Learning objectives

- Discuss the vestibular pathways and pathologies that are central in origin.
- Discuss theoretical mechanisms that would support recovery of function after a central insult.
- Select appropriate tests and measures to identify impairments that result from the central pathways involvement.
- Identify strategies used by experts in the field to reduce symptoms of dizziness, improve balance control, and optimize function in individuals with central vestibular involvement.
- Describe the similarities and differences in management strategies that experts are using to improve function in individuals with central vestibular involvement within different diagnostic groups.

Questions

- What are the important factors that guide your clinical decision making in individuals with CNS disorders and vestibular involvement?
- To what extent did you consider the pathology or disease process, stroke, TBI or MS, in your clinical decisions?
- To what extent does severity or complexity of body functions or structure impairments play in your clinical decisions?
- To what extent does other personal or environmental factors play a role in your clinical decisions?
- What is your expectation for recovery in patients with central vestibular disorders?

Questions

- What tests and measures are selected to capture the vestibular and other impairments seen in central disorders?
- How is your intervention the same or different than a peripheral vestibular disorders?
- How did the outcome of your case inform you in management of future patients?
- What are your questions or uncertainties in your case?
So what defines “peripheral” versus “central”?

- Peripheral vestibular system:
  - Vestibular end organs
    (3 semicircular canals, 2 otolith organs)
  - Vestibular portion of the VIIIth cranial nerve

- Central vestibular system:
  - Vestibular nuclei
  - Vestibulocellular pathway
  - Vestibulocerebellum
  - Vestibulospinal pathway
  - Primary and secondary cortical areas
  - Vestibulocerebellum

Central Vestibular Disorders:

Focal lesions

- Peripheral Vestibular Lesions (#1)
- Acute vestibular nuclei lesions (#2)
- Acute lesions of the vestibular posterolateral thalamus relay station (#3)
- Cerebellar disorders of the flocculus (DBN) and nodulus/uvula (VOR)
Central Vestibular Disorders: Focal lesions to the vestibular nucleus

“Acute vestibular syndrome”

- Rapid onset of severe/sustained vertigo, nausea/vomiting, spontaneous nystagmus with head motion intolerance and postural instability with unsteady gait

(Cnyrim CD et al. JNNP. 2008;79:458-460)
(Kattah JC. Stroke. 2009;40:3504-3510)

Acute Peripheral Vestibulopathy vs. “Vestibular Pseudoneuritis”

- Signs and sx similar to peripheral vestibulopathy which are due to lesions in the brainstem (vestibular nucleus) or cerebellum
- Mostly caused by infarctions or MS plaques at root entry zone (Cnyrim, 2008)

Comparison of PICA and AICA Syndromes (Furman and Whitney, 2000)

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Seen in BOTH PICA and AICA</th>
<th>PICA Syndrome ONLY</th>
<th>AICA Syndrome ONLY (Lateral Pontine Syndrome)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vertigo, lateropulsion, visual illusions, facial numbness, limb numbness, disequilibrium, dysphagia, incoordination</td>
<td>Hoarseness</td>
<td>Trinitus, hearing loss, and facial weakness</td>
</tr>
<tr>
<td>Signs</td>
<td>Vestibular nystagmus, decreased facial sensations ipsilaterally, dissociated sensory loss to pain and temp contralaterally, Horner’s syndrome, ipsilateral limb ataxia, gait ataxia</td>
<td>Saccadic lateropulsion, skew deviation, vocal cord paralysis</td>
<td>Hearing loss, facial weakness, gaze palsy</td>
</tr>
</tbody>
</table>

Damage to the vestibular nucleus

- Infarction of the dorsolateral medulla: “Wallenberg’s syndrome” (most commonly due to PICA or Vertebral aa.)
- Affect the medial and/or superior vestibular subnuclei. Static vestibular signs:
  - ipsiversive cyclorotation of one or both eyes (82%)
  - skew deviation with ipsilateral eye lowermost (44%)
  - complete ocular tilt reaction (33%)
  - tilts of perceived vertical in most patients (94%)  
  - Additional vestibular signs include: torsional spontaneous nystagmus and impaired head-impulse test (Dieterich, 2008)
‘HINTS’ to Diagnose Stroke in Acute Vestibular Syndrome
Kattah JC. Stroke. 2009;40:3504-3510

