Pediatric Vestibular Assessment and Treatment in Children
OSLHA, 2010

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Objectives

- Identify modifications to the vestibular evaluation battery for testing children
- Identify the latest trends in research for conducting this battery
- Describe useful treatment strategies

CCHMC Pediatric Balance Center

- Opened in August 2008
- Team approach:
  - Otolarnygology
  - Audiology
  - PT/OT
- Evaluation Process:
  - Audiological Evaluation
  - Vestibular Evaluation
  - Vestibular (Re)habilitation Evaluation (PT)

CCHMC Pediatric Balance Center

- Who do we see?
  - Children ages 3 and up for Vestibular testing battery
  - Very young children start with our PT
- Who is not a candidate?
  - Children who only have a delay in developmental milestones

Rationale for Testing Children

- To help determine site of lesion
- To determine course of treatment
- To rule out more significant diagnosis
- To help with choice of sides for CI's
- To alleviate fears for families

Common Complaints

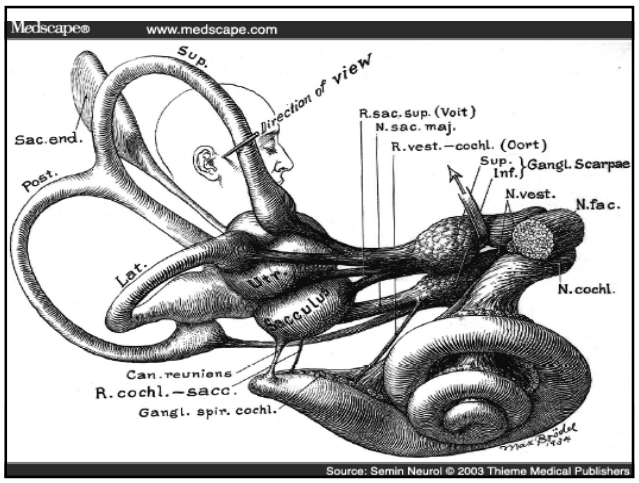
- Delayed motor milestones in conjunction with:
- Ear issues: history of OME, SNHL, tinnitus
- "Clutching" or "Clinging" during spell
- Headaches before, during or after spells
- Sudden falls or days of spontaneous clumsiness
- Fear/anxiety towards provoked dizziness
- Fear of riding in car
- Vomiting/Nausea
- Off balance/Unsteady
- "Floating" feeling
- Leaning or falling (sometimes to one side)
- Disorientation while swimming
- Fear of driving

Prevalence of Dizziness in Children

- A study in 2006 performed a population based report stating 8 % of school children experienced vertigo/dizziness. [1]
- Multiple studies have concluded that otitis media is the most common cause of vestibular disturbances in children. [2-5]
- Caloric abnormalities have been shown in up to half of hearing impaired patients. [6]
- Newer study showed children with profound hearing loss showed a gross motor delay. Syndromic hearing loss was shown to have vestibular dysfunction of the LSCC vs. normal LSCC function shown in the Connexin 26 population. [7]
- One study (2007)suggested that half of their population of adults and children with EVA have symptoms of vertigo. [18]

Maturation of the Vestibular System

- First sensory system to develop. Typically developed by 6 months post conception.
- Myelination of vestibular nerve proceeds rapidly up to 2 years of age.
- Vestibular system use refines into the teenage years



