ASAMS Panel
“Sort’n out Vertigo in Pilots

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I have the following Financial Relationships to disclose:

• Honoraria from: ACS-ATLS Program (Instructor)
• Employee of: FAA

I will not discuss off-label use and/or investigational use in my presentation.
Overview

A Review of Vertiginous conditions and their Civil Aeromedical significance regarding FAA standards

Ears 2U
Terminology
Diagnosis and Tests
Management
Discussion
The Ear
Vertigo

- Balance involves 3 overlapping systems
  - Vestibular
  - Proprioceptive
  - Visual

- Vestibular system primarily helps to prevent retinal image slippage (done through Smooth Pursuit, Optokinetic, and Vestibular Ocular reflexes)
  - Semi-circular canals and Otolithic organs
<table>
<thead>
<tr>
<th>Medical Term</th>
<th>Self-description</th>
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</thead>
<tbody>
<tr>
<td>Dizziness</td>
<td>Sensations of spacial disorientation</td>
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<tr>
<td>Vertigo</td>
<td>Sensation of movement or motion</td>
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<tr>
<td>Disequilibrium</td>
<td>Off balance, imbalance, or giddiness, walking on uneven surfaces</td>
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<tr>
<td>Oscillopsia</td>
<td>Difficulty walking, riding, or reading, unable to focus on objects with movement</td>
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<tr>
<td>Physiologic dizziness</td>
<td>Motion sickness, space sickness, height vertigo, mal de debarquement syncope, blacking out</td>
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<tr>
<td>Presyncope</td>
<td>Lightheadedness or impending faint, hyperventilation</td>
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<tr>
<td>Psychophysio logic dizziness</td>
<td>Panic attacks, hyperventilation, agoraphobia</td>
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<tr>
<td>Ocular dizziness</td>
<td>Trouble focusing</td>
</tr>
<tr>
<td>Multisensory dizziness</td>
<td>Dizziness or imbalance with unfamiliar surroundings</td>
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<tr>
<td>Central dizziness</td>
<td>Spinning in the head</td>
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Vertigo

What to look for in the Hx

- How long did it last? Did it come back?
- Nausea or vomiting? Incapacitation?
- Hearing loss? Tinnitus? Pressure or pain in ear?
- Visual symptoms? Headache? Photophobia?
- Falling? Loss of consciousness?
- Trauma?
- What brings it on?
- Comorbid conditions? Medications? Previous Surgery?
Vertigo

Additional Hx

- Co-morbid conditions? Diabetes, Migraine, MS, Hypertension, CV or Cerebro-vasc, etc.
- Family Hx (Hereditary conditions-Ushers, Familial Hearing loss, etc.?)
- Previous Ear surgery? Cholesteatoma, Stapes, Perilymph fistula, Tympanosclerosis, TM perf, etc.
Vertigo

Sorting out Vertigo by time periods...

If the Vertiginous attacks lasts:

**Seconds** (consider)
- Benign Paroxysmal Positional Vertigo (BPPV)
- Post-traumatic labyrinthine dysfunction
- Orthostatic hypotension

**Minutes** (consider)
- Vertebrobasilar insufficiency
- Migraine attacks – with or without headaches
Vertigo

If the Vertiginous attacks lasts:

**Hours** (consider)
- Meniere’s syndrome
- Migraine attacks

**Days-Weeks** (consider)
- Vestibular Neuronitis
- Acute toxic or traumatic labyrinthine injury
- Labyrinthine infection
Vestibular Testing

- Good CN Exam
- Gait analysis (ordinary & tandem gait)
- Romberg (Standard & Tandem)
- Oculomotor exam (Frenzel lenses)
- Step tests (Fukuda etc.)
- Dix Hallpike (latency)
- Head-Shake (Frenzel lenses-1Hz x 10sec)
- Head-Thrust (Fixates-Refixation saccade?)
- Oscillopsia Test (Read within 2 lines at rest)
- Fistula Test
Pneumatic Otoscopy

• Positive and negative pressure applied to middle ear

• Hennebert’s Sign/Sx – Nystagmus & vertigo with pressure, alternates with (+/-) pressure

• Seen in patients with Perilymph Fistula, Syphilis, Meniere's disease, Superior Canal dehiscence syndrome
Dizzy Evaluation

• **ENG**
  - When documentation of vestibular function is necessary
  - Diagnosis uncertain and chronic symptoms
  - Severe symptoms and not suspicious of acute vestibular infection
  - Patients unresponsive to conservative treatment

• **MRI**
  - Any suspicion of central lesions on exam or by objective testing

• **Posturography / Rotary Chair testing / VEMP**
  - Complex vertigo cases and rehab assessment
Vestibular Testing

- **ENG-Open/Closed; Air vs. Water (Tests lateral SCC only)**
- **Rotational Chair Testing**
- **Computerized Platform Posturography**
  - Motor control and Sensory Organization tests
- **Electrocochleography (ECOG)**
- **ABR**
- **VEMP’s (Vestibular Evoked Myogenic Potential)**
Electronystagmography (ENG)

- Has several components: Oculomotor tests,
- Positional / 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 Horizontal SCC 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 tracks a randomly moving target
- Latency – difference in time between movement of the 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

Horizontal Saccades

Horizontal Eye Position

R20
R10
0
L10
L20

500 MS
1.11

Peak Velocity

Mean = 502

NORM
100%
100%

ABNORM

Rightward

Leftward

SACCADE AMPLITUDE (DEG)

Accuracy

Mean = 94

130
110
90
70
50

Rightward

Leftward

SACCADE AMPLITUDE (DEG)

Latency

Mean = 144

400
300
200
100
0

Rightward

Leftward

SACCADE AMPLITUDE (DEG)
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 opposite direction

• Eye movements are recorded and compared in each direction

• Asymmetry suggestive of CNS lesion

• High rate of False Positive results
Smooth Pursuit & Optokinetic Tests

Horizontal Tracking

Horizontal Eye Position

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

Tracking Gain

Velocity Gain

Rightward

Target Frequency (Hz)

Accepted cycles: 36

Optokinetic

40°/sec Right/HorizEyePos

40°/sec Left/HorizEyePos
Smooth Pursuit Test

Horizontal Tracking

Horizontal Eye Position

DEGREES

R20
R10
0
L10
L20

500 MS 1:57

Tracking Gain

VELOCITY GAIN

1.25
1.00
0.75
0.50
0.25

Rightward

0.7 0.6 0.5 0.4 0.3 0.2 0.1

TARGET FREQUENCY (HZ)

Leftward
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 stimulation)

• Cold and Warm water or air flushed into EAC
Caloric Testing

• COWS (Cold Opposite, Warm Same) direction of the FAST phase of Nystagmus

• Stimulation in 0.002-0.004 Hz range (Head movements in 1-6 Hz range)

• Visual fixation should reduce strength of caloric responses by 50-70%
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

SLOW PHASE VELOCITY (DEG/SEC)

0 20 40 60 80 100 120
SECONDS
ECOG

Electrode
ECOG Electrocochleography

Normal
ECOG

Abnormal ECOG
Vestibular Evoked Myogenic Potentials (VEMP’s)

- Utricle and Saccule detect linear acceleration
- Saccule is 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
Posturography

• Used to tests integration of balance systems

• Useful in quantification of fall risk

• Most useful in following conditions:
  • Chronic Dysequilibrium 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 - Aphysiologic
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

• “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 and balance training

• Useful in testing children that will not allow caloric irrigations

• Used with borderline caloric tests when water calorics cannot be used
Vestibular Pathology

Peripheral

• BPPV
• Alternobaric vertigo
• Vestibular Neuritis
• Meniere’s Disease
• Superior Canal Dehiscence
• Infectious
• PLF’s
• Tumors/Cholesteatoma
• Inner Ear barotrauma
• Inner Ear Decompression sickness
Meniere’s Disease

Results from “Cochlea Hypertension”

Typical Meniere’s disease:
- Causes episodes of vertigo that last hours
- Causes fluctuating unilateral hearing loss in low frequencies; Worsens over time
- Causes Tinnitus
- Causes Aural Fullness or pain
- Episodic in nature and may be “Progressive” or “Non-progressive”
- Can be associated with Migraine

Increased fluid in the inner ear causes swelling.
Meniere’s Disease

- Idiopathic Endolympatic Hydrops (aka “Ear Glaucoma”)
  - Genetic, Autoimmune, Hereditary, Trauma, Infectious, Vascular
- Classic Sx’s: Vertigo, Fluctuating HL (Low Freq), Pressure/Pain, Tinnitus / Roaring (Most Hx’s are incomplete)
- Drop attacks (Tumarkin’s Crisis-No LOC) late finding
  - Acute Utriculossaccular dysfunction
- Treatment-LSD (1500mg), Diuretics, Surgery
Meniere’s Disease

- Variants may have more prominent **Auditory vs. Vestibular**
- Other diseases may mimic (Otologic syphilis, PLF, Migraine, tumors, etc.)
- Famous Meniere’s patients
  - Alan Shepard (Had shunt done at HEI) and flew
  - Van Gogh, Emily Dickinson, Peggy Lee, Martin Luther

- Path Code Data Pull:
  56 Class I, 29 Class II, 92 Class III  Total = 177
Endolymph Flow Pathway

- Endolympathic sac
- Endolympathic duct
- Cochlear aqueduct
Endolymphatic Hydrops

Dilation of Scala Media & Reissner’s Membrane
Vestibular Nerve Section
Benign Positional Vertigo (BPPV)

BPPV results when crystals in the vestibule dislodge into canals

Typically noted rolling over in bed

Causes vertigo that last seconds, can occur several times a day, depending on head position

Does NOT cause hearing loss

May resolve on its own, sooner with treatment
BPPV
Dix-Hallpike Maneuver

Positive test

• Up-beating nystagmus-Rotary component towards the affected ear

• Nystagmus to the stimulated side

• Lasts 15-45 seconds--Latency of 2-15 seconds

• Fatigues easily
Dix-Hallpike Maneuver

Use Frenzel Lenses
Benign Positional Vertigo (BPPV)

Treatment Options:

Do nothing

Canal Repositioning maneuvers
  Semont Liberatory or Epley Maneuver
  Other repositioning devices (chair/vibrator)

Severe cases - Surgery

FAA Path Code (BPPV & Labyrinthitis-60 Cases)
Semont (Liberatory) maneuver

For right ear
Epley Maneuver

1. Sitting upright
2. Lying down with head tilted 45 degrees to the side
3. Lying down with head tilted back
4. Lying down with head tilted 45 degrees to the side again
5. Sitting upright again

30-60 Seconds
30-60 Seconds
30 Seconds

Finished
Repeat x 2
Vestibular Neuronitis

(AKA Vestib Neuritis, Neurolabrynthitis, Viral Labyrinthitis, Epidemic Vertigo, Acute Vestibulopathy)

Viral or bacterial infections of the inner ear and or 8th nerve. May have antecedent URI. Hearing rarely affected.

Typical Viral Neuronitis

Causes episodes of vertigo that last for hours or days. The initial episode is usually the worst—Dramatic!

Fall to side of lesion
Usually does not have hearing loss
Often goes away on its own, but many require treatment for N/V
Normally does not recur
Perilymph Fistula

Due to “loss of inner ear hydraulics” around RW or OW

History of Barotrauma or straining (“Pop”) resulting in Vertigo

May have associated SNHL; Dx with Hx and Pneumotoscopy

May heal spontaneously with bed rest

Surgical exploration with patch to RW or OW may be required
Cholesteatoma

Acquired Cholesteatoma

Perforation of ear drum with destructive cholesteatoma
Cholesteatoma

**ACQUIRED CHOLESTEATOMA**

- Eardrum intact
- Cholesteatoma has eroded through bone of ear canal exposing the bones of hearing
Superior Canal Dehiscence Syndrome

- First described by Dr. Lloyd Minor in 1998
- Symptoms: Vertigo associated with Low Freq sounds
- Oscillopsia common with triggering activities
- May have fullness/autophony; CHL (inner ear)
- Cause: Dehiscence of the SSC in the MCF (L>R)
- Treatment: Observation or Surgery
Alternobaric Vertigo

• Transient

• Thought to be caused by increased and asymmetric middle ear pressure (only one ear clears)—URI’s

• A small number of pilots will admit to having experienced it

• Rare to see a pilot come in complaining of it
Central Causes of Vertigo

- Vascular malformations
- Ischemia / Stroke
- Trauma
Central Causes of Vertigo

• Tumors
  • Variety of CNS tumors-Acoustics, Mid-brain, Pons, etc.
• Multiple Sclerosis (MS)
• Vascular- Ischemia and A-V Malformations
• Arnold-Chiari malformation
  Type I: Complete or partial herniation of the cerebellum-tonsils below foramen magnum.

Type II: Herniation of vermis and pons down into to cervical canal. Small, dilated 4th ventricle.

Type III: High cervical or occipitocervical hernia containing cerebellum-tissue.

Type IV: Hypoplasia of the cerebellum sometimes associated with encephalocele.
Central Causes of Vertigo
Arnold-Chiari malformation
Questions?

Comments?
THANK YOU!