Vestibular Issues in Pediatric Head Trauma

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Specificity and Sensitivity of the Vestibular Screening Questionnaire (VSQ) in Children with Motor and Speech Disabilities

Conclusion:

- VSQ is **not** a relevant tool to use in further clinical practice

- Positive vestibular screening of the JRH Pediatric population: 9/42 = 21%
Overview

1. Incidence

2. Review of the vestibular system

3. Possible Vestibular sequel post TBI
   - definition
   - mechanisms of injury
   - testing

4. Treatment strategies
Incidence: dizziness post pediatric TBI

- Most studies include dizziness as a post-concussion syndrome. It is more common in minor head trauma.

- Top symptoms of 348 children (6-18 yo) upon admitted to the Emergency secondary to TBI (Grubenhoff et al. 2011)
  - head ache
  - nausea
  - dizziness
  - not feeling “sharp”
  - blurred/double vision

- Chart review: 72 hours post head injury → dizziness and headaches were a primary complaint in 50% (Eviatar Let al 1986)
What is pediatric dizziness

- spinning
- feeling as if on a boat
- light headed
- shaky
- unstable
- swinging feeling

(Balkany 1986)

- ceiling falling in
- sudden unexplained stopping
- fear of open or busy spaces
- fear of crowds

(Nandi and Luxon, 2008)

Most common pediatric definition = off balance

(Alsalaheen et al 2010)
Rehabilitation strategies for prolonged recovery in pediatric and adolescent concussion.


- 10-20% of concussions take longer than 1 month to heal
- residual symptoms may include:
  - vestibular symptoms
  - neck muscle, whiplash issues
  - exercise intolerance
  - memory issues

‘At this point these problems respond better “active rehabilitation” via specific targeted strategies rather than strict rest’
Anatomy

Figure 1: The Outer, Middle, and Inner Ear
**Otoconia**: Matrix of gelatinous glucoprotein with solid calcium carbonate crystals. It is denser than the surrounding fluid and tissues. It tends to be ‘left behind’ due to inertia.

**Macula**: Hair cells distributed throughout a sheet of sensory epithelium.
Vestibular Pediatric results post TBI:

**BPPV**

Dix Hallpike Maneuver

[Figure 1: The Outer, Middle, and Inner Ear]

Vestibular Pediatric results post TBI:

- BPPV = Benign Paroxysmal Positional Vertigo
- “VPB” = “vertige positionel benigne”
- BPV = Benign Paroxysmal Vertigo
  (pediatric migraine precursor (2-6 yo))

√ Incidence of BPPV in pediatrics: Low (O’Reilly et al. 2010, Jahn K et al. 2011, Naguib et al. 1984)
Perilymphatic Fistula

**Definition:**
- leak of perilymphatic fluid into the middle ear
  (Balkany et. al. 1986)

**Frequency:**
- higher in children than adults

Balkany et al. 1986, Jahn et. al. 2011, McCall et al. 2011, O’Reilly et al 2011)
Vestibular Pediatric complications post TBI

Perilymphatic Fistula

Presentation:

- fluctuating symptoms
- positional dizziness
- increased symptoms with sneezing, lifting, straining..
- ± hearing loss
- ± hearing the eyes blink, heal contact

Vestibular Pediatric complications post TBI

**Perilymphatic Fistula**

**Clinical diagnosis:**
- Valsalva
- Tulio (clapping by the ear)
- Tragal pressure

**Treatment:**
- Rest & avoid Valsalva type situations
- Surgery
Vestibular Pediatric complications post TBI
Labrynthine concussion

**Definition:**
- direct or indirect labrynthine or 8th nerve damage.

**Mechanisms of trauma:**
- direct or indirect trauma or
- disruptions of the microcirculation of vestibule nerves resulting hemorrhage and inflammation. (O'Reilly et al. 2011, Naguib et al. 1984)
Vestibular Pediatric complications post TBI
Labrynthine concussion

Characteristics:
- often without demonstrable skull fracture
- dizziness on movement and/or somatoform dizziness
- gait and balance dysfunction
- decreased concentration  (Eviatar et al. 1986)
Labyrinthine concussion symptoms:

**vertigo / dizziness**

vertigo = dizziness described as spinning

dizziness = non specific, non vertigo sense of motion

**pathology:** imbalance of the vestibular afferents

**aggravating factors:** head movement (if severe: eye movements)

**duration:** brief (minutes)

post vertigo → possible nausea

relieved by: avoidance, holding

(Ravid et al, 2003)
Labyrinthine concussion symptoms:
Somatoform Vertigo

**Definition:**
dizziness provoked by dynamic visual inputs

**Dizziness:**
boat like feeling, uncomfortable, oscillatory dizziness, heavy headedness

**Aggravated by:**
department stores, school, being a car passenger, (dynamic visual environments), stress, fatigue
Labyrinthine concussion symptoms: Somatoform Vertigo

- no systematic studies on somatoform vertigo in children and adolescents (Jahn et al 2011, Jahn 2011,)

Cause of symptom: Unclear, visual dependency (Eviatar et al 1986)

somatoform vertigo = visual vertigo = space motion discomfort = non specific dizziness

http://englishirond.wikispaces.com/file/detail/schoolyard.jpg/337501576
Labyrinthine concussion: Gait and balance dysfunction

- Few studies specifically on pediatric vestibular balance issues post TBI

- College-age football players return to normal balance (BESS) within 5-10 days (McCrea et al 2003)

- Adults tend rely on visual input, and not integrate vestibular input post TBI (Rubin AM et al 1995, Slobonov et al 2008)
Children show decreased dynamic balance after mild traumatic brain injury.
Gagnon I, Swaine B, Friedman D, Forget R.

- Studied balance skills at
  - 1, 4, and 12 weeks post mTBI
  - of 38 children (7-16 yo) and
  - aged matched controls
  - (friends of the TBI)

Fig 1. Raw score mean and standard error of the mean (SEM) at 1, 4, and 12 weeks for both groups on the BOTMP balance subtest. Legend: □, children with mild TBI; ■, control children. *P≤.05; **P≤.01; ***P≤.001.
Conclusions:

- Children with mTBI show deficits at 12 weeks post-injury

- Specifically in demanding/sensory integration tasks i.e: tandem eyes closed

- Deficits in sensory integration or inability to efficiently use proprioceptive + vestibular input

(Gagnon et al. 2004)
Labyrinthine concussion: Assessment tools:

• head thrust

• dynamic visual acuity

• post rotary chair nystamus test

• subjective visual vertical bucket test (for children $\geq 4$ y.o.)

• nystagmus assessment: not described in presentation
• Static balance assessment; not described
• Dynamic balance assessment: FGA not described
Labyrinthine concussion:  
Head Impulse Test: (Halmagyi head thrust

**Evaluation:**
The client's head is unpredictably and rapidly (180°/sec) rotated (~ 20°) while the client looks at a target.

**Abnormal test result:**
Clients' eye move with their head, needing a refixation saccade.

**Pathology Evaluating:** VOR pathology of the direction going towards
Labyrinthine concussion:
Head Impulse Test: (Halmagyi head thrust)
**Labyrinthine concussion:**

**Dynamic Visual Acuity testing:**

**Evaluation:**
The difference between the static (acuity with head stable) and dynamic acuity (acuity level while head is being oscillated).

**Abnormal test result:**
losing 3 or more lines
Labyrinthine concussion:
Dynamic Visual Acuity testing:

Pathology Evaluating:

➢ VOR pathology

Symptom: i.e: difficulty seeing clearly when walking or running
**Labyrinthine concussion:**

**Post rotatory chair nystagmus test:**

**Evaluation:** Chair is turned at a constant velocity for a constant amount of rotations (180 deg/°, 5-10 cycles) (Jahn et al 2011)

**Outcome measure:** Duration of post rotatory nystagmus after right and left turning

**Abnormal:** Significantly unequal durations of nystagmus, diminished/prolonged nystagmus
Labyrinthine concussion:
Post rotatory chair nystamus test:
Labyrinthine concussion:
Subjective vertical bucket test:
Labyrinthine concussion:
Subjective vertical bucket test:  (Zwergal et al, 2009)

- Alternative to the Rod & Frame test
- Abnormal=2.5 degrees off true vertical
- Abnormal: indicates utricular dysfunction, central pathology
- Zwerglal et al 2009: SVV abnormal in 14 of 14 brain stem CVA pts (mean 4.1°, range 2.7-6.6°)  

Zwergal et al, 2009
Three Goals of Vestibular Rehabilitation:

