SPAU315 Audiology Practicum I

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Recommended Procedure

Tympanometry

Date: August 2013

Correction: June 2014

Due for review: August 2018

Essential reading

https://www.thebsa.org.uk/wp-content/uploads/2013/04/Tympanometry-1.pdf

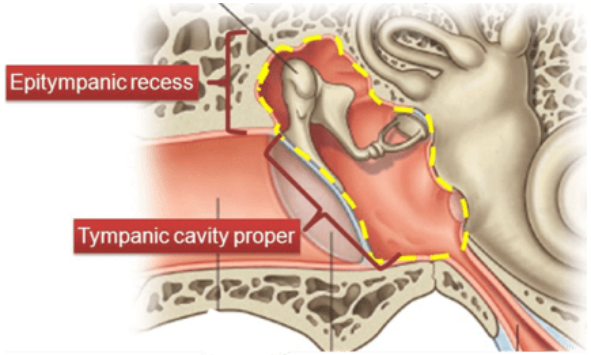
Brief anatomy recap

Tympanic Membrane (TM): 3 layers

1) Outer layer of skin: Stratified squamous epithelium
2) Middle layer: Fibrous connective tissue
3) Inner layer: A single layer of mucosal connective tissue

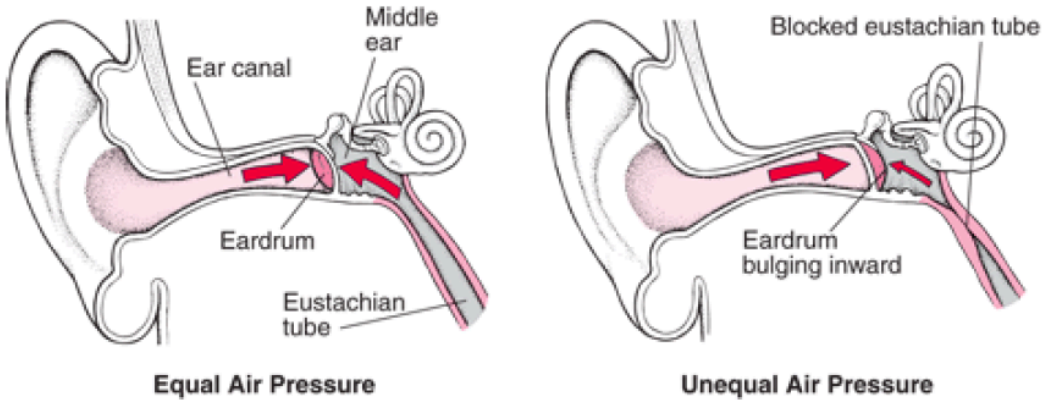
Middle Ear: 2 major air spaces

1) Epitympanic recess (contains the upper half of the malleus and the greater part of the incus)
2) Tympanic cavity proper



Eustachian tube

- Connects the ME cavity with naso-pharynx to allow equalization of pressure across TM
- 36mm long
- 2 parts: osseous portion (12mm) – less steep than cartilaginous
  cartilaginous portion (24mm) – opens into naso-pharynx



Function of the ME

- An acoustical transformer
- An impendence-matching system

What is impedance?

- A measure of the rejection or acceptance of energy per unit time
- A system of high impedance accepts energy less readily than one with low impedance
- In the ear: the lower the impedance, the easier it is for sound to transfer from the middle ear into the inner ear.

What does the ME do?

- Allows improved transmission of sound energy to pass from the outer ear (full of air) into the cochlea (full of fluid)

- The impedance mismatch arising from the air-filled outer and middle ears compared to the fluid-filled cochlea requires an impedance matching transformer, otherwise 99% of the incoming sound will be reflected.

ME impedance-matching system

- Its malfunctioning could result in 30dB loss of sound!

- 2 parameters promote the efficient energy transfer:

    1) Arial ratio
    2) Lever system

Arial Ratio

- Ratio of the TM 20 x area of stapes footplate
- Acoustical pressure therefore increases at the oval window
- Which results in a 26dB boost of sound
- Remember: pressure = force per unit area

Lever System

- Manubrium of the malleus and the long process of the incus lie roughly parallel (with the manubrium about 1.3 times longer)
- This forms a lever system supplying additional aimplification

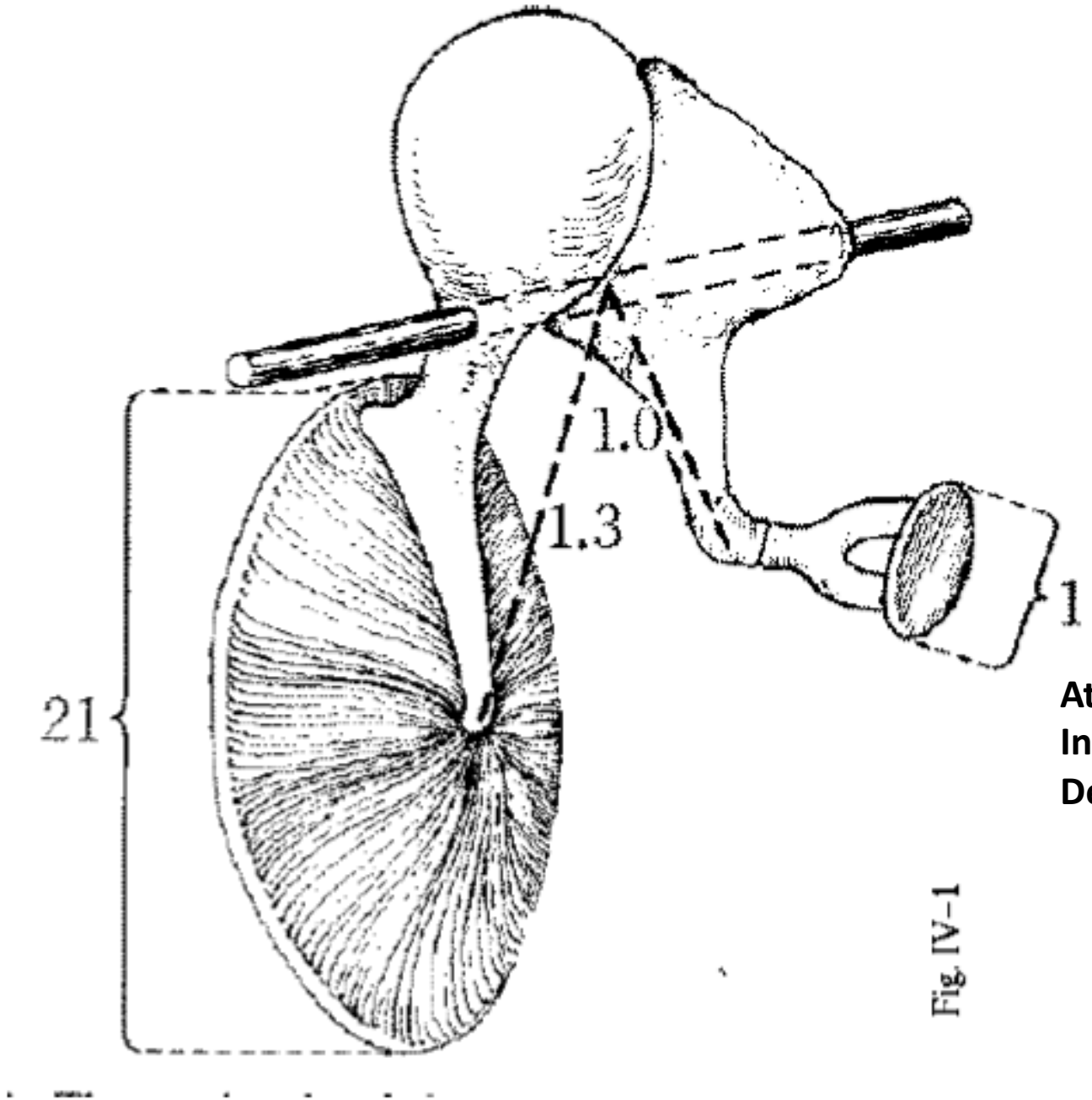


Fig. IV–1

At the oval window:
Increase in pressure
Decrease in velocity

What is immittance testing?

