

**My Head is Spinning:  
A Look at Pediatric  
Vestibular Testing**

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Vestibular and Balance PROGRAM

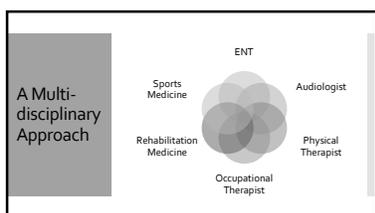
No financial disclosures

**WHY pediatrics?!**

- Early identification of vestibular impairment**
- Can lead to the formulation of an effective (re)habilitation plan
  - Can help identify a serious pathology that may be easily treatable or rule out a more significant diagnosis
  - Can help prevent delay in the achievement of developmental milestones and cognition
  - Can assist with the choice of side for cochlear implantation

- Pediatric Vestibular Programs**
- Children's Hospital of Philadelphia
  - Children's Healthcare of Atlanta
  - Boston Children's Hospital
  - Nemours Children's Health System
  - Vanderbilt University Medical Center
  - Michigan Medicine
  - University of Miami Health System
  - Cincinnati Children's Hospital

- Beginnings**
- Vestibular and Balance Program started early Spring 2017
  - Modeled program after CHOP
  - Close working relationship with Dr. Violette Lavender



**Prevalence of Vestibular Symptoms/Disorders**

**Prevalence**

Children with hearing loss are 2 times more likely to have dizziness or balance problems than children with normal hearing

**Prevalence**

- General pediatric population:
  - Ranges between 0.7% and 1.5%
- Cochlear implant population:
  - 80% showed reduced or complete loss of function
- Hearing loss population:
  - 30-50% of children with hearing loss have unilateral or bilateral vestibular loss
- Otitis Media population:
  - 50% with otitis media may have vestibular disturbance

**Migraine Population**

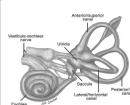
- 10% of children meet International Headache Society (IHS) criteria for migraine headache
- Vestibular symptoms occur in 25% of migraine children
- 30% to 50% of patients with vertigo have migraines
- Migraines are reported in children as young as 3 to 4 years of age

**Concussion Population**

- 30% report symptoms of varying balance impairments as long term sequelae
- Cincinnati Children's Hospital reports that post-concussion dizziness is the 2nd most common reason for referral to their pediatric vestibular clinic
- 80% of patients recover in the 1<sup>st</sup> 3 weeks following concussion
- If they continue to report symptoms > 3wks post concussion, it is called Post Concussion Syndrome

**Vestibular Overview and Risk Factors**

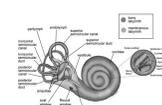
**The Vestibular System →**  
Central Nervous System + Inner Ear + Eyes



- These work together for "Balance"
- Dysfunction in any of these can result in "Dizziness"
- Poor balance, poor coordination, delayed motor skills

**The Vestibular System →**

**Our Purpose:** To help determine if the inner ear might be involved with patient's dizziness



**The job of the vestibular system**

The vestibular system is responsible for maintaining postural control and stability of images on the fovea of the retina during the sensation of motion.

This information is used by the central vestibular pathways to control reflexes that are mediated by the vestibular system.

Disorders of vestibular function result in abnormalities in these reflexes that cause sensations that reflect abnormal information about motion.

**Vertigo**

- "Vertigo" is true rotation of self or surroundings
- This can be inner ear
- And most appropriate referral for vestibular testing
- Non-vertigo is lightheadedness, unsteadiness, presyncope, and imbalance
- This can be cardiovascular, neurologic, or systemic disease

**Vestibular Signs & Symptoms**

- Falling out of chairs
- Delayed motor skills
- Nausea or vomiting
- Migraine
- Imbalance
- Motion sickness
- Reading difficulties
- Vision disturbance: acuity (stationary or with head movement), blurry, double
- Poor spatial relationships: skip words or letter while reading or disorganized writing
- Hearing loss, tinnitus, aural fullness

### Delayed Motor Skills

- Jumping jacks: 6-8 years of age
- Ski jacks: 8-10 years of age
- Touching toes and return to stand position: 3-5 years of age
- Single leg balance stance with eyes open/closed for 20 seconds: 5-8 years of age
- Eye hand coordination task- nose to fingers: 5-9 years of age

