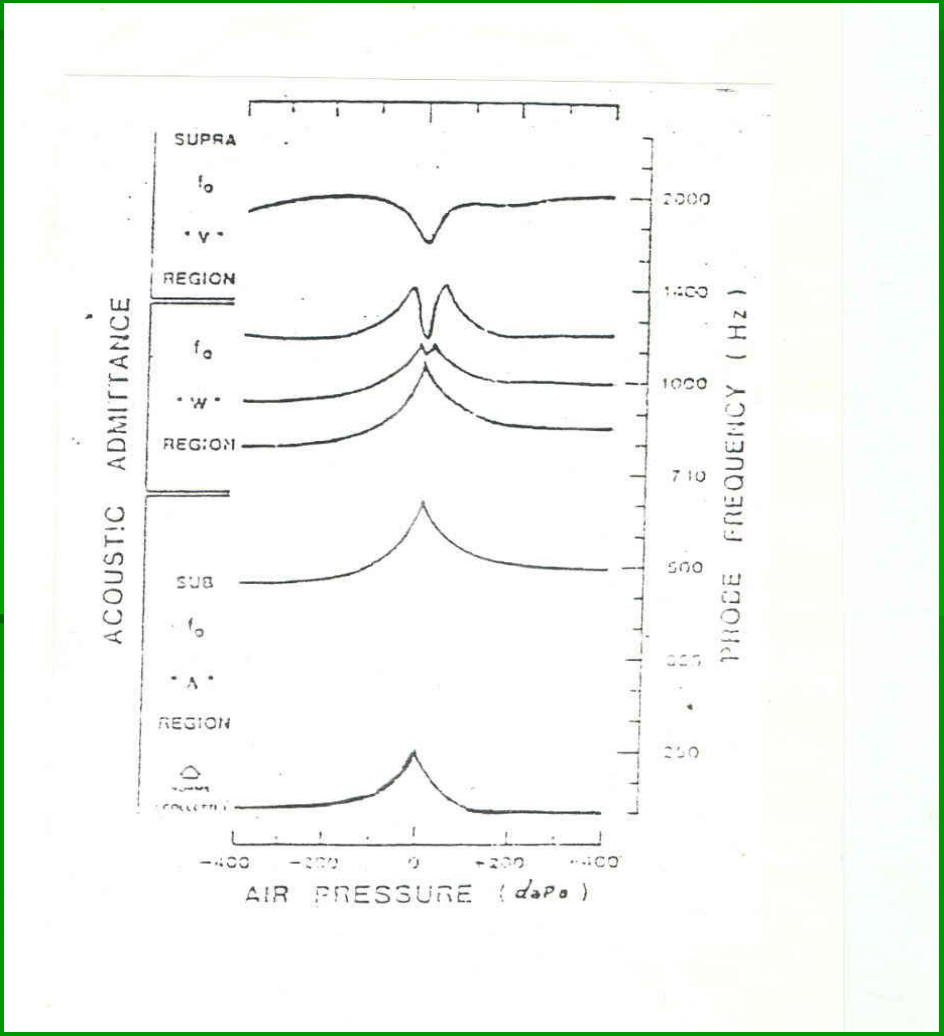


Figure 7–10. *Continued*



Multiple component or multiple frequency tympanometry

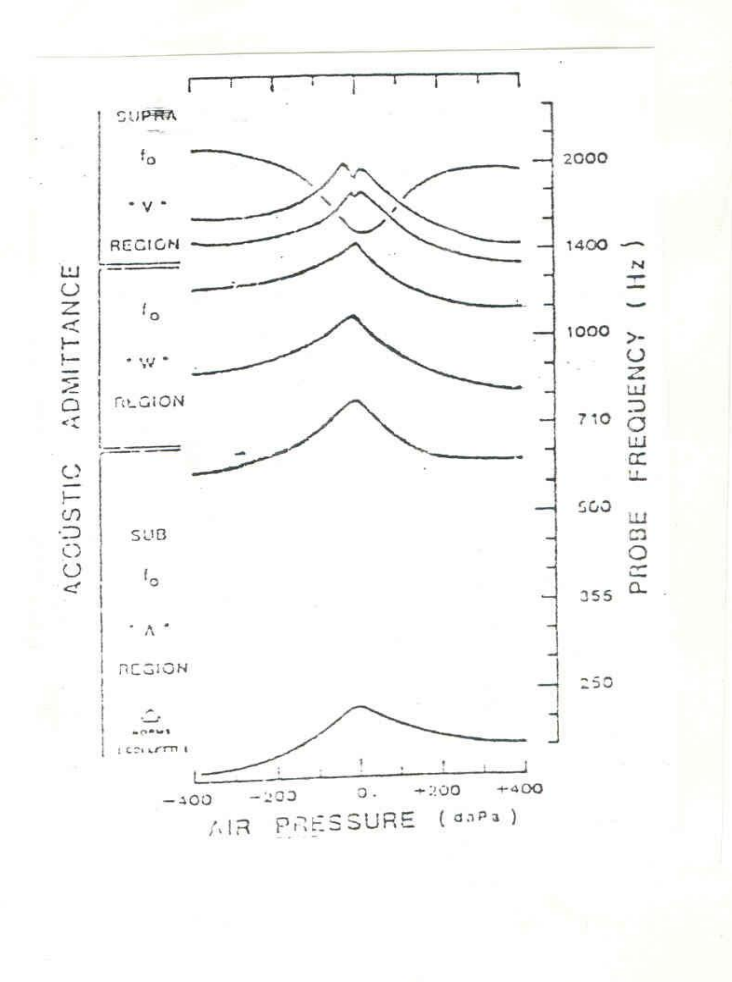
- Colleti(1984)



هنجار

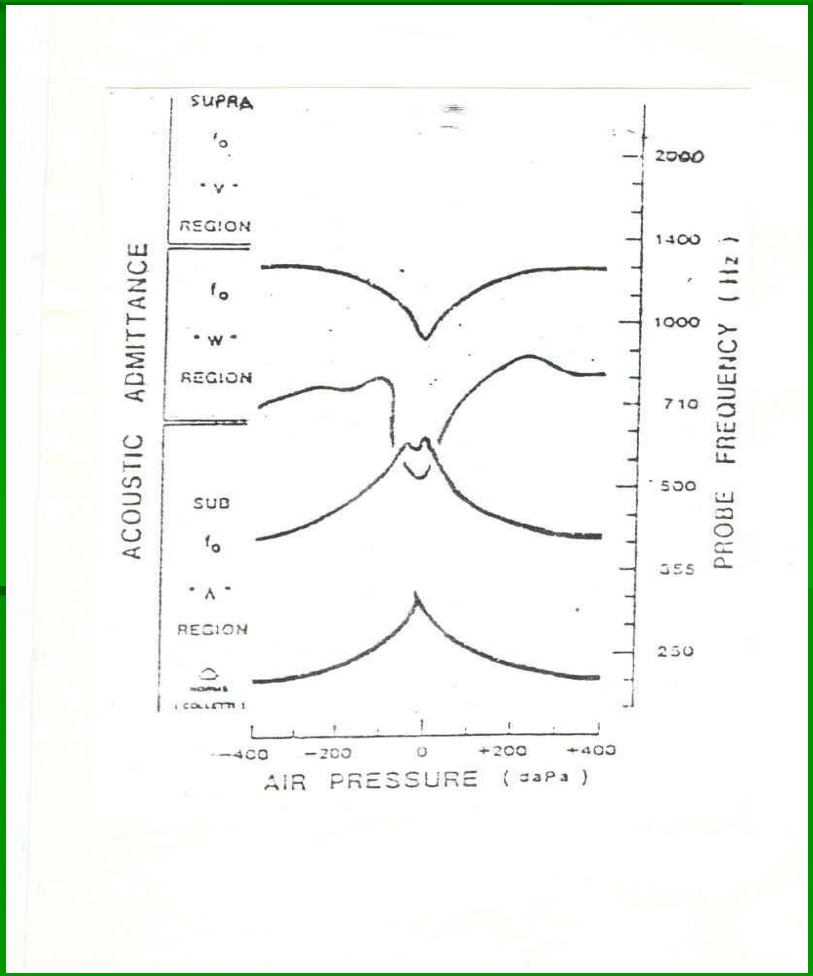
Multiple component or multiple frequency tympanometry

پاتولوژی های سخت کننده
گوش میانی



Multiple component or multiple frequency tympanometry

پاتولوژی های شل کننده گوش میانی



تمپانومتری سه بعدی