- A battery of tests useful in the diagnosis of hearing impairment through the measurement of mobility of the TM and ossicular chain

- Aim: To see how well the middle ear mechanism is performing its impedance matching function

- Quick, objective, non-invasive and easy to do!

Admittance measures obtained

- Volume of the external ear canal
- Tympanogram
- Middle ear pressure
- Acoustic reflex thresholds
- Acoustic reflex decay
- Non-acoustic reflexes

Admittance Techniques

- When performed as part of a complete test battery, powerful tool in evaluation of:

 - Conductive

 - Cochlear

 - Retro-cochlear

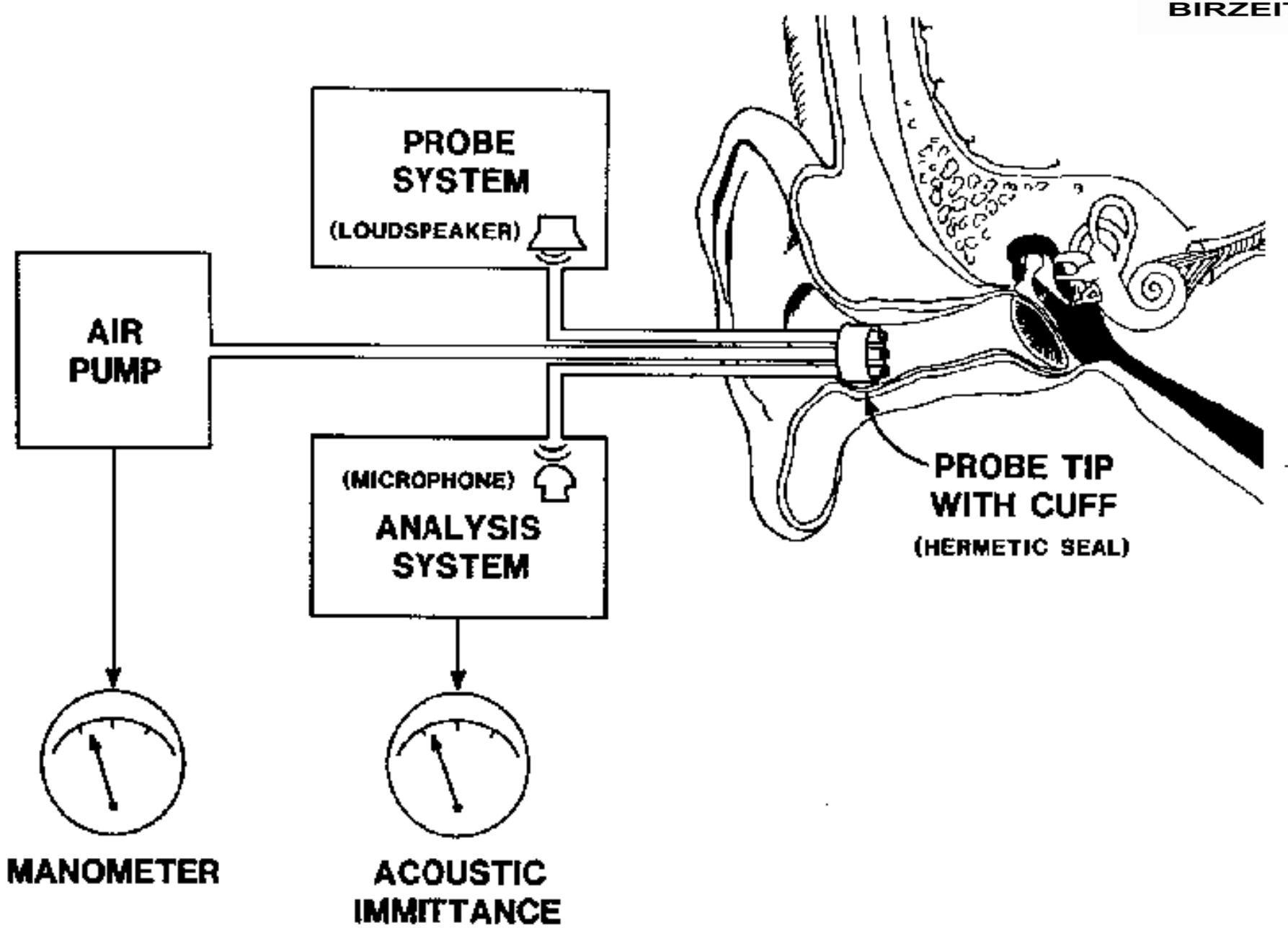
 - Brainstem disorders

Tympanometry

- Acoustic admittance as function of ear canal pressure
- Tympanogram: A graphic display of TM compliance as a function of pressure changes in the External Auditory Meatus (EAM)
- Sensitive to:
  - Middle ear effusion
  - Cholesteatoma
  - Ossicular adhesions
  - Space-occupying lesions in contact with eardrum
  - Ossicular discontinuity
  - Perforations
  - Ear canal occlusions

What do we need to do Tympanometry?

- DO OTOSCOPY!
- Hermetic seal of probe in ear canal
- Variable air pressure in ear canal
- Probe tone
- Some way to monitor the SPL in ear canal