Anatomy Review-Descending Pathway

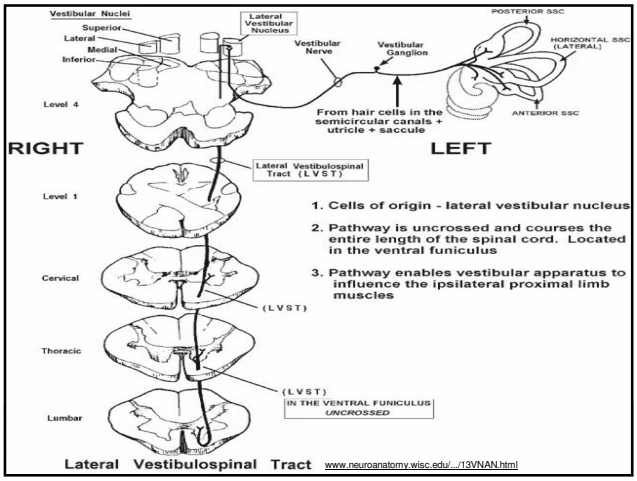
- 3 Reflexes
  - Vestibular-Ocular Reflex (VOR)-maintains image stability during rapid head movements.
  - Vestibulospinal Reflex (VSR)-maintain posture and center of gravity in upper and lower limbs.
  - Vestibulocolic Reflex (VCR)-maintains the head in horizontal gaze position independent of trunk movement. Called the "righting reflex" of the neck.

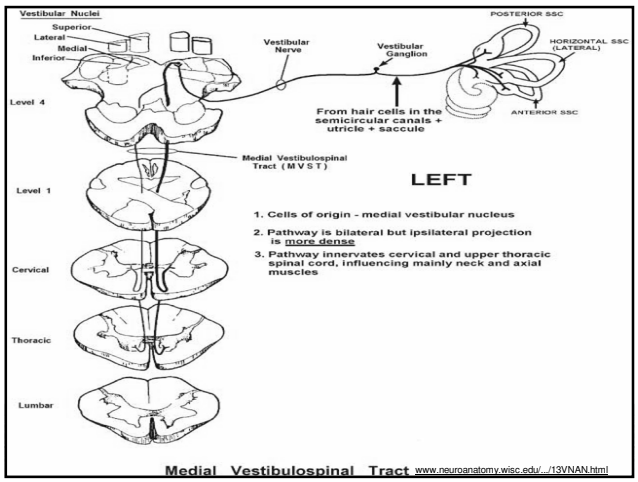
Cincinnati Children's change the outcome

Anatomy Review-Descending Pathway

- Central Vestibular Anatomy
  - Signals are relayed from vestibular nuclei to:
    - Extraocular motor nuclei (VOR)
    - Spinal cord (VSR)
    - Brainstem
    - Cerebellum-maintains calibration of VOR, VSR and VCR
    - Reticular formation
    - Thalamus
    - Terminate in the vestibular cortex (located in the parietal and insular regions)

Cincinnati Children's change the outcome





Take Home Message:

- A working knowledge of the vestibular anatomy will take you far working with children.

Test Battery- CCHMC

- History
- Computerized Dynamic Posturography
- Rotary Chair
- VNG
- High Frequency Headshake
- VEMP (research only)
- Bedside Exams

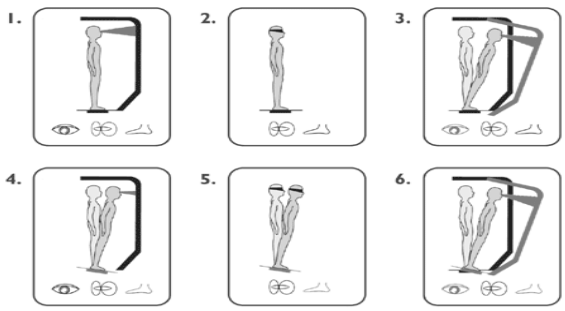
Pediatric Vestibular Evaluation References

- Valente (2007) presented normative data on children ages 3 to 11 years of age using rotary chair, CDP and VEMPS. [8]
- Normative data (2006) was collected for children ages 3-11 using VEMPS. [9]
- CDP has been mentioned many times in literature for normative data on the SOT test. [8,10-11]
- Pediatric caloric irrigations were reviewed showing differences between adult and pediatric results. [12&13]

Computerized Dynamic Posturography

- Sensory Organization Testing (SOT)
- Motor Control Test
- Adaptation Test
- Headshake SOT

SOT Test Conditions



Sensory Organization Test

Example Normal CDP

Headshake SOT (HS-SOT)

