Testing Vestibular Function

The University of Texas Medical Branch,
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Grand Rounds Presentation
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December 14, 2005
Testing Vestibular Function

- Four percent of patients 18-65 yo visit PCP with complaint of "dizziness"
- Three percent consider it "Severely incapacitating"
- Third most common complaint in elderly
Testing Vestibular Function

- Otolaryngologist is considered balance specialist
- Often PCP for dizzy patients
- Private practice physicians often quoted “I wish I knew more about dizzy patients”
Objectives

- Describe office examinations of dizzy patients
- Describe vestibular function studies
- Review indications for vestibular function studies
- Review efficacy of office and vestibular function studies
Office Examination of the Dizzy Patient

Dix-Hallpike Maneuver

- Used to provoke nystagmus and vertigo commonly associated with BPPV
- Head turned 45 degrees to maximally stimulate posterior semicircular canal
- Head supported and rapidly placed into head hanging position
- Frenzel glasses eliminate visual fixation suppression of response
Dix-Hallpike Maneuver
Dix-Hallpike Maneuver

Positive test

- Up-beating nystagmus
- Nystagmus to the stimulated side
- Rotary component to the affected ear
- Lasts 15-45 seconds
- Latency of 2-15 seconds
- Fatigues easily
Pneumatic Otoscopy

- Positive and negative pressure applied to middle ear
- Hennebert’s sign/symptom – nystagmus and vertigo with pressure, alternates with positive and negative pressure
- Can be present in patients with perilymphatic fistula, syphilis, Meninere’s disease, SCC dehiscence syndrome
Head Shake Nystagmus

- Evaluates unilateral vestibular weakness
- Head tilted back 30 degrees
- Shake back and forth for 30 seconds as quickly as possible
- Unilateral vestibular deficit causes slow phase nystagmus to the side of lesion
- Low sensitivity (27%)
- Good specificity (85%)
Head Thrust Test

- Inhibitory response not as robust as the stimulatory response to stimulate VOR
- Movements that overcome the inhibitory response of vestibule will result in VOR lag
- Head tilted 30 degrees
- Rapid head movements to either side with focus on examiner’s nose
- Patients have catch-up saccade when rotated to side of weakness
- Sensitivity 75%, Specificity of 85%
Dynamic Visual Acuity

- Used for bilateral vestibular weakness
- Visual acuity checked on Snellen chart
- Rechecked while rotating head back and forth at 1-2 Hz.
- Loss of 2-3 lines considered abnormal
Romberg Test

- Patient asked to stand with feet together and eyes closed
- Fall or step is positive test
- Equal sway with eyes open and closed suggests proprioceptive or cerebellar site
- More sway with eyes closed suggests vestibular weakness
Romberg Test
Fukuda Stepping Test

- Originally described by Fukuda using 100 steps on a marked floor.
- Patients are asked to step with eyes closed and hands out in front.
- Rotation by more than 45 degrees is abnormal.
- Rotation usually occurs to the side of the lesion.
- Rotation often found in asymptomatic patients.
Dysdiadochokinesia Testing

- Most commonly tested with the hand slapping test
- Abnormalities seen in patients with cerebellar dysfunction
- Poor sensitivity and specificity
Tandem Gait Test

- Patients are asked to walk heel to toe in a straight line or in a circle.
- Complex function evaluates many aspects of balance.
- Poor performance seen in cerebellar lesions, but can be seen in many disorders.
- Poor sensitivity and specificity.
Orthostatic Hypotension

- Most often in patients on BP meds with “light headedness” on sitting to standing
- Defined as drop of SBP 20mm HG or DBP 10mm HG within 3 minutes of standing
- Tilt exams offer objective measurements with well established norms
- Patients with no symptoms will often “Tilt”
Voluntary Hyperventilation

- Patients asked to over breathe for 90 seconds to 3 minutes
- Hyperventilation causes symptoms in some anxiety disorders
- May provoke symptoms in normal
- Poor test for vestibular diagnosis
Quantitative Vestibular Testing

- Diagnosis unclear
- Prolonged symptoms unresponsive to conservative treatment
- Screen for central disorders
- Evaluate prior to surgical ablation procedures
- Documentation of vestibular deficits
Electronystagmography (ENG)

- Divided into oculomotor tests, positional and positioning tests, and caloric tests
- Only vestibular test with the ability to test individual labyrinths separately
- Relies on the vestibulo-ocular reflex (VOR) to test the peripheral vestibular function
- Mostly a test of HSCC function
Electronystagmography (ENG)
Electronystagmography (ENG)
Electronystagmography (ENG)

- Oculomotor tests
  - All test eye movements that originate in the cerebellum
  - Saccadic tracking
  - Smooth pursuit tracking
  - Optokinetic testing
Oculomotor Tests

- **Saccadic tracking**
  - Patients concentrates on a randomly moving target
  - Latency – difference in time between movement of object and eye (150-250 ms)
  - Velocity – speed of saccade 200-400 degrees/second low end of normal
  - Accuracy – amount of undershoot/overshoot of target (75-120%)
Saccadic Tracking
Saccadic Tracking
Saccadic Tracking

Horizontal Saccades

Horizontal Eye Position

Peak Velocity

Mean = 462

Accuracy

Mean = 133

Latency

Mean = 202
Smooth Pursuit Test

- Tests ability to accurately and smoothly pursue a target
- Gain of eyes compared to movement of target
- Saccade movements eliminated from calculations
- Asymmetrical pursuit highly suggestive of central disorders
Optokinetic Tests

- Vestibular system and optokinetic nystagmus allow steady focus on objects.
- Target is rapidly passed in front of subject in one direction, then the other.
- Eye movements are recorded and compared in each direction.
- Asymmetry suggestive of CNS lesion.
- High rate of false positive results.
Smooth Pursuit and Optokinetic Tests

Horizontal Tracking

Horizonal Eye Position

Frequency = 0.30 Hz  R Gain = 0.91  L Gain = 0.95  Phase Shift = -0.4°

Tracking Gain

Target Frequency (Hz)

Accepted cycles: 36

OPTOKINETIC

40°/sec Right/HorizontalEyePos

40°/sec Left/HorizontalEyePos
Smooth Pursuit Test

Horizontal Tracking

Horizontal Eye Position

Tracking Gain

VELOCITY GAIN

TARGET FREQUENCY (HZ)
Smooth Pursuit and Optokinetic Tests
Positional and Positioning Testing

- Positional test
  - Insults to vestibular system are compensated by stimulation
  - Maximal compensation in head up position
  - Tests for nystagmus in static head positions
  - Vertical or direction changing nystagmus suggests central disorder

- Positioning test
  - Used to determine presence of BPPV
  - Quantitative Dix-Hallpike maneuver
Positional and Positioning Testing

Positional

Sitting with Vision/Horizontal Eye Position

Supine with Vision/Horizontal Eye Position

Sitting w/o Vision/Horizontal Eye Position

Supine w/o Vision/Horizontal Eye Position

Horizontal Eye Position

Vertical L Eye Position

HALLPIKE: Head Right

HALLPIKE: Head Left

Horizontal Eye Position

Vertical L Eye Position

Head Rt with Vision/Horizontal Eye Position

Head Lt with Vision/Horizontal Eye Position

Head Rt w/o Vision/Horizontal Eye Position

Head Lt w/o Vision/Horizontal Eye Position

U20

R20

L20

D20

L10

R10

L0

R0

DEGREES
Positional and Positioning Testing
Positional and Positioning Testing

HALLPIKE: Head Right

Horizontal Eye Position

Vertical L Eye Position

DEGREES
Caloric Testing

- Established and widely accepted method of vestibular testing
- Most sensitive test of unilateral vestibular weakness
- Patient positioned 30 degrees from prone (HSCC vertical allowing max stim)
- Cold and warm water/air flushed into EAC
Caloric Testing

- **COWS (cold opposite, warm same)** – direction of the nystagmus
- **Stimulation in 0.002-0.004 Hz range** (Head movements in 1-6 Hz range)
- **Visual fixation should reduce strength of caloric responses 50-70%**
- **% caloric paresis = 100 * [(LC + LW) − (RC + RW)] / (LC + LW + RC + RW)**
Caloric Testing

Bithermal Caloric

- Right Cool Peak SPU: 15 °/sec
- Right Warm Peak SPU: -14 °/sec
- Left Warm Peak SPU: 16 °/sec
- Left Cool Peak SPU: -16 °/sec
Caloric Testing

Caloric Weakness: 66% in the left ear
Caloric Testing

Caloric Weakness: ****
Rotational Chair Testing

- “Gold standard” in identifying bilateral vestibular lesions
- Used to monitor for progressive bilateral vestibular loss (gentamicin toxicity)
- Used to quantify bilateral vestibular loss – vestibular rehab vs. balance training
- Useful in testing children that will not allow caloric irrigations
- Used with borderline caloric tests when water calorics cannot be used
Rotational Chair Testing
Rotational Chair Testing

- Sinusoidal Harmonic Acceleration Test
  - Most commonly performed
  - Rotates patients at frequencies from 0.01-1.28 Hz
  - Unilateral lesions have gain and phase asymmetries to the affected side
  - Reduced gain across all frequencies or phase leads suggests bilateral vestibular lesions
Rotational Chair Testing

Kaplan et al.

- 198 adults tested
- 29 patients with bilateral loss by chair testing
- 25/29 with bilateral caloric weakness by ENG
- 3/29 with unilateral caloric weakness by ENG
- 3/45 patients with unilateral caloric weakness by ENG had abnormal chair tests
Posturography

- Used to test integration of balance systems
- Useful in quantification of fall risk
- Most useful in following conditions:
  - Chronic disequilibrium and normal exams
  - Suspected malingering
  - Suspected multifactorial disequilibrium
  - Poorly compensated vestibular injuries
Posturography
Posturography

- 5/6 – Vestibular dysfunction
- 2,3,5,6 – somatosensory and vestibular dysfunction
- 3,6 – visual preference
- 1,2,3,4 or any combination with normal 5/6 - apophisiologic
Vestibular Evoked Myogenic Potentials (VEMP’s)

- Utricle and saccule detect linear acceleration
- Saccule slightly responsive to sound due to its position near the oval window
- VEMP’s stimulate the saccule and record EMG output in the SCM
Vestibular Evoked Myogenic Potentials (VEMP’s)

- Clicks or tones presented to the ear stimulate saccule, inferior vestibular nerve, vestibular nucleus, medial vestibulospinal tract, accessory nucleus, cranial nerve XI
- EMG of SCM records output after click stimulation of ear
- Allows unilateral testing
Vestibular Evoked Myogenic Potentials (VEMP’s)

- VEMP’s may be absent in patients with vestibular neuritis
- Patients with lower threshold VEMP’s and a conductive hearing loss same side may have SCC dehiscence syndrome
- Absent in bilateral vestibular loss in aminoglycoside ototoxicity
- VEMP’s show higher thresholds and are absent in patients with Meniere’s disease
- Absent in acoustic neuromas
- May be used in failed vestibular nerve section
Dr. Peltier’s Dizzy Evaluation

- History – will give diagnosis in majority of disorders
- Physical
  - Head and Neck Exam
  - Spontaneous nystagmus on tracking
    - Vertical or direction changing nystagmus = MRI and neurology referral
  - Pneumatic Otoscopy
    - If positive consider diagnosis of fistula, Meninere’s, CT, syphilis
  - Dix Hallpike
    - If positive, Eply maneuver twice, if still dizzy, ENG
  - Head thrust test alone or with head shake nystagmus
    - If positive, start vestibular exercises
    - If no response - ENG
  - Rhomberg Test
    - If equal sway with eyes closed and open neurology referral, ENG
Dr. Peltier’s Dizzy Evaluation

• Fukuda stepping test if suspected vestibular dysfunction and normal head shake/head thrust tests, or proceed to ENG
• Orthostatic measurements if directed by history
• Dynamic visual acuity if possibility of bilateral loss

- Audiogram
  • Obtain in every dizzy patient. Cost effective exam for acoustic neuroma, useful in other diagnosis
Dr. Peltier’s Dizzy Evaluation

- **ENG**
  - Patients unresponsive to conservative treatment
  - Severe symptoms and not suspicious of acute vestibular infection
  - Diagnosis uncertain and chronic symptoms
  - Pre-op when vestibular ablation procedure considered
  - When documentation of vestibular function is necessary
  - When referred from neurology for evaluation

- **MRI**
  - Any suspicion of central lesions by physical, or objective testing

- **Posturography/Chair testing/VEMP**
  - Not available at UTMB
  - Of questionable clinical utility
References

- Kaplan, Marais et. al. (2001), Does High-Frequency Pseudo-random Rotational Chair Testing Increase the Diagnostic Yield of the ENG Caloric Test in Detecting Bilateral Vestibular Loss in the Dizzy Patient? *Laryngoscope, 111*: 959-963