- **HINTS:**
  - Head Impulse Nystagmus Test of Skew
  - “Dangerous” Oculomotor Signs suggesting stroke vs. peripheral vestibular lesion (100% sensitive, 96% specific):
    - Negative head impulse test  
    - Direction changing nystagmus with eccentric gaze  
    - Skew deviation (vertical ocular malalignment)

‘HINTS’ to ‘INFARCT’

**‘INFARCT’**

- Impulse Normal
- Fast-phase Alternating
- Refixation on Cover Test

Central Vestibular Pathway:
Focal lesions to the thalamic nuclei

- Infarction of the posterolateral thalamus (afferent relay for multisensory vestibular cortex areas)
- Signs and symptoms of a unilateral lesion of the posterolateral thalamus
- Causes vestibular tonus imbalance without ocular motor signs but with perceptual and postural deficits
  - Deviations of perceived visual vertical
  - Imbalance of stance and gait with lateral falls (interposition)

(Dietenich, 2008)

(Vestibular thalamic nuclei)

What is the “pusher syndrome”

- First described by Patricia Davies in 1985.
- Described the behavior of some patients post stroke who use their non-paretic extremities to actively push themselves toward their paretic side.
- Loss of lateral postural control.
- Related to spatial “neglect”

(Purves, 2001)
Pusher Syndrome: Abnormal Subjective Postural Vertical

- Altered perception of vertical
- Damage results in lateropulsion or "contraversive" pushing

Incidence

- A study of 327 patients with acute stroke and hemiparesis showed an incidence of ipsilateral pushing behavior in 10.4%
- Left brain damage = 47%
- Right brain damage = 53%

(Chandler et al, 1996)

Recognizing Pusher Syndrome...

(3) Variables important to recognize:

1. Spontaneous body posture
2. Increase of pushing force by spreading of the non-paretic extremities from the body
3. Resistance to passive correction of posture

*Severe misperception of their own upright body orientation although visual-vestibular processing is intact. (Karnath, 2003)

“The pusher”...

- A patient typically with right-side brain damage and pusher syndrome.
- These patients, while sitting (left) or standing (right), spread the nonparetic extremities from the body to push away actively from the nonparetic side.
- The result is tilted body posture.
- If not assisted by the examiner, the patients push themselves into a lateral inclination until they fall toward the hemiparetic side.

(Davies, 1985)

Incidence

- A study of 327 patients with acute stroke and hemiparesis showed an incidence of ipsilateral pushing behavior in 10.4%
- Left brain damage = 47%
- Right brain damage = 53%

(Pederson et al, 1996)

Treatment for Pusher Syndrome

- “allow patient to repeatedly experience the consequence of his spontaneous self-determined position... to recognize that what he perceived as safe and upright was not”
- “use tactile and verbal feedback to orient the patient to true vertical” (Bohannon, 2003)
- “approach is based upon the observation that visual-vestibular processing, and thus orientation perception of the visual surroundings, is not impaired with patients with pusher syndrome.” (Karnath, 2003)
Prognosis

- Disorder can be well compensated for by the brain

- 6 months post stroke, “pushing” behavior is rarely still evident

- Patients with contraversive pushing take 63% longer than patients without such behavior to reach the same functional outcome level (Karnath, 2002)

Central Vestibular Disorders: Focal lesions to the cerebellum

Cerebellum

- Functions as:
  - Comparator of intended versus actual movement
  - Compares info from cortex to peripheral sensory (GTO, proprioception, vestibular apparatus, eyes, ears)
  - Error-correcting mechanism
  - Role in motor skill adaptation

Cerebellar signs

- Ocular:
  - Saccadic dysmetria (typically overshoot)
  - Abnormal smooth pursuit
  - Nystagmus
    - Downbeat
    - Direction-changing, gaze-evoked
  - Failure of fixation suppression during VOR Cx
  - Failure of fixation suppression with fixation removed during spontaneous nystagmus
- Incoordination
- Ataxia (dysmetria, dysrhythmia, dyssynergia)

D's (posterior fossa)