### Common Risk Factors

- Cochlear implants
  - Pre and post
- Cochlear malformation
  - EVA
  - Partitioning defects
  - Common cavity
  - Mondini malformation
- VIII nerve defects
  - Wispynerve
  - Absent nerve
  - ANSD
- Ototoxicity
  - Vestibulotoxicity
- Syndromes
  - Usher
  - Waardenburg
  - Pendred
  - Head Trauma
  - Sports
  - Concussion

### Syndromes with Vestibular Expressivity

- Branchiootrenal (BOR)
- Pendred
- Cogan's
- Neurofibromatosis type II
- CHARGE
- Marshall
- Spino cerebellar ataxia
- Waardenburg
- Von-Hippel Lindau
- Usher
- 10% of children with severe congenital hearing loss have Usher Syndrome which is also characterized by vestibular hypofunction and retinitis pigmentosa

### Diagnoses Associated with Vestibular Dysfunction in School Aged Children

- Migraine
- Concussion/cranial trauma
- Chronic Otitis Media
- Sensorineural Hearing Loss or Cochlear Implants
- Ototoxicity/vestibulotoxicity
- Vestibular neuritis/labyrinthitis
- Benign Paroxysmal Positional Vertigo (BPPV)
- Unilateral or bilateral vestibular hypofunction
- Superior Canal Dehiscence or Perilymphatic Fistula
- Brain tumor
- Post operative or epilepsy related vertigo
- Enlarged Vestibular Aqueduct
- Panic/Anxiety Disorders
- Functional Disorders

### Identifying Potential Patients

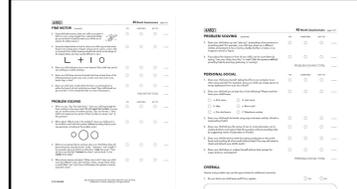
### How to find at risk patients

- Ask about patient's gross motor milestones
- Ask family to fill out the Ages and Stages
- Ask family to fill out the pDRS- pediatric Disability Handicap Inventory

### Ages and Stages



- 3 month to 60 month
- Categories:
  - Communication
  - Gross Motor
  - Fine Motor
  - Problem Solving
  - Personal Social





**Dynamic Visual Acuity**

• "The clinical test of horizontal dynamic acuity is a reliable test for children as young as 3 years. It is simple and inexpensive, and will enable identification of those for whom more extensive testing is warranted."

Robert G. Lang, "A Decade of dynamic visual acuity for children" International Journal of Pediatric Otorhinolaryngology 66(10):1593-1596, 2002

**Other Bedside Screeners**

- Romberg's Test: <https://www.youtube.com/watch?v=1y1gk18mm0Q>
- Sharpened Romberg: <https://www.youtube.com/watch?v=FM7y50c6M4>
- Fukuda Step: <https://www.youtube.com/watch?v=c8b7T5VWx4c>
- Past Pointing Test: <https://www.youtube.com/watch?v=4cc-WuUkFk>

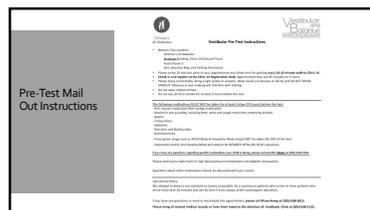
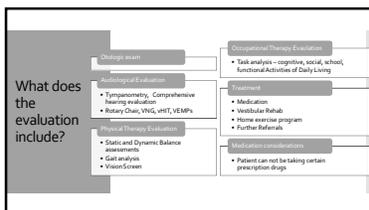
**The Referral Process**

- When to refer for further dx testing**
1. Dizziness or vertigo as the main symptom
  2. If the bedside test results are positive
  3. Suspected vestibular migraine
  4. If not cookie cutter BPPV (maneuvering without knowing for sure could make the problem worse)
  5. Concussion kids who are not experiencing relief from symptoms or are not making progress in therapy
  6. Kids who haven't met developmental motor milestones and are not progressing with therapy and there are no other significant developmental delays
  7. Kids where you want to be able to monitor progress with therapy (pre and post testing)
  8. Kids on ototoxic medications that report dizziness or vertigo

- More reasons to refer**
- When more information is needed to confirm or rule out a diagnosis
  - Document unilateral/bilateral dysfunction, the involved ear, and compensation status
  - Confirm BPPV
  - Detect central issues that are missed during physical exam
  - Decide if additional testing or therapy is needed
  - Provides quantitative information
  - To monitor progress with treatments or therapies
  - To obtain pre and post operative information

