Emerging Vestibular Function Tests

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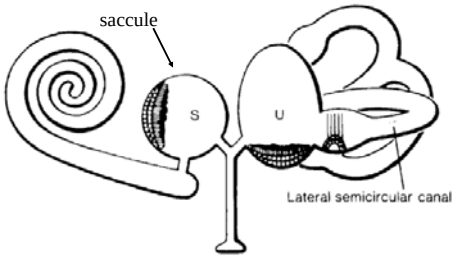
Five motion sensors – can only measure two



Schematic of Inner Ear (Frenzel, 1955)

There a lot to dizziness beyond the ear

- Inputs – ears, eyes, somatosensation, internal models
- Integration – CNS
  - Sensory gain and timing
  - Integration of sensory input
  - Cognitive contribution
- Output – eyes, posture, spatial orientation

Technology driving the current advances

- Response triggered averaging (cheap computers)
  - VEMPs (otoliths and central)
    - Limb VEMPs
  - Also (not covered today)
    - Ocular and various other muscle VEMP's
    - Sound induced vestibular responses (response triggered Tullio's).
    - Etc.

Limb VEMP's

- If saccule activation produces an evoked myogenic potential in neck, shouldn't it also produce one in the limbs ?
- Reasons for looking into limb VEMP's
  - Sometimes SCM VEMP's can't be done (neck pain, weak neck).
  - Pathways to the limbs must traverse cervical and lumbar spinal cords – potential for diagnosis of cord lesions

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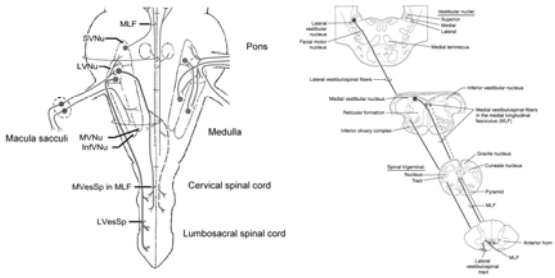
VEMP reflex arc including limbs



Haines DE. *Neuroanatomy: An Atlas of Structures, Sections, and Systems*. Philadelphia: Lippincott Williams & Wilkins; 2000, fig. 7-30, p. 219.

Leg VEMPs

- Using a similar methodology to SCM, we have obtained VEMP's in gastrocnemius.
- Main differences:
  - Longer latency
  - Weaker response (about 1/3 of SCM)
  - Crossed and uncrossed components very different

Rudisill HE. and Hain TC (2008). "Lower extremity myogenic potentials evoked by acoustic stimuli in healthy adults." Otol Neurotol **29**(5): 688-92.

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Leg VEMP method

- Electrodes on Gastroc
- Stand on toes to activate muscle
- Head forward (not turned to L or R)
- 500 clicks (more than 128 used for SCM)

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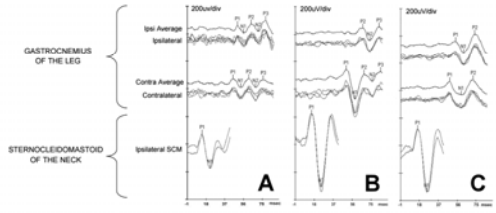
Gastroc VEMPs



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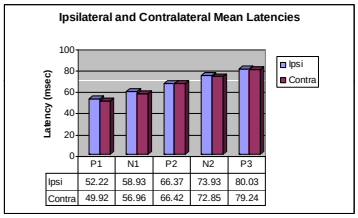
Latencies are Longer



	P1	N1	P2	N2	P3
Ipsi	52.22	58.93	66.37	73.93	80.03
Contra	49.92	56.96	66.42	72.85	79.24

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Figure 6. Peak-to-Peak Amplitudes for P1-N1 and P2-N2.