- Diplopia
- Dysphagia
- Dysarthria
- Dysmetria

Cerebellopontine angle

www.jstor.org

www.thebarrow.org

http://departments.bloomu.edu
Clinical Decision Making: A Case Report

The Use of Body Weight Supported Treadmill Training in the Treatment of a Patient with Acute Wallenberg’s Syndrome

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Department of Neurology
Program Director for Rehabilitation and Wellness
VCU Parkinson's and Movement Disorders Center
jhoder@vcu.edu

Case Description: Client History

- 67 y.o. ♀
- Social Hx: Retired bookkeeper, married
- Living Environment: 2-story walk-up apartment bldg with her husband
- General Health Status: Independent with all ADL’s, community ambulator
- PMH: hypertension

Introduction

- Purpose:
  To describe a unique application of body weight supported treadmill training in conjunction with vestibular exercises for the management of a patient with acute Wallenberg Syndrome

Client History

- Chief Complaint: presented to the ER with c/o severe headache and dizziness
Case Description:
- MRI (+) Right SAH secondary to PICA aneurysm

Surgical Intervention
- s/p surgical clipping to Right PICA aneurysm
- Post-op symptoms c/w Wallenberg’s Syndrome

Physical Exam
- Right upper extremity (+) dysmetria with finger-to-nose, eyes closed > eyes open
- Sensation decreased to light touch on right side of face and left upper extremity
- Proprioception intact at bilateral ankle, toes
- ROM bilateral UE and LE WNL’s
- MMT bilateral UE 5/5, LE 5/5, except left knee flex 4/5

Horner’s Syndrome
- Ptosis:
  - drooping of upper eye lid
- Anhydrosis:
  - decreased sweating on affected side of the face
- Miosis:
  - constriction of the pupil

Physical Exam
- Dysarthria
- Dysphagia requiring feeding tube
- Ptosis of right eyelid c/w Horner’s syndrome
- Diplopia
- Horizontal nystagmus with c/o vertigo
- Ataxia with lateropulsion during stance to the right (ipsiversive)
Wallenberg’s Syndrome
(a.k.a. Lateral Medullary Syndrome)

- **Vestibular nuclei:** Vertigo, nystagmus, imbalance
- **Inferior cerebellar peduncle:** Ipsilateral limb ataxia, dysmetria
- **Trigeminal nucleus:** Ipsilateral facial hemianesthesia;
- **Nucleus ambiguus:** Vocal cord paresis, decreased gag, palatal weakness
- **Lateral Spinothalamic Tract:** Contralateral pain and temp from body
- **Descending sympathetic fibers:** Ipsilateral Horner’s Syndrome

“Wallenberg’s Syndrome” (a.k.a. Lateral Medullary Syndrome)

- Vertigo, spontaneous nystagmus
- Skew deviation, altered subjective visual vertical (eyes roll toward side of lesion)
- Ipsilateral limb ataxia
- Gait and saccadic **lateropulsion** toward side of lesion (ipsilateral)

Pathologic Postural Changes

- Abnormal Vestibular Spinal Reflex response
- Midline disorientation with **ipsiversive** lateropulsion

“Pusher Syndrome”

- “approach is based upon the observation that visual-vestibular processing, and thus orientation perception of the visual surroundings, is not impaired with patients with pusher syndrome.”

(Karnath, 2003)
Wallenberg’s Syndrome: Pathologic Change in Subjective Visual Vertical

- Abnormal Ocular Tilt Response
- Damage results in change of subjective visual vertical (eyes roll toward side of lesion)

(Brandt, 2000)

Visual vertical and postural vertical information are inaccurate.

Pt falls without realizing they are actively shifting out of BOS!

Pt is unable to maintain unsupported, upright stance

(Dieterich, 1992)

Inpatient Rehabilitation

- Following 41 days of inpatient rehabilitation, the patient was discharged to home.
- 3 days after discharge, pt c/o new onset of increased LE weakness
- MRI (+) bilateral SDH with right > left
- Pt s/p craniotomy to evacuate right SDH

Inpatient Rehabilitation

- Admission #1
  - Total FIM score 82
  - Motor FIM score 55
  - Bed mob. req min A
  - Transfers req min A
  - Ambulation req mod A with RW for 20 ft w/ LOB and pt inconsistently self-correcting
  - Balance: Berg N/A