**What is needed for our testing?**

- Ages: 3-11
- While some modifications allow for testing to be completed on younger children, generally speaking vestibular testing requires:
  - Patient/willing participants
  - Able to follow multi-step commands/directions
  - Tolerate goggles for extended period of time
- Significant developmental delays often result in the inability to complete or accurately interpret testing



**Medications**

Patient can not be taking any of the following meds for at least 72 hours:

- Anti-nausea medication/Anti-vertigo medication
- Alcohol, including cough medicines containing alcohol
- Aspirin
- Tricyclics & Sedatives
- Narcotics and Barbiturates
- Anticholinergics

Prescription drugs such as ADHD Meds & Headache Meds should NOT be taken the DAY of the test.  
Depression and/or Anti-Anxiety Meds will need to be WEANED off by the child's physician.

(Certain medications may affect the results due to the chemical calibration of the tests.  
Certain medications may indicate false positives or mask a true vestibular issue.

## Vestibular Assessment and Treatment

**When? Where?**

- Vestibular Lab location - at COA Clinic 14, Test Room 3
- Appointments are Tuesdays mornings
- Audiology testing takes up to + 3 hours

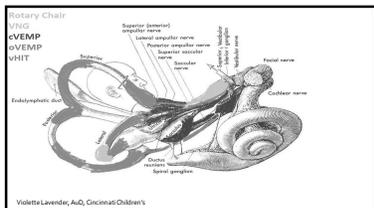
**CoA Vestibular Lab**

Clinic 14 of the McWane building




**Clinical Tests of Vestibular Function**

- Vestibular Evoked Myogenic Potentials (VEMP)
- Video Head Impulse Test (vHIT)
- Rotational Chair
- Videonystagmography (VNG)
- Caloric irrigations



### Selecting Test Battery

- Test protocol tailored to pt's age
  - VEMP can be done on infants
  - Rotary chair can be done on infants but won't be quantitative
  - 1 year or older can attempt everything except OPE and saccadic OPE and saccolineary years or older
  - 4 years or under should start with physical therapy unless otherwise specified by the professional

### Case History

- Describe dizziness without saying the word dizzy
- How long do episodes last?
- How often do they occur? When did it first start?
- Is there anything you can do to provoke or stop the dizziness?
- Other symptoms that occur along with dizziness
  - Headaches, nausea, vomiting, and fatigue, etc.
- Concussion
- Recent ear infections
- Medications

### Audiological Evaluation the day of

- Otologic exam
  - Cerumen
- Tympanograms
  - Can affect caloric and VEMPs

### Importance of the hearing test

Since congenital hearing loss is highly associated with vestibular dysfunction this assessment is important no matter the age.

As many of the following tests should be completed as possible because the hearing status can assist in differentiating between diagnosis:

- Behavioral hearing testing in the soundbooth
- Auditory Brainstem Response (ABR) if behavioral hearing testing cannot be obtained
- Tympanometry
- Otoacoustic Emissions



### VEMP

- Short latency electromyographic (EMG) potentials measured in response to high level acoustic stimuli
- Cervical VEMP (cVEMP)
  - Uses the sternocleidomastoid muscle (SCM)
  - Assesses the saccule and inferior portion of the vestibular nerve
- Ocular VEMP (oVEMP)
  - Uses the extraocular muscles
  - Assesses the utricle and superior portion of the vestibular nerve



### Cervical VEMP

Ipsilateral response  
Inhibitory response

Pathway:  
Outer/Middle Ear → Sacculle  
→ Inferior Vestibular Nerve  
→ Vestibular Nucleus → Vestibulospinal Tract → CN IX (Accessory) → Ipsilateral sternocleidomastoid muscle

**Cervical VEMP**

- Normative Data
  - P1 Latency: 12-18 ms
  - No Latency: 20-26 ms
  - Threshold for pure TB: 90dB HL
  - EMG scaling
- Abnormal Finding
  - Asymmetry ratio of greater than 30% is considered abnormal
  - If threshold for pure TB is less than 90dB, then suspect possible superior canal dehiscence
- Possible Pathology
  - Likely absent if ME pathology (fluid) is present
  - Should be normal in children with SNHL
  - May be tucked down to less than 8ydB in cases of SCC dehiscence or other third window issues