Probe Assembly

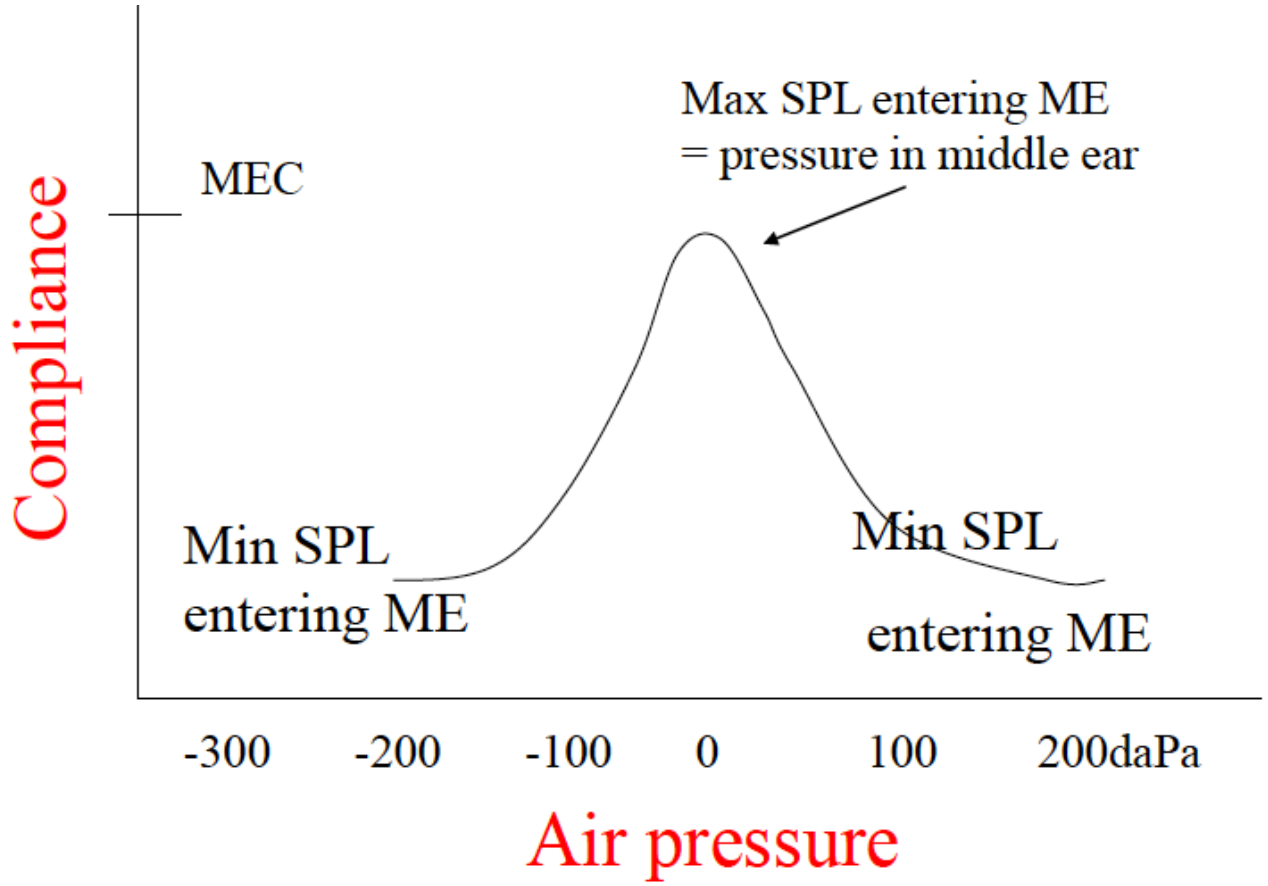
- Variable intensity low frequency probe tone
- Air-tight seal using probe tip
- Microphone picks up sound in ear canal
  - To control level at sound source and maintain the sound pressure at pre-set level
  - To measure the amount of sound reflected back from the TM and middle ear system

Ear Canal Volume (ECV)

- Single numerical value of acoustic impedance of middle-ear system
- Measured as the equivalent volume in cm3 of a column of air with the same acoustic compliance as the middle ear system being tested

- Ear wax?
- Perforation?
- OME?

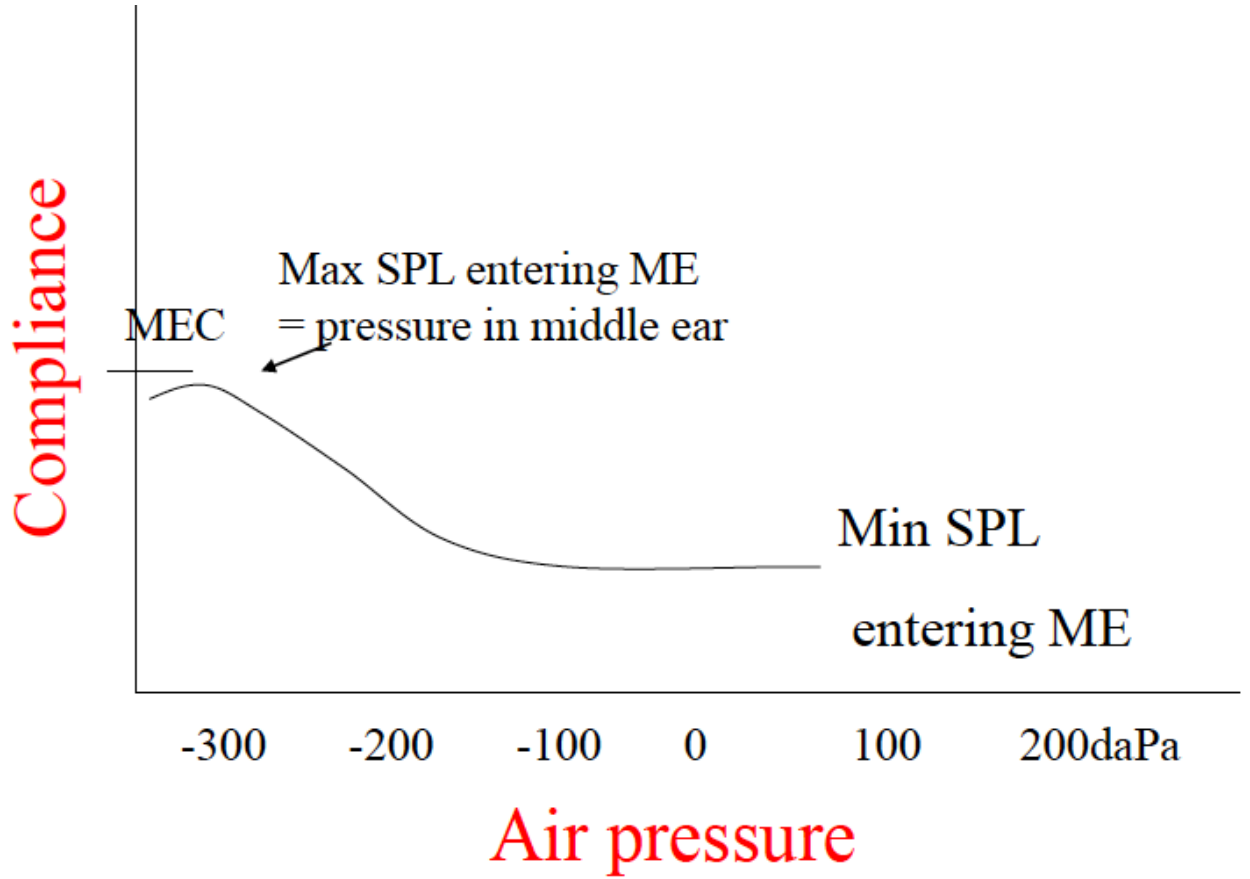
ME Compliance & Pressure



ME Compliance = height of peak

ME Pressure = Pressure point of max peak

ME Compliance & Pressure



Middle Ear Pressure: Normal Range Values

(According to BSA, June 2012 draft)

Ear Canal Volume

0.6 – 2.5cm³

0.4-1 cm³ (children)

Middle Ear Pressure

+/- 50 daPa (decaPascals)

(down to –150 for children)

Middle Ear Compliance

0.30 –1.6 cm³ (mean 0.7cm³)

Classification of Tympanograms (Jerger)

Type A

- ECV:

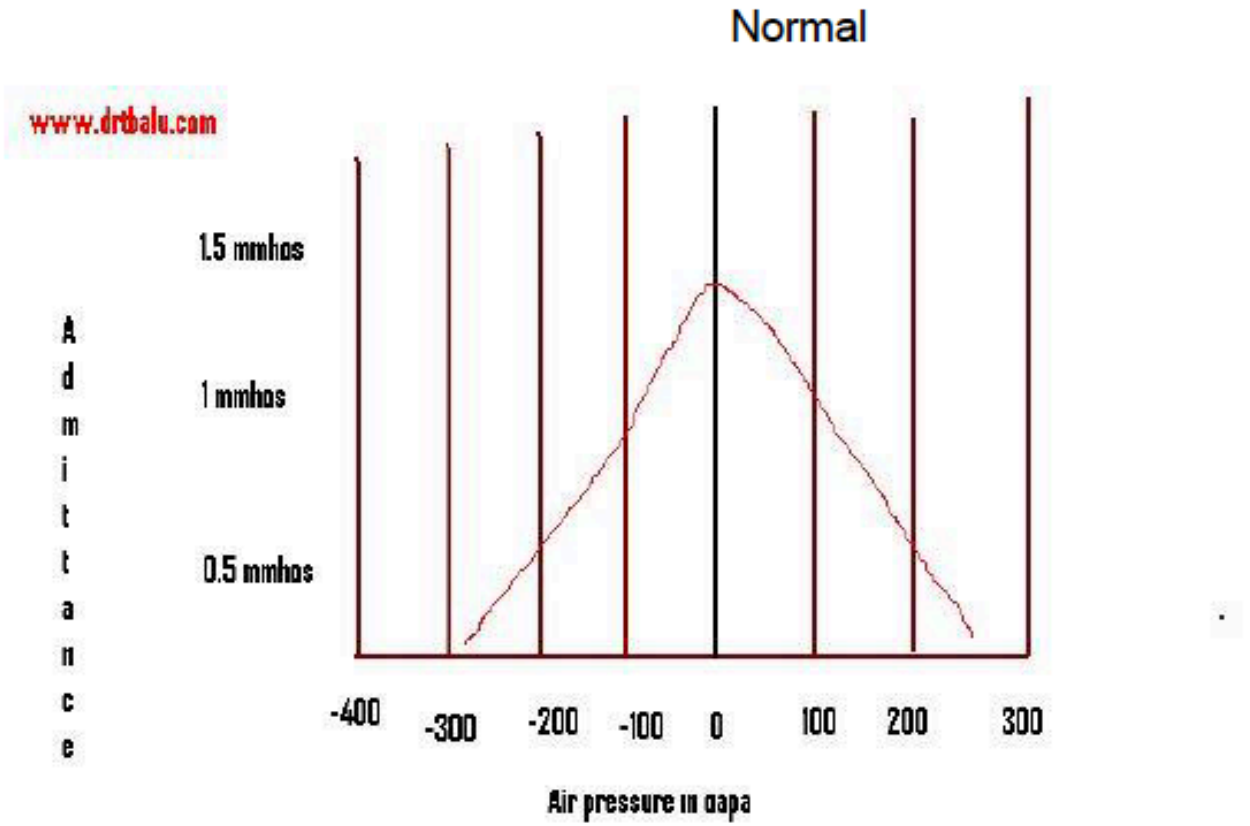
0.6-2.5-adult

- Compliance:

0.30 –1.6 ml

- MEP:

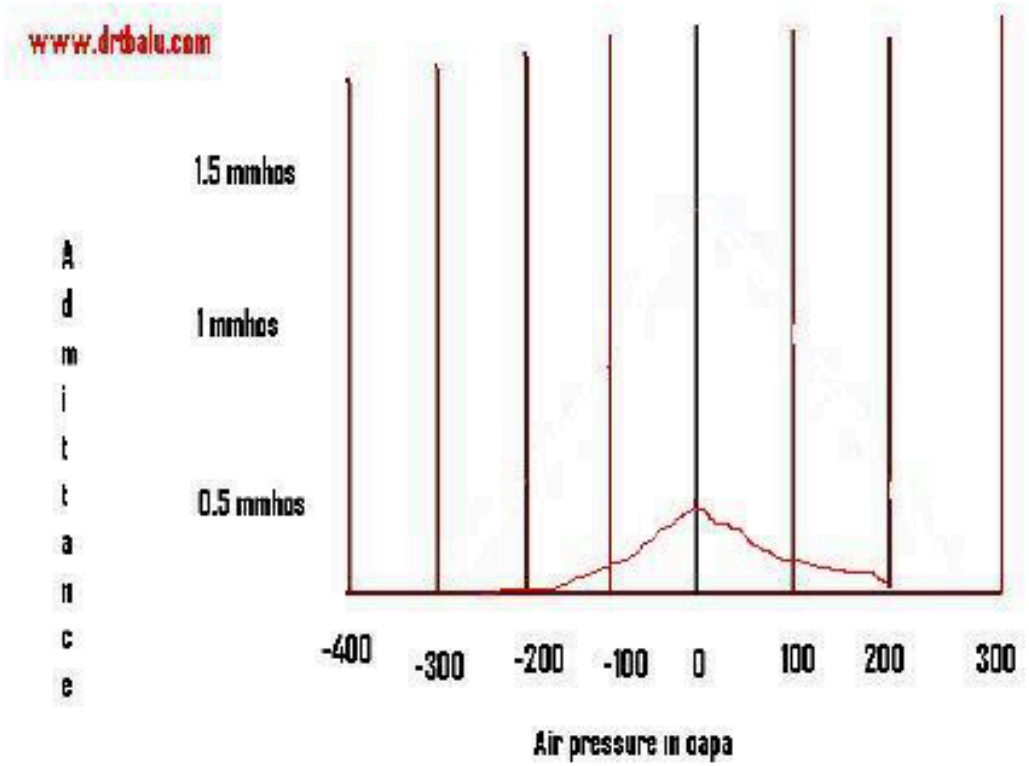
+- 50 daPa



Classification of Tympanograms (Jerger)

Type As

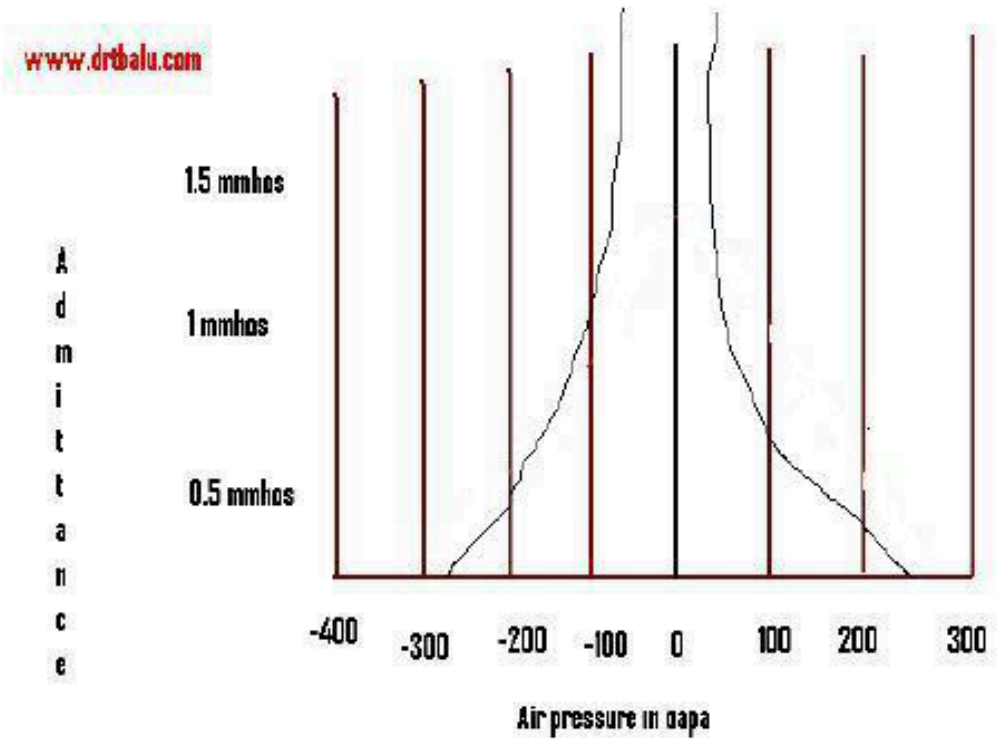
- Shallow curve
- Stiff ME system
- Compliance low
- usually < 0.2mm
- Glue, otosclerosis