- Admission #2
  - Total FIM score 71
  - Motor FIM score 40
  - Bed mob. req mod A
  - Transfers req mod A
  - Ambulation req mod A with RW for 20 ft w/ LOB and patient unable to self-correct
  - Balance: Berg score of 24/56

Methods of intervention

- Admission #1
  - Functional Training

- Admission #2
  - Functional Training
  - Vestibular exercises during BWSTT

Body Weight Supported Treadmill Training (BWSTTT)

- Current literature for patients with cortical lesions and hemiplegia
  - Visitin et al. (1998)
  - Kosak (2000)
  - Laufer et al. (2001)
Vestibular Disorders of Central Origin

Why?

- Provides trunk control with less demand on therapist
- Trunk orientation to midline during task oriented activity
- Decreases fear of falling

Protocol

- 3x/week
- Initially for 3 min @1.2 mph then increased to 20 min @2.0 mph
- Performed to patient tolerance
- Vestibular exercises
- Followed treadmill with over ground

Outcomes

- **Discharge #1**
  - Total LOS 41 days
  - Total FIM score 96
  - Motor FIM score 64
  - Indep bed mobility
  - Transfers with sup
  - Amb x150 ft w/ RW with occ. min A
  - Stairs x2 flts w/ NBQC with sup

- **Discharge #2**
  - Total LOS 21 days
  - Total FIM score 91
  - Motor FIM score 63
  - Indep bed mobility
  - Transfers with sup
  - Amb x150-200 ft with RW with occ. CG
  - Stairs x2 flts w/o device req occ. CG
  - Berg Balance 40/56

Outcomes: FIM data

Discussion

  - 18 inp rehab patients with LMS infarct
  - mean admit motor FIM 50.9 ± 13.0
  - mean discharge motor FIM 76.9 ± 10.5
  - mean d/c motor FIM for PICA 69.0 ± 13.8

- Kelly et al (2001)
  - 58 cases over 3 years
  - Hemorrhagic CVA only 50% FIM scores of min assist to no assist

Dieterich (1992)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Head and body tilt without imbalance</td>
</tr>
<tr>
<td>II</td>
<td>Head and body tilt, with considerable imbalance, no falls</td>
</tr>
<tr>
<td>III</td>
<td>Head and body tilt, falls only with eyes closed</td>
</tr>
<tr>
<td>IV</td>
<td>Head and body tilt, falls with eyes open</td>
</tr>
</tbody>
</table>
Time course of recovery

- Grade IV to become Grade III was 25 ± 8 days.
- Grade III to become Grade II was 19 ± 13 days.
- Grade II to become Grade I was 32 ± 13 days (Dieterich, 1992)

Patient course of recovery from Group IV to Group II was **21 days**

Treatment options

  - trunk orientation “the physical anchor of internal representation of body orientation in space”

- Transient event…speed up the process?

Prospective Case Report

- Assess patient perception of vertical (Herdman, 2000)
- Assess static and dynamic visual acuity
- Assess gait speed (Perry, 1995)
- Assess endurance via 6 minute walk test
- Quality of Life Measurement/subjective complaints scale (DHI)

Altered Subjective Visual Vertical

Vestibular rehabilitation of central vertigo in a 47 year-old female with Multiple Sclerosis

Herb Karpatkin PT, DSc, NCS, MSCS
Hunter College, NY
Introduction

- Vestibular impairments are common in MS
- Common cause of disability due to vertigo and disequilibrium, and falls
- Frequent presenting complaint, infrequent referral for rehabilitation

Vestibular impairments in MS

- Vertigo common initial complaint
- Experienced by over 20% of all persons with MS
- BPPV most common cause (higher than in non MS)

Pathophysiology

- Central Vestibulopathy- Damage to Cerebellar and/or Pontine structures, root entry zone of CN8 (MS, CVA, TBI)
- Peripheral Vestibulopathy- pathology of the semicircular canals or otoliths
- Different pathologies, different symptoms, different treatments

Vestibular Rehabilitation

- Frequently used with good results in peripheral vestibular dysfunction
- Infrequently used in Central dysfunction, especially in MS
- Anecdotal evidence suggests poor results for vestibular rehabilitation in Central dysfunction. This is not supported by the literature