**Ocular VEMP**

- Contralateral response
- Excitatory response
- Pathway
  - Outer/middle ear → Utricule → Superior vestibular nerve → Vestibular nucleus → medial longitudinal fasciculus → CN III (Oculomotor) → inferior oblique muscle of the eye

**Ocular VEMP**

- Normative Data:
  - No Latency: 9-10 ms
  - P1 Latency: 12-19 ms
- Abnormal findings:
  - Asymmetry ratio of greater than 30% is considered abnormal



**Video Head Impulse Test**

- This test is not recommended for patients < 5y/o
- Vision and overall development must be good to administer
- Testing via iVOR
- Tested at a frequency of 3-5Hz
- Can administer at bedside - watch for overt corrective saccades

**vHIT:**

Target (stickers, iPhone) should be centered on a wall at a place that is eye level for patients.

Sit patient AT LEAST 3 meters (3.28 ft) from the target. (recommended to be no further than 3.5 meters (3 ft))

**Recording**

- Make sure the pupil is seen when patient moves eye up, down, right, and left.
- If you do not have patient's pupil centered within recording window, "goggle slippage" will likely occur
- Kids have larger pupils than adults. If your recordings are "dark" and/or pupils do not remain within recording window, by adding more light in the room to force pupils to decrease in size.

**VHIT**

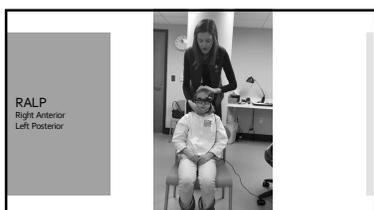
- Ask patient to relax. Instruct patient to keep their eyes on the target.
- Inform patient that audiologist will move their head, rapid and unpredictable movements, to the left, right, front and back.
- Aiming to move the head only  $\pm 15$  degrees to right and left (aim just outside of target).
- "good" Peak head velocity will be accepted at  $150^\circ$  degrees/second for horizontal and  $120^\circ$  degrees/second for vertical for pediatrics
- Stop task as soon as  $7-15$  "good" impulses are obtained to the right and left.
- If you can only get  $5-6$  "good" impulses with a child and there is a repeatable pattern, move on.



**VHIT**

**RALP**

**LARP**



**Interpretation**

- Instantaneous Gain values** - What is the relationship between head and eye movement at each msec.
- The dot scatter plot shows each 50 msec measurement from each impulse. They should all hover around a gain.
- Velocity Regression Gain** - 8% is significant asymmetry

**Interpretation**

- Normal: no compensatory (overt or overt) saccades and normal, symmetrical gain
- Eye velocities mirror head velocities (equal and opposite)
- If VHIT is administered several weeks post-acute issue (neuropathy, etc.), it is likely that abnormality has already resolved on its own.



**Rotational Chair Testing**

- Assesses the VOR by measuring eye movements during passive, whole-body rotation
- Assesses peripheral, central, and bilateral function as well as compensation
- Sinusoidal Harmonic Acceleration** - Assess gain, symmetry, and phase of VOR. Response patterns may be correlated with peripheral, central, or bilateral function.
- Step Velocity Test** - Time constant and symmetry in clockwise and counterclockwise direction. Latency measures determine central vs. peripheral pathology.

Set Up



Determine which Goggles fit the patient best.

- Use "adult" binocular goggles if possible.
- If binocular goggles do not fit, use "pediatric" monocular goggles.
- If neither fit or patient will not tolerate them (due to age, etc.) then use stick camera.
- Looking to see if nystagmus is present or not.

Goggles



Goggles



Set Up



- Set the chair to the patient's size.
- The patient should be seated with the head above the back of the seat, high enough to allow the head guide to sit just below the widest part of the skull. This keeps the head tilted slightly forward.
- Use a booster seat to elevate patient to the correct height.
- If a patient is very young use the sport harness/carsuit.

Set Up



Secure the seatbelts

- Buckle the lap belt
- There are two straps that cross over the patient's chest and attach to the chair
- Strap the patient's feet to keep them from using their feet against the wall to stop or start themselves

Set Up



- Use the headstraps to keep the head secure
- \*\*\* Inform the patient that the straps are to keep them in just the right place and not because they will be moving very fast, etc.