Classification of Tympanograms (Jerger)

Type Ad

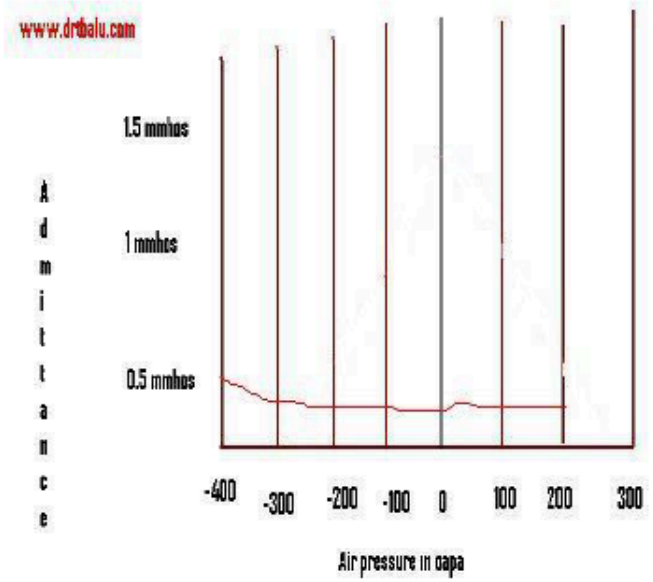
- Flaccid system
- Vol: Normal
- Discontinuity?
- High compliance
- Pressure variable
- negative to normal
- Pressure



Classification of Tympanograms (Jerger)

Type B

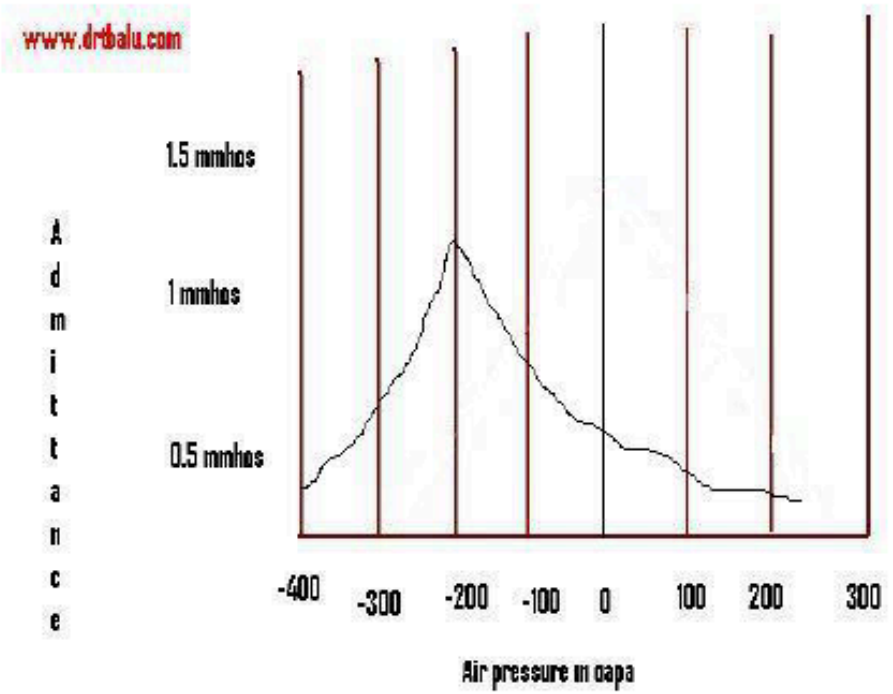
- Flat, no compliance
- Volume normal usually
- Pressure may be difficult to measure
- check volume before deciding: small vs. large



Classification of Tympanograms (Jerger)

Type C

- Negative pressure
- Compliance normal
- Resolving or pre-cursor ME problem
- Volume normal



No result/ Difficult to obtain seal?

- No measureable C or MEP or very reduced
- Large ECV if recorded (>2.5cm^3)
- Perforation or patent grommet
- Check equipment

Type	Characteristics	Indication
A	Peaks at 0 daPa	Normal
Ad:	Unusually high peak	Suggests ossicular dislocation.
As:	Reduced peak	Suggests ossicular fixation.
B:	Flat, no peak	Indicates reduced movement, usually a sign of middle ear fluid or a space-occupying tumor.
Type B with an abnormally large volume	>2.0 cc volume	Indicates a perforation or patent ventilation tube.
Type C:	Negative pressure	Indicates abnormal negative peak.
Type D: Notching	Shows a dip in the peak	Indicates scarred eardrums or a hypermobile tympanic membrane (TM).
Type B with an abnormally small ear canal volume	< 1.0 cc	Indicates faulty probe function, usually the probe is against the ear canal wall or blocked with cerumen.

Tympanometry Procedure

- Calibration of equipment: Daily check vs. 6 month laboratory test
- Preparation of patient: Seated, ambient noise in room < 50dB (A)
- Otoscopic examination: Looking for contraindications
- Instructions/description of test: Avoid unnecessary movement, avoid speaking or swallowing once probe is fitted. Soft tip being used to seal ear canal.

- Choose tip to fit canal and attach to probe
- Straighten ear canal by pulling pinna gently upwards and backwards while inserting probe with rotatory movement. Children-Pull pinna down and outwards
- Point probe in direction of TM. Be aware that you do not seal tip against canal wall
- Change tip size if not sealing
- Start tracking at 200daPa
- Press stop once test has clearly been recorded, and peak evident, Usually lower limit around -300 daPa

Valsalver and Toynbee Tests

Valsalver

- On closed nose swallowing, negative middle ear pressure develops in healthy persons
- In an intact tympanic membrane, pneumatic otoscopy or tympanography can be used to measure changes in **middle ear compliance**
- In a perforated tympanic membrane, the manometer of the impedance bridge can be used to measure **middle ear pressure** changes.

Toynbee

- Forced expiration with mouth closed, pinch nose and blow
- If TM intact- Can be seen bulging on otoscopy
- If TM perf- air escaping may be heard with stethoscope

Acoustic Reflex

Occurs when the stapedius muscle, located in the middle ear, automatically contracts as a result of a loud enough sound (acoustic stimulation) at intensities 70dBHL – 95dBSL. This normally will occur bilaterally!