Vestibular rehabilitation in MS

- Vestibular sx in MS often combined with other factors leading to imbalance
- Fatigue, spasticity, sensory loss
- Fatigue most common finding
- With worsening fatigue, worsening of other sx

Purpose

- The purpose of this case report is to describe rehabilitation in a 47 year-old female with MS with new onset CO complaints of vertigo
Patient Description

- 47 yo MWF, Dx RRMS, EDSS 3.5
- Dxed at 29 yo with optic neuritis, BLE paraesthesia
- Medications- Betaseron, baclofen, gabapentin
- Slowly progressive difficulties with gait and balance
- New onset (2 weeks prior to PT visit) CO vertigo and “heaviness” in her head with rapid head movements

Exam Results or Non-Vestibular Findings.

- ROM-10° left plantiflexion contracture
- MMT- Left hip 4/5, knee flexion 4/5, ankle dorsiflexion 3/5
- Spasticity-1 MAS left plantiflexors, (+) babinski and clonus; progressed to 2 MAS after 6 minute walk
- Sensation intact

Balance and Ambulation

- BBS 52/56, following 6 minute walk 48/56
- DGI-21/24, following 6 minute walk 16/24 with LOB on head turning activities
- 6MWT-687 feet (256,232,199)

Vestibular exam

- DHI-49/100 (moderate handicap)
- Hallpike Dix (-)
- Spontaneous nystagmus
- Vertigo did not always match nystagmus
- Direction changing nystagmus

Vestibular Evaluation

- Head turning activities (vertical >> horizontal) resulted in direction changing nystagmus, diplopia, and vertigo
- VOR2 testing (standing)-immediate loss of balance (B) directions
- C/O vertigo with all head turning activities, or standing/moving on unstable surfaces, stairs

Diagnosis- Central Vestibulopathy

Based on-
- Medical Diagnosis
- (-) Hallpike Dix
- Direction changing nystagmus
- Vertigo and Nystagmus did not match
- Worsening of vestibular symptoms with fatigue
**Prognosis**

- Expected Frequency and Duration
- Predicted outcome
- Goals:

**Treatment**

**Vestibular Rehabilitation-Phase 1 (2 weeks)**
- Vestibular Ocular Reflex (VOR-1) training (in sitting)
- Vertical horizontal, diagonal movements
- Slow head speed, short range, 5-10x/day until sensations of mild to moderate vertigo is produce (± 30 sec.)
- Increase range and speed as tolerance increases
- Frequent rests given over course of treatment to limit fatigue

**Vestibular Rehabilitation-Phase 2 (4 weeks)**
- VOR 1 training in standing
- VOR2 training in sitting

**Vestibular Rehabilitation -Phase 3 (ongoing)**
- VOR 1 training on uneven surfaces, narrow base of support
- VOR 2 in standing with fast speeds, all directions

**不平衡 retraining (carried out during both phases)**
- Single limb stance
- Tandem stance
- Gait with vertical and horizontal head turns
- Stairs with spotting
- Left plantiflexor stretch
- Left dosiflexion strengthening

**Outcomes**

- Berg Balance Scale-55/56, post 6MW-52/56
- Dynamic Gait Index 23/24 post 6MW 20/24
- Dizziness handicap Inventory- 22/100
- 6MWT-812 (291/271/250)

**Mechanisms of Recovery?**

- Adaptation-Long term change in response of a system to its input
- Habituation- long term reduction in neurologic response to a noxious stimuli thru repeated exposure to that stimuli
Mechanisms of Recovery?

- Adaptation limited due damage to CNS substrate?
- What is the role of neuroplasticity?
- Habituation limited by neurogenic fatigue?
- Intermittent exercise?