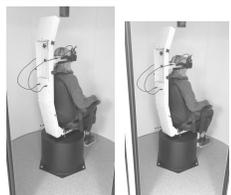
SHA: Sinusoidal Harmonic Acceleration

- Task with vision denied
  - VOR 20 Hz
  - VOR 10 Hz
  - VOR 4 Hz
- Obtain as needed
  - Test clockwise Hz. If an abnormal result is found
  - Then do counterclockwise. Responses are abnormal, then you have an abnormal result.

SHA testing involves sinusoidally accelerating the rotary chair to a standard peak velocity of 90-100 degrees across several frequencies of rotation from 0.05 to 0.6 Hz or higher. The SHA generates three primary measures of vestibular function: gain, phase, and symmetry. (MPBD pg 64-65)

MPBD - Manual of Pediatric Balance Disorders, O'Reilly, et al.

SHA



SHA

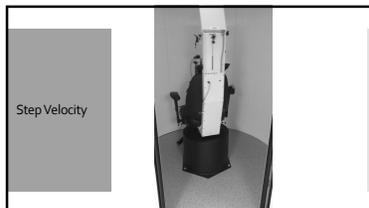


### Step Velocity

- Step Velocity (CW) – right (clockwise), 45 sec moving, 45 sec still
- Step Velocity (CCW) – left (counter clockwise), 45 sec moving, 45 sec still
- Task with vision denied

The Step Velocity Test slow-phase eye velocity resulting from symmetric presentations of rapid acceleration of the chair to a constant rotational velocity, and subsequent deceleration of the chair to rest, is used to assess the state of the vestibular organ and the central processing of vestibular information. (MPBD pg 97)

MPBD - Manual of Pediatric Balance Disorders, O'Reilly, et al.



### SHA Interpretation

- Gain
  - low if peripheral or post-tasting
  - high if central
- Phase Lead -> peripheral issue
- There is no such thing as a phase lag. If you get one, re-calibrate and try again.
- Abnormal low frequencies typically mean a peripheral issue.
- You must take well to prevent false entry. Typically, the low frequencies become abnormal because of high frequencies. If you get the opposite, reset with more challenging tasks.

### SV Interpretation

- Slow Decay – if nystagmus suppression is slow, the finding is central
- Fast Decay – peripheral
- Gain: how much nystagmus is present
  - Low Gain – peripheral
  - High Gain – central

### Videonystagmography (VNG) and Caloric

Evaluates the VOR by measuring eye movements. Assesses peripheral and central function.

- Spontaneous and gaze nystagmus
- Optokinetic nystagmus
- Saccades
- Smooth Pursuit
- Head Shake
- Positional Testing
- Dix-Hallpike
- Caloric Irrigations

### Oculomotor Testing

- Oculomotors can be completed with child in the rotary chair with child sitting on the table tracking stimulus on TV screen
- Complete in the rotary chair if possible
- Oculomotor norms are not accurate until 7+ years of age

### VNG

- Calibration
- Gaze – Left, right
- Saccades
- Smooth Pursuit – Slower, Faster
- OPKs – Right, Left
- Spontaneous Nystagmus
- Have to instruct clearly and sometimes have to repeat

### OPK Testing

- OPK black and white hair appear on wall.
- Instructions
- Low Gain: could indicate vestibular hypofunction
- High Gain (above 1.0) associated with central vestib function such as migraine or cerebellar lesion

### Positionals

- Static Positionals
  - Head Right
  - Head Center
  - Head Left
  - Body Right
  - Body Left
- Dynamic Positionals
  - Dix Hallpike

Calorics



Calorics

**Purpose:** to determine if one inner ear balance system is weaker than the other inner ear balance system or if there is a bilateral weakness

**Symmetry and directional preponderance** used to assess differences between ears

**Evaluates:**  
Horizontal Semicircular Canals  
Low frequency region of the semicircular canal response (0-100 Hz)

Calorics

- Most likely only for age 7 years+
- Water vs. Air
- This test is dependent on if the goggles fit for recording and if patient can understand instructions to keep eyes open, etc.
- ALWAYS complete otoscopy prior to administering Caloric test Battery to rule out the following:
  - Oculovestibular
  - Presence of foreign object in ear canal
- ALWAYS complete Tympanometry prior to administering the Caloric test battery to rule out the following:
  - "Tight"
  - Tubes
  - Middle-Ear Pathology such as presence of fluid
- Do NOT use the word dizzy or "you might feel sick" when instructing patients to help keep them calm during testing.