- Only performed if SOT is normal
- Calculates the effect of head movement upon a patient's ability to maintain their balance
- More specific to vestibular impairment than standard SOT
- Is problem isolated to a specific movement axis
- Useful information for treatment plan

HS-SOT

- When:
  - If symptoms are fleeting
  - If other diagnostics tests are normal (example: VNG/RC)
  - Correlates with higher demand activities

CDP Pediatric Modifications

- SOT normative data from 3 years of age in software.
- The "parachute" game
- We constantly encourage throughout entire test and tell them to "stand like a statue"
- Place sticker of child's choice eye level on visual surround to stare at

CDP Pediatric Modifications

- Use blind fold for young children "batman mask" for condition 2 and 5
- Similar to Wii or Wii fit games
- Was there an appropriate adaptation pattern?

Rotary Chair

- Sinusoidal Harmonic Acceleration
- Step Velocity Test
- Tolerated well by children
- Not ear specific
- A range of frequency Information available

Rotary Chair Pediatric Modifications

- We have 3 options for recording eye movement:
  - See-through goggles
    - Binocular recording
    - Does not obstruct vision
    - Door must be closed
    - Best option for older children
  - Single camera goggle
    - Door can be left open, mask occludes vision.
    - Good for claustrophobic or young children.
    - Only one eye can be recorded
  - Electrodes
    - Do not have to keep eyes open, however door has to be shut
    - You can record horizontal channel only (3 electrodes)
    - Drawback: very noisy with children who move a lot

Rotary Chair Pediatric Modifications

- Use of booster seat and car seat for very small patients under 3.
- Some children can sit on parents lap
- Team Testing: One can run the equipment, one goes in the enclosure with the child
- We call it the "Rocket Ship" or blasting off

Rotary Chair Pediatric Modifications

- Tasking for children
  - Singing songs
  - Listing: ice creams flavors, toppings on a sundae, pizza toppings, nintendo/playstation games, classmate names, cartoon characters, plots to movies, TV shows, and books
  - Very young children: counting, singing, "20 questions", colors, toys in their room

Example Normal RC

VNG

- Standard VNG protocol
- Often, ocular-motor evaluation completed in the rotary chair enclosure
- High frequency headshake included

Pediatric Modifications VNG

- "Scuba Diving"
- Use water, when possible, due to small canals
- Use of 42 deg warm water for pediatric patients who cannot tolerate full 44 deg
- Air calorics needs to point at TM for full 60 sec
  - Good for TM perforation and tubes WARNING: be mindful if you see a paradoxical response
  - WARNING: be careful not to seal off the ear canal and build too much pressure for both water and air

Pediatric Modifications VNG

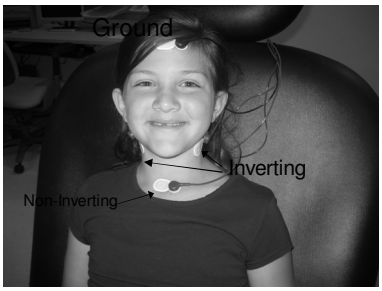
- Use of monothermal warm caloric screen [14] when appropriate
- We tell the children that the water is "magic". Tasking for 120 seconds go quickly when they use their imagination to tell you all about their "flying" or "spinning" adventures!
- Use of a TV instead of a light bar so the children follow a cartoon character instead of red dot
- TV also helps pacify children between tests or if they need a break
- Pediatric sized scuba mask
- See tasking from RC slides

Example Normal Calorics

VEMP

- Auditory evoked myogenic response measured from the sternocleidomastoid muscle
- Thought to show saccule and inferior vestibular nerve pathway
- Lab protocol is for research purposes only at this time due to lack of FDA approval
- For IRB approved research: elicit the response with 500 Hz TB
- Latency, asymmetry, and asymmetry ratio are being collected