This means that a signal directed to one ear, is able to elicit a reflex in both ears simultaneously

- Bilateral **contraction of stapedius muscle** in response to acoustic stimuli (and vocalisation)
- Increases stiffness of the ossicular chain and tympanic membrane, when the stapedius contracts
- Change in compliance (MEC)
- If there is change the stapedius muscle must have been activated
- Can be ipsi or contralateral stimulation

Reflex will occur only if the following are intact and functional

- Middle Ear
- Cochlea
- Auditory Nerve
- Stapedial branch of CN VII

The immitance test or procedure is NOT measuring the ear muscle contraction directly, but is actually measuring the *effect of the middle ear muscle contraction on tympanic membrane stiffening*

Clinical Implication: Interpretation of results

The ASR is observed as a decrease in admittance, time locked to the stimulus, for the probe tone that has been used to monitor the ME immitance

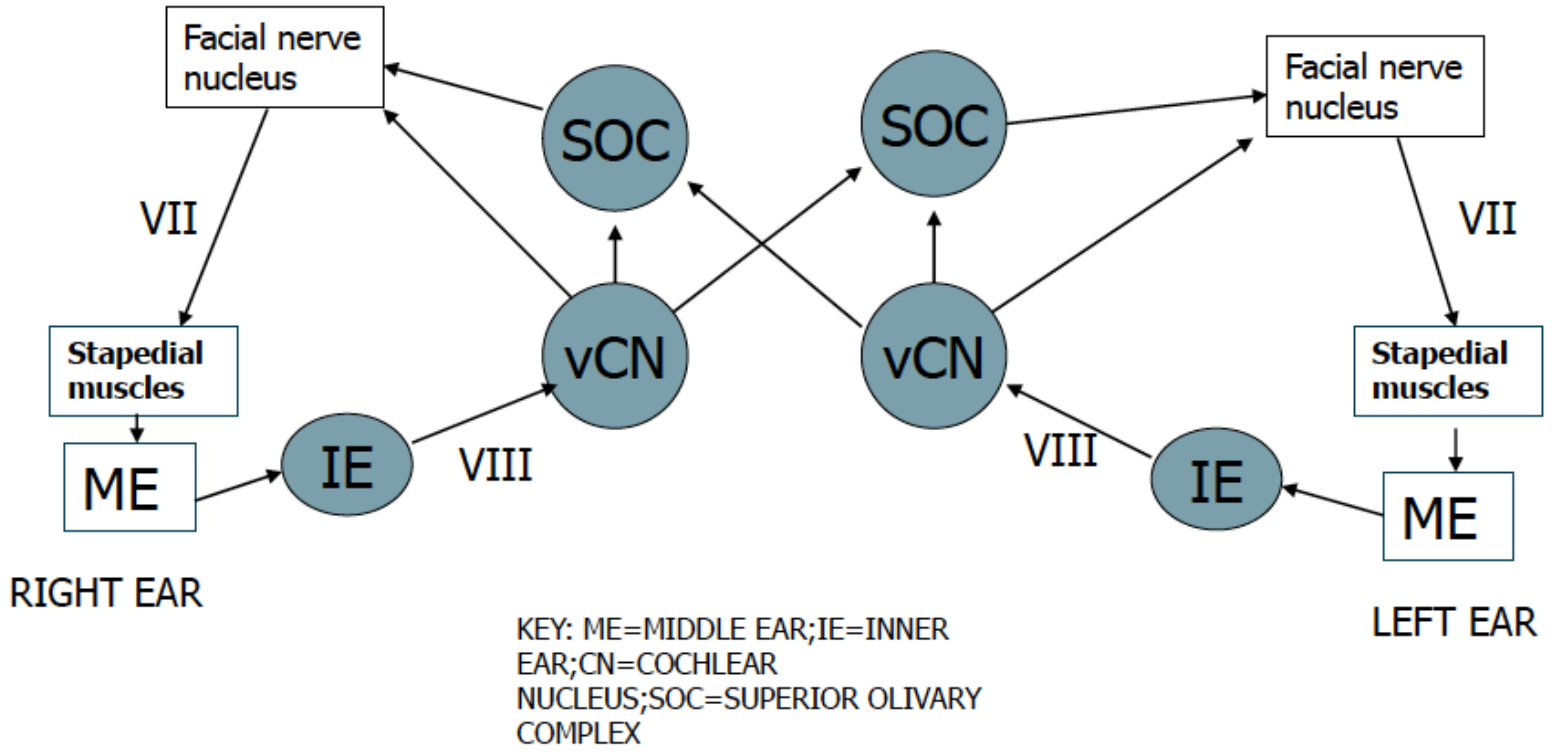
- Mechanical changes in the middle ear may obliterate the recording of the AR. The muscles may contract, but the pathological conditions will obliterate the effect of the contraction on the stiffness change necessary to record the contraction with the immittance machine.

- ASR usually absent ipsilaterally with ME disease, and elevated contralaterally when stimulus is in ear with CHL.

Acoustic Reflex threshold- Definition:

- Lowest level of sound needed to generate a measurable change in middle ear compliance
- In normal hearing occurs at 70-95 dB sensation level
- Presence of reflex at normal levels confirms continuity of VIII nerve (up to superior olive where reflex is mediated) and the VII cranial nerve

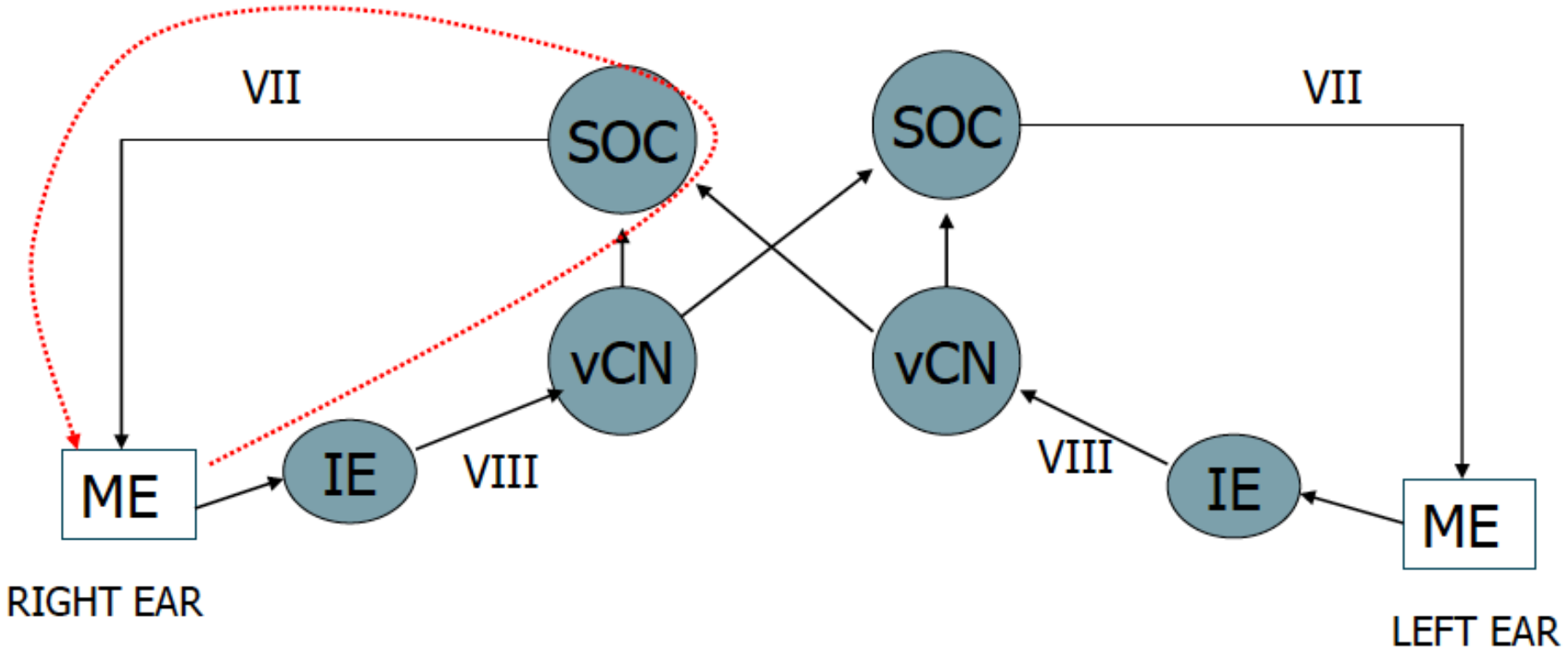
Acoustic Reflex Pathway



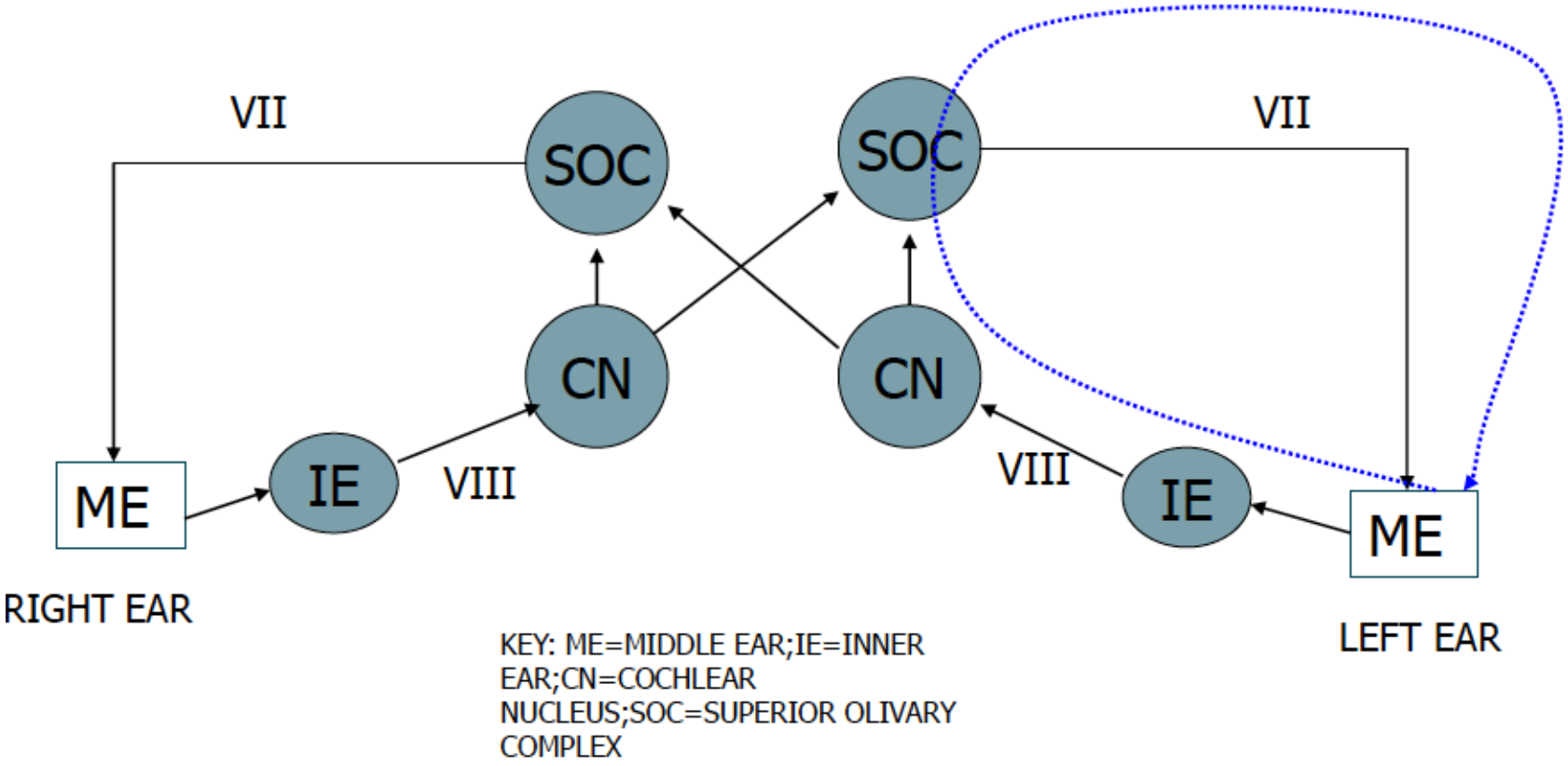
The ipsilateral acoustic reflex

- Same ear for stimulus ear (activating signal) and the probe ear (acoustic reflex response made)
- As pure-tone signal for ART and probe signals are presented through the same tube, ipsilateral acoustic reflex, more prone to artefacts and calibration problems.

Right ipsilateral pathway



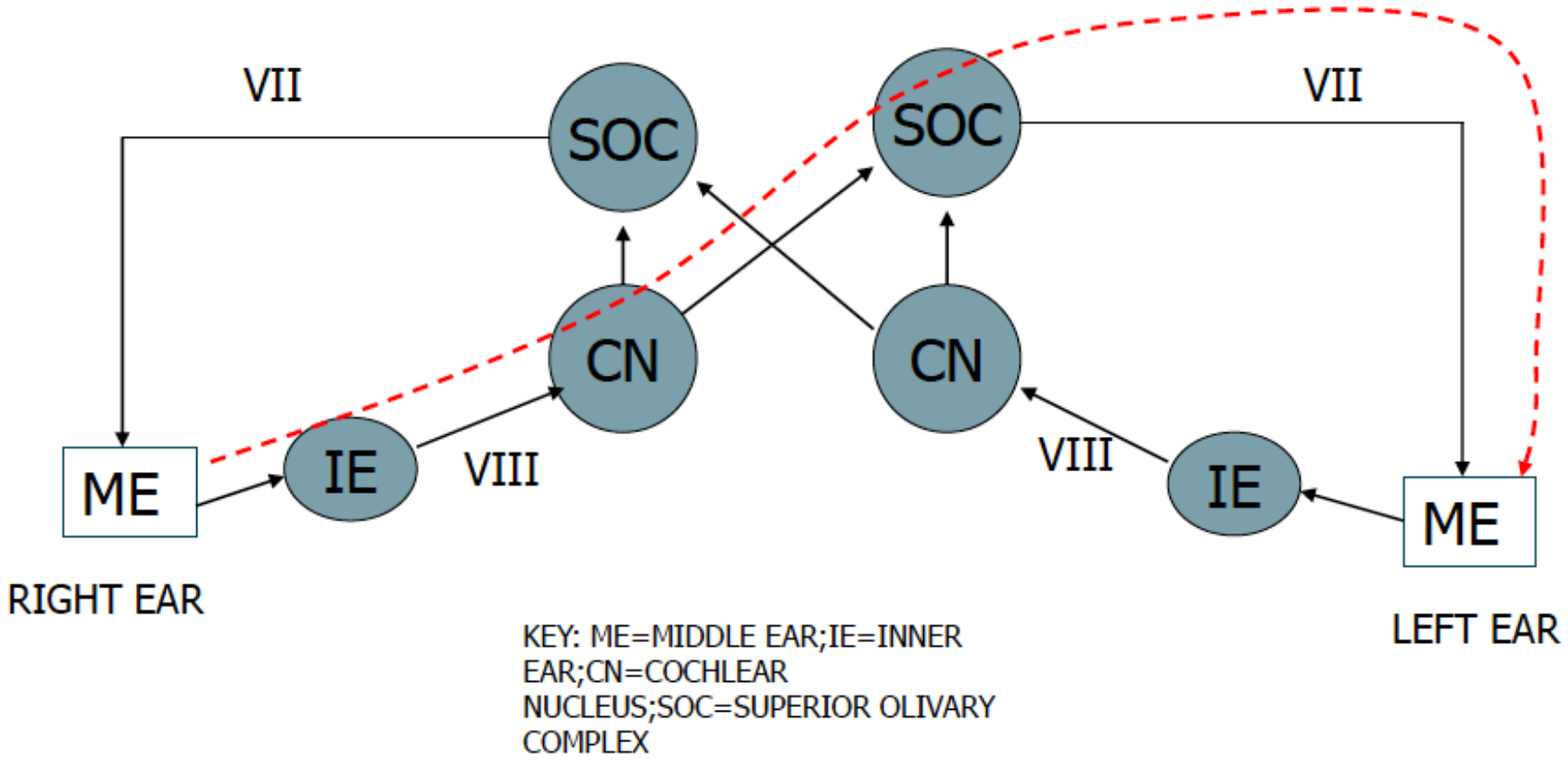
Left ipsilateral pathway



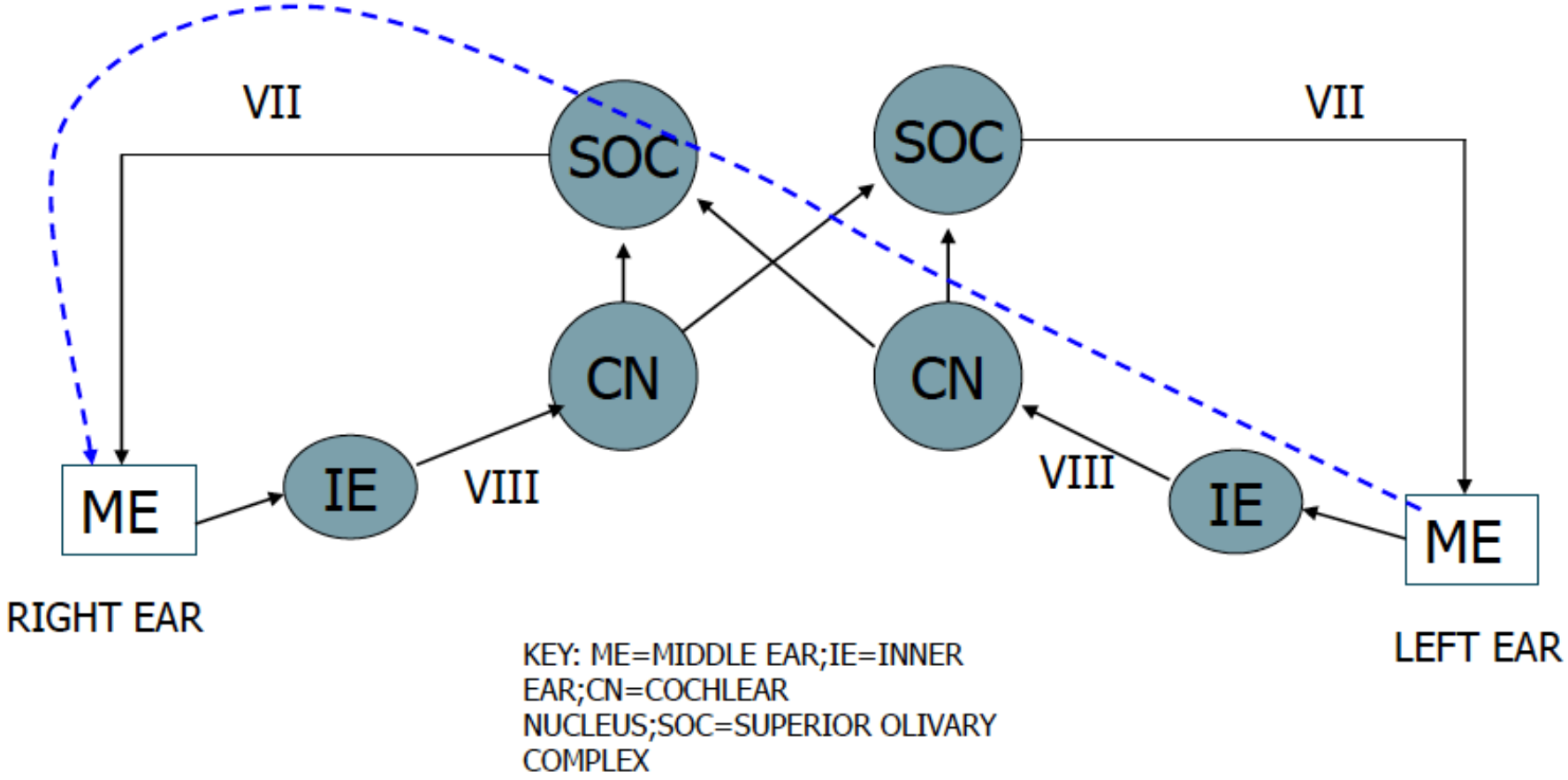
The contralateral acoustic reflex

- One ear receives the stimulus and the other ear (contralateral) immittance change is monitored and its response recorded
- Relatively free of artefact and calibration issues

Right contralateral pathway



Left contralateral pathway



Measuring ARTs

⇒Frequencies tested 500Hz, 1kHz, 2kHz, 4kHz presented for at least 1.5s duration (4KHz less reliable).

⇒Intensity of stimulus started at 70 to 80dB.

⇒If AR is NOT detected increase stimulus by 5 to 10dB until AR elicited or maximum intensity of stimulus reached (<110dB).

⇒If AR is detected, reduce intensity by 5dB until no longer present.

- A normal ipsilateral acoustic reflex threshold (i.e, within the 70-95/100 dB HL range) suggests that no large conductive component is present in that ear
- If present, sensorineural hearing loss probably is no worse than moderate, and the ipsilateral acoustic reflex pathway is largely intact
- A normal contralateral acoustic reflex threshold (ie, within the 70-95/100 dB HL range) suggests that no large conductive component is present in either the stimulated or recording ear

Let’s watch

- https://www.youtube.com/watch?v=djqZ6AweZfw

References

- British Standard Specification for Instruments for the measurement of aural acoustic impedance/admittance BS EN 61027: 1993 (IEC 1027:1991)
- Recommended Procedure for Tympanometry (BJA 1992,26,255-257)
- Hunter, L & Shahnaz, N. 2014 Acoustic Immitance Measures: Basic and Advanced Practice. Plural Publishing, San Diego.
- Hunter, L. (2013, September). 20Q: Acoustic immittance - what still works & what's new. *AudiologyOnline*, Article 12131. Retrieved from: http://www.audiologyonline.com

References II

- Silman, S. and Silverman, C. A. (1991) Auditory Diagnosis Principles and Applications Academic Press ISBN 0-12-643451-4
- Anderson, H., Barr, B. and Wedenberg, E. (1970) Early diagnosis of VIIIth nerve tumours by acoustic reflex tests Acta Otolaryngol., 262, 232-237
- Metz, O. (1946) The acoustic reflex measured on normal and pathological ears Acta Otolaryngol. Suppl., 63, 1-254
- Olsen, W.O., Bauch C.D. and Harner S.G. (1983) Application of Silman and Gelfand (1981) 90th percentile levels for acoustic reflex thresholds. J. Speech Hear. Dis., 48, 330-332

References III

- Sanders, J.W. (1984) Evaluation of the 90th percentile levels for acoustic reflex thresholds. Paper presented at the Annual Convention of the American Speech-Language-Hearing Association, California.
- Silman, S., and Gelfand, S.A. (1981a) The relationship between magnitude of hearing loss and acoustic reflex thresholds. J. Speech Hear. Dis., 46, 312-316
- **Acoustic Immittance Measures** Wiley, T. L. and Fowler, C. G. (1997) Singular ISBN 1-56593-693-0