Tasking

- Tasking is a large part of the test battery
  - SMI
  - Step velocity
  - Calorics
  - Positioning
- It can be one of the biggest challenges
- Need to ask questions patient can answer, do not want to over OR under task



Reinforcement

- Stickers
- Books
- Bubbles
- Toys
- Anything that will keep the child motivated to keep participating!!

Treatment Options

Treatment

- Vestibular Rehabilitation Therapy
  - Head, body, and eye exercises to retrain the brain to recognize and process signals from the vestibular system and coordinate them with information from vision and proprioception
- Surgical intervention
  - To repair or stabilize inner ear function or stop the production of sensory information or prevent its transmission from the inner ear to the brain
- Medication
  - Vestibular suppressants, steroids, antivirals, antibiotics
- Canalith Repositioning
- Dietary Considerations
  - I.e. Migraines, Meniere's Disease

### Vestibular Rehabilitation Therapy

- **Adaptation**
  - Long term changes in the neuronal response to stimulus
  - Includes motor learning
  - Improve postural stability, motor development, alignment
- **Substitution**
  - Alternative strategies to replace lost or compromised function
  - Centralize programming
  - Train the sensory re-weighting and integration
- **Habituation**
  - Reprogramming of postural responses to decrease sensitivity to movement or visual stimuli

### Returning to School

- Gym
- Extracurricular activities
- Reading
- Behavior
- Frequent Falls

### Returning to School

Academic Accommodations	Academic Modifications
<ul style="list-style-type: none"> <li>• Long Term needs (3 weeks)</li> <li>• Can include:                             <ul style="list-style-type: none"> <li>- Standardized testing arrangements</li> <li>- Extra time on work</li> <li>- Changes in class schedule</li> </ul> </li> <li>• May include a 504 Plan or Formal IEP Plan</li> </ul>	<ul style="list-style-type: none"> <li>• More prolonged and more permanent change to educational plan</li> <li>• Modifications depend on severity and type of symptoms as well as teaching style in the classroom</li> <li>• Special education with specific items in Formal IEP/504 plan</li> </ul>

### Case Study #1

### History

- 13 year old male
- Premature birth
- Developmental delay
- Hydrocephalus with VP shunt (last revision October 2016 per mom)
- Asthma
- Panhypopituitarism
- Headaches
- Pt is in 6th grade and has an IEP
- Patient was recently seen by neurology to evaluate the status of his shunt given recent complaint of dizziness and headaches, and per mother everything looked good.

### History

- "Random" bouts of dizziness
- Per pt report the dizziness occurs most often when he bends down.
- Episodes last for less than a minute and don't occur every day or even every week
- Pt's mother reported that in May, June and August he reported the dizziness a few times sporadically, but no episodes occurred in July
- Pt described his dizziness as feeling unsteady but denied any falls
- Does not report objects or the room to be spinning around him
- Mother also reported a recent increase in headaches.

### Evaluation

- Normal hearing and middle ear function, bilaterally.
- **Rotational Chair Testing**
- **Spontaneous Nystagmus:** No nystagmus with vision or vision denied/normal beats.
- **Gaze Test:** No nystagmus present.
- **Sinusoidal Harmonic Acceleration (SMA):** Revealed gain, symmetry, and phase within normal limits to 0.5, 1.6 Hz, and 6.4 Hz.
- **Velocity Step Test:** Normal time constant and symmetry in clockwise and counter-clockwise directions.

### Evaluation

- **Vestibular Evoked Myogenic Potentials**
  - Present and symmetrical, bilaterally, for both ocular and cervical VEMPs.
- **Video Head Impulse Test**
  - Normal VOR responses in the plane of the lateral, anterior and posterior semicircular canals.

### Evaluation

- **Videonystagmography (VNG)**
  - **Saccade Test:** normal velocity, acceleration, and latencies.
  - **Smooth pursuit tracking:** normal gain and symmetrical responses
  - **Optokinetic Test:** normal gain in clockwise and counter-clockwise directions
  - **Static Positional:** no positional nystagmus observed
  - **Dynamic Positioning:** no nystagmus observed
- **Caloric Testing:** Monothermal warm caloric irrigation screening revealed a hyperactive response in the right ear. (200 ml, pt vomited following second ear irrigation that further testing to confirm hyperactive response could not be completed.)