VEMP

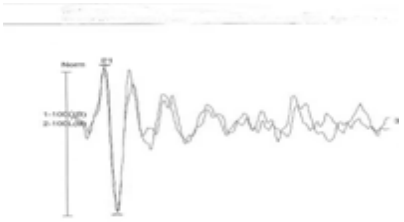


VEMP pediatric modifications

- We use a TV with cartoons: if they are contracting at the predetermined rate the cartoon stays on, if not the cartoon freezes
- We teach them to "make muscles" in their neck when the sound comes on
- Quick if just testing for presence or absence, longer if finding threshold
- Successfully completed down to 9 months old in our lab

Example Normal VEMP

- 9 month old:



Bedside Exams

- Head Thrust Exam
- Fukuda Stepping Test (with HS)
- DVA Screening
- Romberg Test (or use foam)

Bedside Modifications

- Must make child feel secure
- Try blindfolding, children have a hard time keeping their eyes shut
- Character sticker on the tester's nose to do head thrust testing

Patients seen in our Clinic by Diagnosis

- Migraines or Migraine Equivalent (BPV-C)
- Concussions
- EVA
- Concussions
- SNHL
- Panic/anxiety disorders
- Autoimmune conditions (ex: Cogan's)
- Ototoxicity/Vestibulotoxicity
- Unilateral Vestibular Hypofunction
- Cerebellar Degenerative Diseases
- Bilateral Hypofunction
- Vestibular Neuritis/ Labrynthitis
- Other: Superior Canal Dehiscence Syndrome, Mitochondrial Disorders

Referrals

- ENT
- Sports Medicine
- Neurology
- PT/OT
- Hematology/Oncology

Research in Progress

- Normal Study
  - Current trends:
    - Shorter latencies for VEMPS
    - Increased gain in lower frequencies for RC
    - Some 3 to 4 year olds do not meet current norms on SOT
    - Hyperactive caloric responses
- EVA Study
  - Comparing symptomatic vs. asymptomatic
  - Most all children in either group have some sort of abnormal finding

Cases

- Normal 3 year old
- Child with EVA

Vestibular Rehab is Documented in Children

- Medeiros et al. (2003) reported children with vestibular disorders who underwent vestibular rehab had positive changes in their CDP scores [15]
- Rine et al. (2004) showed improvement of motor development and postural control following intervention in children with sensorineural hearing loss and vestibular impairment[16]
- Jones et al. (2002) concluded deaf children demonstrated better balance and motor skills following vestibular rehab[17]

Vestibular Rehab Goals

- Facilitating the VOR
- Habituating provoked dizziness/motion intolerance
- Substitution for disorder systems
- Adaptation
- Improving functional mobility

Facilitating the VOR

- Exercise:
  - Child bounces on a therapy ball while playing "I Spy" or catch
  - Child walks and finds "Waldo" in a book or spot targets
  - X1-X2 exercises with progression

Habituation

- Goal: To habituate patient's symptoms by provoking movements
- Exercise:
  - Have the child practice turning 180° by doing the "Oompa Loompa Dance" along a line
  - Practice with padded mats rolling and turning on side
  - Demonstrating provoked dizziness in a safe environment

Substitution

- Goal: Use alternative strategies for vestibular dysfunction.
  - For example: Substitute the abnormal VOR pathway with smooth pursuits and cervical proprioception
- Exercise:
  - Active eye-head movements between two targets
  - "Remember Target"

Adaptation

- Goal: Facilitate long term changes and to substitute alternative strategies

Functional Mobility

- Walking on Cloud 9 Pillows
- Dynamic walking tasks including weaving in and out of cones and moving over obstacles

Other Tests For Vestibular Rehab

- Perception Time Test (PTT)
- Dynamic Visual Acuity test (DVA)
- Gaze Stabilization Test (GST)
- Functional Reach Test
- Peabody

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Dynamic Visual Acuity test

- Calculates the loss of visual acuity with head movements
- Impaired dynamic visual acuity can effect the patient's ability to correctly perceive objects during everyday movements
- Indicator of physiologic compensation
- Picture options available for young children

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Case Studies

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