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Electronystagmography (ENG)
Diagnoses Balance Problems
Why We Treat Balance Problems

- Balance related falls result in more than 300,000 hip fractures annually with a mortality rate of 30% within one year.
- Balance related falls account for 1/2 of all accidental deaths among the elderly.
- Dizziness and loss of Balance is the most common complaint from our senior population.
- Each year 40% of our seniors experience falls.
- Treat Symptoms (Some symptoms can lead to depression and can be worse than chronic pain problems).
Common Symptoms

• Vertigo: The sense of motion when there is none

• Disequilibrium: Can't stand up/ walk without falling down

• Loss of Proprioception: The inability to know where your body parts (limbs fingers) are without senses (touch and sight)

• Pressure sense on sole
ENG
An Instrument that measures eye movements (and analyzes them)
Eye Movements Create Potentials

Fig. 3-3. Effect of changes in the orientation of the corneoretinal potential on the voltage between recording electrodes.
Basic Idea

- You need various senses and control systems to balance.
- Eye movements give a quantitative measure of a patient's ability to respond to various tests that reveal which balance component is malfunctioning.
- ENG measures eye movements.
Walking is Tough
4 Visual Control Systems

• Vestibular and Optokinetic keep visual targets on the fovea despite *movements of the head*

• Pursuit keeps visual targets on the fovea despite *movements of the target*

• Saccade places new targets on the fovea
Summary so Far

• Keeping balance should be very difficult task

• Your body has 4 advanced control systems and multiple senses in order to make balancing or walking a trivial task

• If any of these control systems or senses are compromised, you can not balance
Looking Closer at the Biology of the Control Systems
Inner Ear

Membranous Ampulla

As the head rotates movement of the endolymph causes the cupulae on both sides of the head to bend in opposite directions. The difference in activity between the paired ampullae results in the sensation of movement.

Membranous Labyrinth

Macula of Saccule

Hair cells bend under gravitational force

Gelatin layer

Otoconia

Head held upright

Head held bent forward
Oculomotor Neurons

- 6 muscles (2 for each axis)
- There is a stream of neural impulses to each extraocular muscle when the eye is in a relaxed position
Optikinetic and Vestibular
Reasons for Balance Disorders

- Extra water in semi-circular canals and/or Saccules that changes viscosity or density of endolymph: Infections, direct or close impact to ear, many drugs

- Central Disorders: Physical trauma that results in edema of CNS.

- Loud sounds: lightning victims
Reasons for Damaged Senses

• **Ocular:** Bifocals, cataracts, glaucoma, maculopathy

• **Sematosensory:** Joint Disease, arthritis, trauma (whiplash), Sensory neuropathy, peripheral neuropathy, dorsal column loss

• **Central Nervous System:** Cerebrovascular accident, Neurodegenerative, tumors, Head injury – Post Concussion
Electrode

- Electrolyte is used to lower the impedance of the epidermis
- Electrode-Electrolyte interface configured in this way is relatively insensitive to movement
Electrode

- Electrodes polarize easily due to a double layer of ions created at the electrode-electrolyte interface

- Polarization creates the \textit{half-cell potential} which is \textbf{not} stable

- Ag/AgCl electrode is used because of its high stability in potential and low impedance
Amplifier

- **Differential Amplifiers**: Amplifies the voltage differences between the two leads.
- **Single-Ended Amplifiers**: Amplifies the voltage of one lead with respect to ground.

*Fig. 3-6. Types of input in biologic amplifiers. A, Single ended. B, Differential.*
Amplifier

• Single ended pick up voltages not at ground potential, including ground-referred interference from power lines

• Differential Amplifiers are relatively insensitive to electrical interference

• Single-Ended Amplifiers are unsuitable for ENG
Potential Change with Eye Movement

**Figure 4-2. Effect of the direction of a 40° eye movement on the signals recorded by bitemporal and vertical electrode pairs.**

A. Eye movement. B. Tracings yielded by bitemporal pair. C. Tracings yielded by vertical pair. The indicated pen deflections assume a recording system calibration of 1° = 1 mm.
Tests

- **BPPV (Benign Paroxysmal Positional Vertigo):** the Hallpike subtest reveals if patient has loose Otoconia in semicircular canal.
- **Inner-ear:** VAT and/or caloric subtest
- **CNS dysfunction:** OPK, Smooth Pursuit, Gaze, Saccade
- **For proprioceptive and somato sensory,** you have to use Posturography (Balance Master, diagnosis and treatment)
Hallpike

- Artificial stimulates semi-circular canal. If there is Otoconia in the semi-circular canal, then it will stimulate the sensors, and trick the brain stem into thinking that the head is moving drastically, stimulating a reflex of the eyes. The reflex causes the eyes to make a characteristic feedback.
Hallpike Performed
Treatment
Pros of ENG

• Quantitative measure of balance

• Non-Invasive, minimal discomfort

• Relatively inexpensive
  – Technician can perform the test
  – Equipment is inexpensive
  – Most 10 x 14 rooms or bigger are acceptable
Exam Room and Proper Grounding

Fig. 3-1. Sample layout of an ENG laboratory.

Fig. 3-2. Consequences of an accidental short circuit (arrow) between the “hot” wire and the metal frame of the patient’s examining table. A. When the frame is grounded, the ground wire completes the circuit and blows the fuse. B. When the frame is not grounded, it remains at 110 V and poses a shock hazard to the grounded patient who touches it. The solid black lines indicate the involved current pathways.
Summary

• We are trying to diagnose whether the problem is central or peripheral. And possibly what is causing the central or peripheral problem.

• Since we know how the 4 controls system work, we perform tests which illuminate which system is malfunctioning.

• We follow eye motion by recording changes in voltage across eye.

• Based on results, we can diagnose the problem.

• Once the problem has been diagnosed, treatment can begin (usually very high success rate).
References

- University of Wisconsin Medical School. Medical Neurosciences 731, unit 2. www.neuroanatomy.wisc.edu/virtualbrain/Index.html

- Wikipedia: Saccade, Smooth pursuit, Optokinetic, Vestibular


Thank You
Questions

• Eye movements are detected by an ENG (Electronystagmography) by measuring:
  a) The magnetic field around the eye
  b) The temperature gradient across the eye
  c) The gravitational field around the eye
  d) The voltage across the eye
  e) the air currents created by eye movements

• BPPV (Benign Paroxysmal Positional Vertigo) is caused by:
  a) Otoconia (calcium carbonate “rocks”) leaving the Saccule and/or Utricule and entering the Semi-circular canals.
  b) Frequent eye blinks which interrupt vision, this causes the saccade control system to malfunction
  c) Ocular neurons not firing on time, this causes delayed reaction and puts the optokinetic system out of sync with the vestibular system.
  d) All of the above
  e) None of the above
Environmental Interaction

Visual, Semato-Sensory, Vestibular Systems

Compare, Select, and Combine Senses

Determination of Body Position
Saccade and Smooth Pursuit

Please note, this is a schematic representation. LEFTS and RIGHTS are not MRI related.

RIGHT frontal eye field turns the eyes to the LEFT.
Possible Topics

- High Impedance necessary in amplifier
- Frequency filters
- Common mode rejection ratio
- Older models used galvanometers and rectilinear output
- Caloric Irrigator