Treatment consideration

- MS is multifactorial- vertigo can coexist with non vestibular findings
- Non vestibular symptoms can limit compensation and adaptation
- Fatigue and temperature rise can worsen sx, therefore evaluate and treat in both non-fatigued and fatigued conditions

Head Injury Case Study

Kim R. Gottshall PhD, PT, ATC
Vestibular Special Interest Group
Combined Section Meeting
San Diego, CA January 2013

The views expressed in this material are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, or the United States Government

General Approach

- History
- Physical
- Auditory tests as indicated
- Vestibular tests as indicated
- Imaging studies as indicated

History

- 24 year old caucasian male active duty Navy SEAL
- Mechanism of injury was a fall 40-60 feet while fast-roping dismount from a helicopter during night time maneuvers 20 October 2011
- Left temporal bone fracture, left mastoid fracture, right suboccipital fracture, subarachnoid hemorrhage, left rib fracture, and right pulmonary contusion
History

- Denies loss of consciousness
- Glasgow coma scale 13-15
- Stunned after fall
- Facial nerve weakness left side of face 5 days after fall lasting eight weeks
- Bilateral hearing loss, right greater than left
- Other associated difficulties not addressed by physical therapy

Petrus Bone Fracture

- Common findings:
  - Hemotympanum (46/90)
  - Bleeding from external ear canal (27/90)
  - Facial paralysis (14/90)
  - CSF otorrhea (13/90)
  - Ossicular dislocation (13/90)


- 50% will complain of dizziness
- Positional nystagmus is most common vestibular finding. UVH can also occur.

(Wennmo C, Svensson C. Acta Oto-laryngologica, 1989; 108(s468):379-383)

Transverse Fractures

- Frontal or occipital blows
- SNHL and vestibular loss in 80-95% due to lacerations of the membranous labyrinth, and vestibular/cochlear nerve
- Facial nerve involvement 50-65% of the time
- CSF often fills middle ear and drains into eustachian tube (salty fluid down throat)
- Tympanic membrane usually intact but a hemotympanum occurs frequently

Schuknecht H, AMA Arch. Otolaryng. 1956;63: 513-528
Tos M, J Laryngol Oto. 1971;85: 1147-1159.)

Potential for reversal of vestibular hypofunction

- Labyrinth concussion may recover completely
- Temporal bone fracture-unilateral compensation not recovery
- Temporal bone fracture–bilateral compensation not recovery

Chief Complaints

- Loss of hearing
- Loud noises exacerbate dizziness
- Dizziness looking up or down
- Difficulty focusing riding in vehicles on bumpy roads
- Difficulty maintaining steadiness in low light on uneven terrain
- Hears clicking sound in left ear with heel strike running

Standardized Instruments

- Dizziness Handicapped Index (DHI) – quality of life measure 0=best 100=worst
- Activities Balance Confidence Scale (ABC) – quality of life measure 0=worst 100=best
- Functional Gait Assessment (FGA) – a measure of dynamic function 30=best 26=fall risk
- High-level Mobility Assessment Tool (HiMAT) 56=best 0=worst

All are most useful as income/outcome measures for rehabilitation
Vestibular Disorders of Central Origin

Vestibular Physical Exam

- Nystagmus – right beating nystagmus
- Saccades abnormal accuracy and velocity
- Dix Hallpike did not illicit positional nystagmus that was latent or fatigueable
- Rotation chair
- Abnormal low gain VOR on sinusoidal testing
- Utricular dysfunction on unilateral centrifugation
- Subjective Visual Vertical @ 300 degrees per second
- OKN within normal limits

Vestibular Physical Exam

- Caloric reduced vestibular response in left ear
- Head thrust test left illicit refixation saccade
- Fukuda step test rotated greater than 90 degrees to the left
- Positive Romberg test

Basic Vestibular Assessment (ENG)

- Components can be done with EOG electrodes (ENG) or with infrared camera (VNG)
- Spontaneous nystagmus
- Horizontal and vertical gaze nystagmus
- Horizontal and vertical saccades
- Smooth Pursuit
- Fixation Suppression
- Positional and Positioning Nystagmus
- Caloric testing

Caloric Tests

- Standard caloric – can be done with water or air
- Best use is looking for peripheral weakness
- Ice calorics – looking for evidence of ablation

Tests of VOR Function

- Rotational chair testing
- Low frequency VOR gain, phase, and symmetry
- Step velocity testing of vestibular time constant

VOR Report for Sinusoidal Tests
Tests of VSR Function

- Computerized Dynamic Posturography
- Sensory Organization Test
  - Eyes Open - platform stable/surround stable
  - Eyes Closed – platform stable/surround stable
  - Eyes Open – platform stable/surround referenced
  - Eyes Open – sway referenced platform/surround stable
  - Eyes closed - sway referenced platform/surround stable
  - Eyes Open - sway referenced platform/surround sway-referenced

