Subjective Visual Vertical (SVV): part of the vestibular test battery

Jorge E. González, Ph.D., CCC-A
Department of Audiology & Speech Pathology
Bloomsburg University of Pennsylvania
Disclosure

Jorge González is a paid consultant to Neuro-Kinetics, Inc., a manufacturer of vestibular test equipment, on audiologic issues and clinical training.
Objectives

Attendees of this lecture will be able to:

- explain the anatomy and physiology underlying the perception of verticality
- describe different techniques, both basic and advanced, used to perform the SVV.
- describe the clinical manifestations of SVV for different vestibular pathologies and the limitations of the test procedure.
- discuss the benefit or possible clinical utility of SVV in diagnosing vestibular pathologies.
Vestibular testing

- Common tests include:
  
  Tests of Horizontal Semicircular Canal (HSCC)
  - Calorics, Head Thrust, head shake, autorotation

  Tests of Posterior / Anterior Semicircular Canal(s) (PSCC/ASCC)
  - Dix-Hallpike, Head Thrust in the RALP / LARP planes

- In examining 2584 cases, Stockwell noted that 1571 (61%) of patients with vestibular complaints had no abnormalities on traditional tests of vestibular function (ENG).

- Many times, reported symptoms do not correlate with those associated with canal dysfunction
  - Lateropulsion (lateral push), rocking, tilting, nonspecific dizziness

- In light of these things, there is the potential that many patients are not being properly diagnosed
The Otoliths

- Within the inner ear, the sensory organs that detect angular movements are the semicircular canals (SCC).

- The sensory organs that detect linear movements are the otoliths.

- The saccule is oriented at 22-46° from the sagittal plane:
  - detects linear vertical movements

- The utricle is oriented in nearly the horizontal plane:
  - detects linear horizontal movements
  - detects the force of gravity
Normally functioning utricles at rest

Perception within CNS due to symmetric neural firing.

Tests of Utricular function

- Historically, include:
  - Parallel swing
  - Linear sled testing

- Limitations:
  - Equipment cost
  - Space requirement
  - Poor sensitivity


http://history.nasa.gov/NP-119/ch2.htm
Examination of the otoliths

Tests of saccular function
- Vestibular Evoked Myogenic Potential (VEMP)
  - