Update on Vestibular Disorders

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The author acts as an unpaid consultant and has received funding for travel from GN Otometrics.

The 6th Sense

Bewegungsempfinden

Ernst Mach 1838 – 1916
Push-Pull Cooperation of Horizontal Semicircular Canals

Dr Dolittle's Pushmi-Pullyu

Vestibular Haircells

Left Vestibular Neuritis

Vestibular Neuritis

Normal Subject

Left Vestibular Neuritis

Weber et al. Neurology 2008
What you see is not what you measure!

- **Bedside Head Impulse Test**
  Assessment of the catch-up saccade.

- **Video Head Impulse Test**
  Vestibulo-ocular reflex and catch-up saccades.

**Modified Vertical Head Impulses**
- LARP: left anterior – right posterior
- RALP: right anterior – left posterior

**Free iPhone App: aVOR**

**Otolith Organs**
Why VEMPs?

**Hexapod Eccentric Rotation**

Measuring the linear vestibulo-ocular reflex is notoriously difficult!

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**Why are the otoliths selectively activated? Evolution**

- Amphibians
- Reptiles
- Crocodylids
- Birds
- Mammals
- Reptiles
- Amphibians

(Carey & Amin, 2006)

- No cochlea
- Use otoliths for 'hearing'
- Sensitive to mid-frequencies

In humans, vestibule and otolith hair cells still have properties allowing activation by sound

Non-physiological stimuli?

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**Sound and Vibration are effective and easy stimuli for the otoliths**

- Air-conducted sound
- Bone-conducted vibration

(Curthoys 2010)

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**Standard cVEMP**

Ipsilateral Projection

- Evoked by air-conducted sound
- Recorded in the ipsilateral SCM

Inhibitory Reflex

- Simultaneous surface and single motor unit recordings from the SCM

(Colebatch and Rothwell, J Physiol, 1993; 2004)

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**oVEMP**

Ocular Vestibular Evoked Myogenic Potentials

- Evoked by air-conducted sound
- Recorded in the ipsilateral SCM

(Colebatch and Rothwell, J Physiol, 1993; 2004)

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**Ocular VEMP**

- Mainly utricle

**Cervical VEMP**

- Mainly saccule

(Walker KP, Rosengren, SM, Clinical utility of oVEMPs. Curr Neurol Neurosci Rep, 2015.)
Standard oVEMP
Contralateral projection

Summary
Cervical VEMPs
Vestibulo-collc reflex
Contralateral projection
Elicited with sound
Otolith test
Mainly saccule

Ocular VEMPs
Vestibulo-ocular reflex
Contralateral projection
Elicited with vibration
Otolith test
Mainly utricle

Complete Testing of the Peripheral Vestibular System
Clinical Test Healthy Subjects
Superior Vestibular Neuritis
Inferior Vestibular Neuritis
Unilateral Vestibular Loss
Horizontal HIT
Anterior HIT
oVEMP
cVEMP
Posterior HIT = Normal Response
Horizontal canal ampulla
Vestibular DivisionVIII nerve
Inferior Superior Cochlear Division
Anterior canal ampulla
Cochlea
Posterior canal ampulla
Saccular macula
"shank"
Utricular macula
"hook"
= Abnormal Response

Canal paresis factor: 94% left

Vestibular Test Battery
oVEMP (Utricle)
cVEMP (Saccule)
Fundus
Calorics
Subjective visual vertical: 10° left
Canal paresis factor: 94% left

Complete Testing of the Peripheral Vestibular System
Horizontal HIT
Anterior HIT
oVEMP
cVEMP
Posterior HIT
Superior Vestibular Neuritis
Aw ST et al. Neurology 2001
Taylor RL et al. Neurology 2016

Patient with Vertigo & Hearing Loss

Vestibular Test Battery

Audiogram cVEMP

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Complete Testing of the Peripheral Vestibular System

'Solated' Posterior Canal Dysfunction

Vestibular Schwannoma

'Isolated' Loss of Posterior Canal Function

2904 patients with 3D vHIT
52 patients with
- 40 unilateral posterior (77%)
- 12 bilateral posterior (23%)
- >80% associated deficits in unilateral posterior loss
- <20% associated deficits in bilateral posterior loss
  - Calorics
  - oVEMP
  - cVEMP
  - Audiogram

Distribution of diagnoses (n=52)
**Associated Deficits in ‘Isolated’ Loss of Posterior Canal Function**

![Graph showing associated deficits in isolated loss of posterior canal function.]

**Correlation vHIT – caloric / VEMPs**

Expected patterns (based on innervation & vascularization):
- Posterior SCC +
  - saccus (cVEMP): 40%
  - cochlea (PTA): 60%
  - saccus + cochlea: 35%
- lateral SCC (calorics): 65%
- utriculus (oVEMP): 50%
- lateral SCC + utriculus: 38%
- Involvement of any of the three (calorics, oVEMP, cVEMP): 83%

Modified after Bradshaw et al. 2009 JARO

**Anterior Canal Sparing after Gentamicin Vestibulotoxicity**

![Graph showing anterior canal sparing after gentamicin vestibulotoxicity.]

**109 Patients (out of 2123) with Bilateral Vestibular Loss**


**VOR Gain**

- RH: 0.5, 0.7, 0.8, 1.0
- LH: 0.5, 0.7, 0.8, 1.0
- RP, LP, RA, LA

**Saccade Amplitude**

- RH: 0.5, 1.0, 2.0, 3.0, 4.0°/trial
- LH: 0.5, 1.0, 2.0, 3.0, 4.0°/trial
- RP, LP, RA, LA

**Disease-Specific Anterior Canal Sparing**

Relative sparing of the anterior SCCs

- Ratio of affected SCCs
- KNO with anterior lesion (p<0.01)
- DISC (p<0.01) vs. CANVAS (p<0.01)
- CANVAS (p<0.01)

![Graph showing disease-specific anterior canal sparing.]

Hierarchical Cluster Analysis
101 patients with bilateral vestibular loss

Anterior Canal Sparing

- Anterior canals less prone to damage or better recovery?
- Accumulation of gentamicin at more caudally located canals (posterior and lateral)?
- Common in
  - Gentamicin vestibulotoxicity
  - Menière’s disease
  - Unknown etiology

Complete Testing of the Peripheral Vestibular System

Horizontal HIT ✓ ✓ ✓ ✓
Anterior HIT ✓ ✓ ✓ ✓
cVEMP ✓ ✓ ✓ ✓
cVEMP ✓ ✓ ✓ ✓
Posterior HIT ✓ ✓ ✓ ✓

Thank you for your attention!