Posturography (CDP)

- Provides us with information on how each individual uses sensory information to maintain balance, long loop motor reflexes & ability to adapt to repeated stimulus

Results from CDP

- SOT
- Head-Shake SOT

Preferred Practice Pattern

From Guide to Physical Therapy Practice

5D-Disorders of the Central Nervous System in Adolescence or Adulthood

Vestibular Rehabilitation

- Treatments that allow individuals to adapt to, compensate for, or respond to a balance disorder

Basic Vestibular Rehabilitation Therapy

- VOR
- COR
- Depth Perception
- Somatosensory
- Gait Training
- Positional Exercises
- Proprioceptive Neuromuscular Facilitation (PNF)
- Aerobic Conditioning
Vestibular Physical Therapy Rehabilitation Exercises

- Vestibulo-ocular reflex (VOR)
  - Moving target
  - Moving head
  - Alternate target-head motion
  - Sequential target-head motion
- Cervico-ocular reflex (COR)

VOR Exercises

Dynavision D2™

- The light speeds are all programmable from 0.25 sec to 5 sec or more.
- The light patterns are programmable.
- The lights can be programmed by Quadrant, by Inner/Mid/Outer Ring or any combination
- The lights can flash Red or Green and any combinational mix as per the defined program.
- Tachistoscope flashes up to 7 digits

COR EXERCISES

- Depth perception
  - Target changing distance
  - Wall push ups
- Convergence exercises
  - Brock string
  - Near to far targets
- Somatosensory exercises
  - Stationary stance with head tilt
  - Sway forward, backwards, side to side
  - 1/4 squats

Depth Perception

Convergence-Brock String

Heave

SOMATOSENSORY EXERCISES

- MULTIDIRECTIONAL BALANCE

- PLATFORMS
CORE STABILITY
- Swiss ball plus
- Eyes closed/head turns
- TRX plus
- Eyes closed/head turns
- CORE STABILITY
  KETTLEBELLS

Vestibular Physical Therapy
Rehabilitation Exercises
- Gait exercises
  - Various surfaces
  - Stair climbing
  - Sidestepping, carioca, changing directions
  - Ball skills
- Aerobic conditioning
  - Walking
  - Cycling
  - Swimming
- Plyometrics

GAIT TRAINING

VITAL REALITY
- Computer Assisted Rehabilitation Environment (CAREN)
- 8 projectors project a virtual reality environment and visual feedback on the inside of a dome screen.
- 24 camera motion capture system that can track 3-dimensional, full-body kinematics.
- Treadmill with force plates on an independent platform with the ability to deliver perturbations.

AERODIC ACTIVITY
Surfing and Paddle Boarding
Multisensory Balance Training System comprising a vibrotactile belt display, force plate, computer and visual display.
Example of Vibrotactile Feedback
inVision Tunnel

- 080410-N-5422G-001
- Army Sgt. Ron Ramirez uses an Invision Tunnel to test his cognitive vestibular visual interaction at Naval Medical Center San Diego's Ear, Nose and Throat (ENT) Clinic.
- This device tests perception time, target acquisition, target following, dynamic visual acuity and gaze stabilization.
- U.S. Navy photo by Mass Communication Specialist 1st Class Cindy Gill (HIPAA Released).

Materials and Methods

- InVision Mirror Tunnel (NeuroCom International, Clackamas, OR, USA)
- Testing was performed in a dimly lit room
- Test distance was 13 feet
- Subjects were seated in a chair with the cross hair on the display at eye level
- The optotype was a letter “E”.
- Subjects were asked to report which way the E was pointing or respond “I don’t know”

Vestibular Visual Cognitive Interaction

inVision Tunnel

- Tracking recovery of vestibular function in individuals with blast-induced head trauma using vestibular-visual-cognitive interaction tests.

Patient Goals

- Short Term Goal: able to walk 20 feet with horizontal head motion and not veer to the side in three weeks as defined by the Functional Gait Assessment (FGA)
- Long Term Goal: decrease horizontal DVAT LogMAR loss to no more than 0.2 LogMAR in six weeks
- Self Goal: the patient’s self-goal was to return to fit for full performance in his assigned position

Team approach

- Initial evaluations by the core treatment team
  - Physical medicine and rehab
  - Neuropsychology
  - Vestibular physical Therapy
  - Neuro-occupational Therapy
  - Speech Pathology
  - Mental health

Example schedule

- Individual Appointments scheduled to meet patients needs
- For Example:
  - Vestibular 1-2x/wk for 8-12 weeks
  - Speech 1-2x/wk for 8-12 weeks
  - Mental Health 1-2x/wk for 8-12 weeks
  - Primary Care 1x week and as needed
Keeping communication

- Care Conference with patient approximately 2 weeks into the program
- Team Approach
- Patients healthcare team meets together with the patient
- Discusses with patient their progress, needs, and goals
- Patient can discuss concerns and personal goals with team

Group discharge

- Patient will have another care conference if needed mid program
- 1 week before the end of the patients program they will have a final care conference
- Accomplishments/goals reached
- What patient needs to continue to work on
- Can the patient go back to full duty or need a medical board
- Included in on conference is a provider and case manager from patients command for continuation of care and seamless transition
- Follow up with primary care

Outcomes

- 9 weeks after evaluation
- STG was met, LTG partially met
- Patient was able to return to unit with limited duties and improved morale

Discussion

- Success can be seen in improvement and return to functional activities
- Was unable to return to full work related activities in his previous capacity as a result of injuries, persistent residual utricular weakness and required use of hearing aid

Summary

Pathology or Disease Process Matters

| Disease process | Severity | Complexity | Recovery/Prognosis
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke 1° central</td>
<td>Mild Moderate Severe</td>
<td>Low to moderate complexity</td>
<td>Good recovery At Risk for 2° stroke Severe may not return to prior level of function</td>
</tr>
<tr>
<td>MS 1° central</td>
<td>Mild Moderate Severe</td>
<td>Moderate complexity Fatigue impacts performance</td>
<td>Good recovery Susceptible functional loss in the future</td>
</tr>
<tr>
<td>TBI Mixed central and peripheral</td>
<td>Mild Moderate Severe</td>
<td>High complexity Multiple systems Cognitive involvement?</td>
<td>Longer recovery? Did not return to prior level of function</td>
</tr>
</tbody>
</table>

Test and Measures

<table>
<thead>
<tr>
<th>Oculomotor</th>
<th>Vestibular VOR</th>
<th>Balance</th>
<th>Ambulation</th>
<th>Self reported Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke</td>
<td>+ Screw deviations SSV*</td>
<td>HT Provoked sylv/LOR Positional test</td>
<td>Romberg Fukuda step test SOT H5 SOT</td>
<td>ABC</td>
</tr>
<tr>
<td>MS</td>
<td>+ Spon Nys + direct changing Nys</td>
<td>BBS DGI MMWT</td>
<td>DHI</td>
<td></td>
</tr>
<tr>
<td>TBI</td>
<td>+ Spon Nys + saccadic abnormalities + convergence + SVV</td>
<td>HT test Calaric Rotatory chair Positional test DGVAT</td>
<td>FGA HIMAT DHI ABC</td>
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</tr>
</tbody>
</table>
Summary: Interventions

<table>
<thead>
<tr>
<th>Osoculumor</th>
<th>Vestibular gase stability</th>
<th>Balance</th>
<th>Ambulation/endurance</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke</td>
<td>Ocular exercise</td>
<td>VOR*</td>
<td>Static standing</td>
<td>Dynamic standing</td>
</tr>
<tr>
<td>MS</td>
<td>VOR x 1 Head movements</td>
<td>NBOS</td>
<td>Sensory input</td>
<td>Progression of VOR</td>
</tr>
<tr>
<td>TBI</td>
<td>Depth perception</td>
<td>Convergence exercises</td>
<td>VOR</td>
<td>Dynamic Q2 DQ</td>
</tr>
</tbody>
</table>

Future Research

- Population based
- Age
- Fatigue in MS
- Effectiveness of osoculumor exercise

References


1/23/2013

Anne Galgon, Jeff Hoder, Kim Gottshall, Herb Karpathik: not to be copied without permission