**Clinical Summary**

- Peripheral dysfunction is not suspected.
- Hyper active caloric response is likely a central finding, however, response could not be repeated.

**Recommendations**

- Follow up with neurology regarding today's results and headaches as previously recommended.
- Proceed with evaluation by vestibular physical therapist as scheduled.

**Case Study #2**

**History**

- 12 y.o. girl
- Dizziness began after an accident to the head with concussion
- Nausea with dizziness for first 2 weeks
- Persistent dizziness with reportedly increased severity
- Worsen Dizziness:
  - Loud sounds - large startle reaction
  - Carbairation: concern, vomit/nausea
  - Indign in the car
  - Bright Light

**History**

- Specialties:
  - Ophthalmology - no medical vision difficulties
  - ENT - with normal hearing test
  - Neurology - MRI unremarkable
- No difficulty with:
  - Pressure differences (swallowing, lifting, eye movements)
  - Tension, acid reflux, or anxiety
- Only mild headache, not correlated to other symptoms
- Birth History:
  - Triple t
  - 24 week premature with 3 month NICU stay
  - History positive for jaundice

**Evaluation**

- Normal hearing and middle ear function, bilaterally.
- Rotational Chair Testing:**
  - Spontaneous Nystagmus: No nystagmus with vision or vision denied. Normal results.
  - Gain Test: No nystagmus present.
  - Sine Wave Harmonic Acceleration (SHA): Revealed gain, symmetry, and phase within normal limits to 0.5, 0.6 Hz, and 0.4 Hz.
  - Velocity Step Test: normal (no constant and symmetry in clockwise and counter-clockwise directions).

**Evaluation**

- Videonystagmography (VNG):**
  - Saccade Test: normal velocity, accuracy, and latencies
  - Smooth pursuit tracking: normal gain and symmetrical responses
  - Optokinetic Test: essentially normal gain in clockwise and counter-clockwise directions
  - Static Positional: no positional nystagmus observed
  - Dynamic Positioning: no nystagmus observed
  - Caloric Testing: Bithermal caloric irrigations revealed a unilateral weakness in the right ear at 48Hz. This value exceeds the safe normal limit. Directional preponderance value was within normal limits.

**Evaluation**

- cVEMP (Cervical Vestibular Evoked Myogenic Potential):**
  - Present responses were noted bilaterally. Responses were symmetrical.
  - An abnormally low threshold was noted in the right ear at 72 dB nHL.

**Clinical Summary**

- Abnormally low VEMP thresholds on the right side and a right unilateral weakness found on caloric testing is consistent with peripheral vestibulopathy.
- Today's results are most consistent with peripheral lesion in the right ear.
- Test results in combination with patient history are consistent with a "top-down" disorder, which may include Superior Semicircular Canal Dehiscence.

**Recommendations**

- Follow up with a pediatric Ear, Nose, and Throat physician given today's results. Consider temporal bone CT scan to investigate anatomy of the vestibular system.
- Continue with physical therapy as recommended. PT will benefit from physical compensation strategies for her condition.

**Case Study #3**

**History**

- 16 year old male
- He of 2 concussions (at age 11 and age 14)
- PT reports headaches, vision loss, and tinnitus
- Reports difficulty hearing and feeling of ears being "full" or "stopped up"
- Recent normal hearing test at referring physician's office

**History**

- Since concussion 1 year ago, pt has been dizzy almost every day
- Dizziness is usually followed or accompanied by headaches and tinnitus
- Reports the "room spin" and lightheadedness
- Dizziness can be provoked by turning his head to either side, cannot do anything to alleviate the symptoms
- PT has been unable to drive regularly, his physical activity has been limited and is less frequently playing video games
- No longer playing sports since his last concussion; pt was a football player
- PT was seen 2 weeks ago in concussion clinic at CoA
- Further recommendations pending audiological vestibular results

**Evaluation**

- Normal tympanograms, bilaterally.
- Rotational Chair Testing**
  - Sinusoidal Harmonic Acceleration (SHA):** Revealed gain, symmetry, and phase within normal limits to sup, lat, and right.
  - Velocity Step Test:** normal time constant and symmetry in clockwise and counter-clockwise directions.