Amplitudes are smaller (roughly 50 compared to 150)

	Ipsilateral Wave I (p1-n1)	Ipsilateral Wave II (p2-n2)	Contralateral Wave I (p1-n1)	Contralateral Wave II (p2-n2)
Mean	45.81	59.52	82.60	48.53
Std. Error of Mean	7.21	6.13	16.92	6.97
Median	42.04	54.55	76.68	43.49
Minimum	21.97	25.18	15.87	21.97
Maximum	83.01	123.83	217.31	137.49

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Somewhat erratic presence P2 best - - about 80%

N=24		P1	N1	P2	N2	P3
Ipsilateral	Present	9	9	19	17	6
	Absent	15	15	5	7	18
Contralateral	Present	13	13	19	17	5
	Absent	11	11	5	7	19

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Leg VEMPs - overall

- Not a good choice as a clinical test
  - They take too long (100 sec)
  - Have to stand on tiptoes
  - Small (only 50 uv)
  - Not reliable – only 80% of normals
- Needs more work
  - Galvanic responses ipsi vs contra depend strongly on head position on neck. Not sure what happens with sound responses

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Triceps VEMP method

•Electrodes on Triceps
•Activate Triceps
•Head forward (not turned to L or R)
•500 clicks (more than 128 used for SCM)

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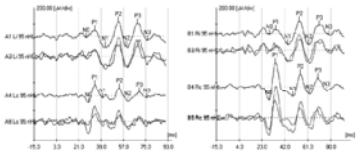
Triceps VEMP when supporting body weight



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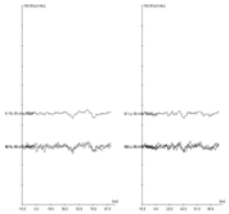
Have to support ones weight
(nothing here where not supporting ones own weight)



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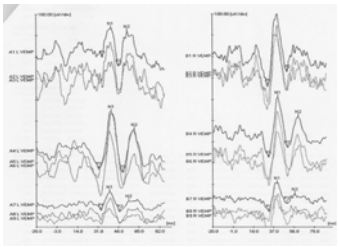
Triceps VEMPs scale with force (10, 15, 20 lbs)



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Latency about 35 msec
Amplitude about 80-90 uv
Both ipsi and contra

	Triceps VEMP **ipsilateral** to acoustic stimulus (SD, 95% CI)	Triceps VEMP **contralateral** to acoustic stimulus (SD, 95% CI)
P1 latency	35.69 ms (7.40, 30.85 – 40.52)	36.29 ms (1.82, 35.16 – 37.42)
N1 latency	44.29 ms (9.51, 38.08 – 50.50)	44.14 ms (3.14, 42.20 – 46.09)
P1-N1 interlatency	8.61 ms (2.50, 6.98 – 10.24)	7.85 ms (3.34, 5.78 – 9.92)
P1-N1 interamplitude	**82.74 µV** (24.54, 66.71 – 98.78)	**94.54** µV (63.58, 55.13 – 133.95)

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Limb VEMPs -- Overall

- Emerging vestibular test
- Saccule input, limbs output
- Certainly relevant to spinal cord function
- Possibly relevant to cervical vertigo (more coming later)

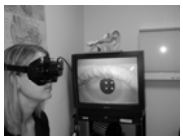
Technology driving advances

- Video Frenzel goggles (tiny cameras on top of eyes)
  - Neck Vibration
  - Cervical vertigo tests
- Other emerging or improved tests – (not covered today)
  - Rebound nystagmus (without fixation)
  - Head-shaking nystagmus
  - Hyperventilation induced nystagmus
  - Valsalva Testing (for SCD)

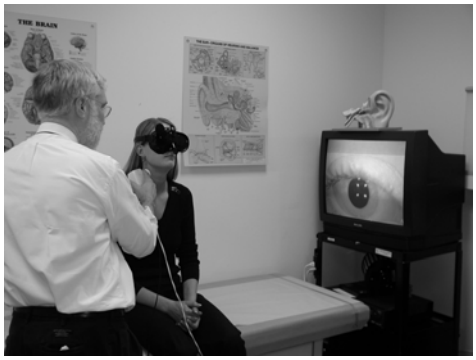
Hain, TC. Head-shaking Nystagmus and New Technology (Editorial). Neurology. 68: 17, 1333-1334 (2007)
Ajroud-Driss S , Sufit R, Siddique T, Hain TC. Oculomotor involvement in myotonic dystrophy type 2. Muscle and Nerve Published Online: Sep 10 2008

Video Frenzels

- Simple but effective new technology
- Allows one rapidly to elicit nystagmus without fixation
- Examiner can judge whether nystagmus is significant, and easily see torsion – often better than ENG



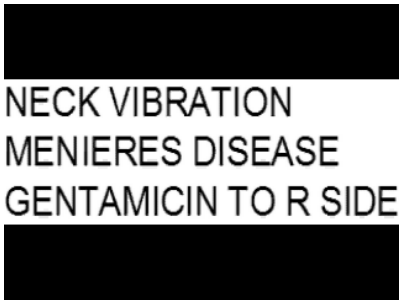
Vibration test



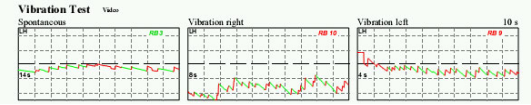
Vibration test

- Method: Apply 60-120 hz vibration to SCM, first one side, then the other. Shower massagers work well for this and are inexpensive.
- Video frenzel goggles – optical frenzels don't work very well
- Compare nystagmus before and during

Vibration Induced Nystagmus



Vibration Induced Nystagmus



Vibration Induced Nystagmus

- Unidirectional horizontal nystagmus strongly suggests contralateral vestibular lesion.

Hamann KF, and Schuster EM. Vibration-induced nystagmus - A sign of unilateral vestibular deficit. *ORL J Otorhinolaryngol Relat Spec* 61: 74-79, 1999.

Dumas G, Perrin P, and Schmerber S. Nystagmus induced by high frequency vibrations of the skull in total unilateral peripheral vestibular lesions. *Acta Otolaryngol* 1-8, 2007b.

Mechanisms of VIN

- Direct generation by the neck ("cervical nystagmus"), perhaps through proprioceptors
- Generation from the inner ear itself
- Interaction between the neck and central vestibular processing ("neck fixation").

Cervical Vertigo

- Vertigo caused or influenced by NECK movement, rather than inner ear movement
- Classic explanations
  - Vertebral artery compression
  - Neck afferents
  - New – Vestibulo-spinal tract impingement in neck ?

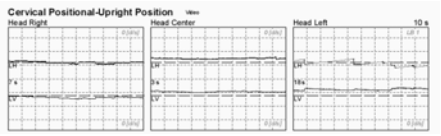
Classic tests for Cervical Vertigo

- Torsion test –
  - Upright move body under still head
    - Assesses COR
    - Implausible test and no data that it works
  - Supine - -dissociate body from head
    - On bloc vs. head turned on neck
    - Difficult to interpret because combines supine position with neck torsion, and history effects.

Newer tests for Cervical Vertigo made possible by video-frenzel

- Compare prone to supine positional
- Simply observe for nystagmus with head turned (upright) – also called "VAT".

Method of testing for cervical vertigo with video-Frenzel goggles



Using this methodology, weak cervical nystagmus is common – especially so in people with herniated cervical disks

Mechanisms for Cervical Nystagmus ?

- Neck afferents
- Vascular compression of vertebrals
- Spinal cord – spino-vestibular pathways in cervical cord

Exciting times for Vestibular Testing

- Inexpensive computers allow response triggered averaging of nearly anything
- Inexpensive devices allow highly sensitive recordings of nystagmus
- Nevertheless, we have a long way to go ! The inner ears are just a little piece of the puzzle.