↑ Gaze stability

↓ Dizziness

↓ Balance Retraining
The Three Principals of Vestibular Rehabilitation

1. **Adaptation:**
   
   The capacity of the vestibular system adapt to neuronal changes, readjusting the gain

2. **Substitution:**
   
   Alternate strategies to replace the lost vestibular system

3. **Habituation**
   
   Long term reduction in the response to provocative stimuli (increased threshold to dizziness)
Traditional Treatment: Gaze stability

1. Adaptation

2. Substitution:
   • saccade substitution
   • imaginary pursuit

Viewing x 1

Viewing x 2
(Herdman et al 1995) (Badarucco et al 2007)
Pediatric Treatment:
Gaze stability:

- Child swings and watches T.V or plays a game (which is not on the swing)

- Bouncing and watching T.V or reading

- Parent moves child’s head + play finding Aldo or a computer game

- Child locates objects out the car window

→ pre gaze stability:

oculomotor home exercises: pursuit, sacade and convergence
Habituation: to decrease dizziness

Exercise:
find a movement that provokes the clients symptoms, and they must then perform it.
- Brandt Daroff
- Head movement (viewing x1)
- trunk forward flexion-ext
- walking → abrupt stop

Intensity:
provokes dizziness but returns to baseline after 5 minutes

Frequency:
1-2 minutes performed 3-4x/day → every 2hrs
**Somatoform dizziness: progression of exercises**

**Exercise:** find a movement that provokes the clients symptoms, and they must then perform it.

- walk and look left/right at objects
- walk while moving arm left to right and looking at outstretched moving thumb
- look at an oscillating mirror or a rotating inverted umbrella
- watch action T.V or video
- spend time at shopping center/hallways

**Intensity:**
provokes dizziness but returns to baseline after 5 minutes

**Frequency:** 1-2 minutes performed 3-4x/day → every 2hrs (with the exception of shopping or long walks)
Principles of Vestibular HEP

- Quantity: 1-5 exercises
- Duration: 10 min. to perform the entire HEP
- Repetitions: X3/day → every 2 hours
- Balance Exercises: Challenging yet safe
- Dizziness Habituation: Symptom provoking, yet only during HEP (max 5 min post) (Whitney and Sparto 2011, Han et al 2011)
Studies on pediatric Vestibular Rehabilitation for TBI

Vestibular rehabilitation for dizziness and balance disorders after concussion.


- Retrospective study: 67 children (8-18 yo), 47 adults (19-73)
- Vestibular rehabilitation outcome was not age dependent
- Should be considered for individuals whose symptoms do not decrease with rest and time.
Adult Vestibular Rehabilitation (VR) Efficacy

- **Gottshall (2011):** few studies on TBI and VR, clinically found vestibular rehabilitation → improved dynamic visual acuity, balance, and reducing dizziness.

- **Ernst et al (2005):** prospective study (n=63): 1) multiple vestibular pathologies 2) lack of correlation with trauma with pathology

- **Post traumatic BPPV:** multiple canal involvement and more treatments until resolution (Ahn et al 2011, Dlugaczyk et al 2011, Suarez 2011)

**Much more work is needed in studying the benefit of vestibular rehabilitation on pediatric PCS:** 1 study found (Alsalaheet et al 2010)
Special Thanks

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**Questions - Comments**
EQUENCY DISTRIBUTION OF CHILDREN PER CATEGORY

Total vestibular evaluations performed  N= 25
Positive evaluation N=13
Negative evaluation N=12

NB. The percentages were calculated using either the total of positive VSQ (N = 35) and the total of negative (N = 38).
Vestibular Pediatric complications post TBI

Vestibular Migraine

Definition
• Episodic attacks of rotary or oscilatory dizziness, with or without a headache,
• “a condition that can be triggered by head trauma” (Eviatar et al. 1986, Jahn et al 2011)

Characteristics:
- duration: of symptoms min ↔ hours,
- symptoms during an attack;
  nystagmus, ± sensitivity light/noise
  ± poor balance rarely tinnitus
- between attacks: symptom free
Vestibular Pediatric complications post TBI

BPPV

Canalithic Repositioning Maneuver: Modified Epley

(from Tannenbaum et al., 1998)
Incidence: general pediatric dizziness

- 8-15% school age children experience vertigo
  

YET

- In a hospital review the documented incidence of vertigo as a primary complaint was 1%

  (Niemensivu R et al. 2006)