**Evaluation**

- Videonystagmography (VNG)**
  - Saccade Test:** normal velocity, accuracy, and latencies
  - Smooth pursuit testing:** normal gain and symmetrical responses
  - Optokinetic Test:** normal gain in clockwise and counter-clockwise directions
  - Static Positional:** right beating nystagmus in the majority of positions
  - Right beating nystagmus post-headshake**
  - Dynamic Positioning:** right beating nystagmus in both conditions, however, nystagmus not consistent with a pattern of BPPV
  - Caloric Testing:** Monothermal warm caloric irrigation screening revealed normal results.

**Evaluation**

- Vestibular Evoked Myogenic Potentials**
  - Present and symmetrical bilaterally for both ocular and cervical VEMPs.

**Clinical Summary**

- Results are consistent with a non-localizing bias of the vestibular system.

**Recommendations**

- Vestibular Rehabilitation evaluation
- MRI, as per concussion clinic recommendations

# Case Study #4

**History**

- 31 month old male
- Congenital CMV
- Bilateral profound SNHL & bilateral cochlear implantation
- Born at 36 weeks; NICU stay for 40 days due to concerns with breathing and CMV

**History**

- Parental concern of balance
- Pt started walking at 18 months, has been receiving PT services through EI
- Reports pt seems to fall often and "back into things"
- Pt demonstrates a wide base when standing and walking
- Seems to stand on the inside of his feet
- Misc:
  - Hx of allergic rhinitis
  - Hx of BMS tympanostomy tubes today

**Evaluation**

- Tests able to be completed:
  - Head Thrust
  - cVEMP
  - Rotary Chair

**Evaluation**

- Tests not able to be completed:
  - vHIT
  - VNG
  - Caloric
  - cVEMP

**Evaluation**

- Head thrust screening: abnormal, catch up saccades present, bilaterally
- cVEMP: no VEMP present bilaterally
- Rotary Chair:
  - VOR 0.6 Hz: abnormal, no nystagmus
  - VOR 0.08 Hz: abnormal, no nystagmus

**Clinical Summary**

Bilateral weakness of vestibular function

**Recommendations**

Recommend patient receive VOR therapy and balance therapy services

# Case Study #5

**History**

- 34 year old male
- ATV accident with "right petrous temporal bone fracture with extension in the semicircular canals" and TBI
- Hospitalized for 4 days
- Severe dizziness for 3-2 days following the injury
- Cochlear damage with fracture, right sided profound SNHL
- Pt followed by rehab medicine, physical therapy, ENT and audiology for HL
- Referred by PT to determine POC

**History**

- Difficulty walking in a straight line and on uneven surfaces but pt seems unaware per mom
- Pt is "off balance" and "leans backwards and to the right"
- Dizzy episodes with eversion, around bright lights and lights flashing per pt
- Headaches accompany dizzy episodes, last 15-30 min 1-2x/day
- Was seen by audiology about 3 months after the accident

**Rotary Chair Results**

**Sinusoidal Harmonic Acceleration (SHA):**

- Low gain
- Clockwise asymmetry
- Phase leads

**Rotational Chair Summary**

**Step Velocity**

Normal time constant and symmetry in clockwise and counterclockwise directions

**VNG Results**

- Gaze: left beating nystagmus
- Saccade Test: normal velocity, accuracies, and latencies
- Smooth pursuit tracking: normal gain and symmetrical responses
- Optokinetic Test: normal gain in clockwise and counterclockwise directions
- Static Positional: left beating nystagmus in the majority of positions
- Left beating nystagmus post-headshake
- Dynamic Posturing: left beating nystagmus in both conditions; however, nystagmus not consistent with a pattern of EPPV
- Caloric Testing: Bithermal caloric irrigations revealed a unilateral weakness in the right ear.

**cVEMP**

**oVEMP**

**vHIT**

Covert and overt saccades present

**Clinical Summary & Recommendations**

- Right sided vestibular hypofunction
- Follow-up with physical therapy to aid in POC

**Now what?**

**Referrals**

Deficits may include:  
Dizziness  
Balance  
Visual-motor  
Ocular-motor

**How to make a referral**

- Email [balance@childcentral.org](mailto:balance@childcentral.org)
- This is forwarded to AUDIOLOGY, PT, OT and REHABILITATION MEDICINE
- Information will be reviewed at monthly team staff meeting and test order will be determined based on age, symptoms, etc.

**Any questions?**

**Contact Info**

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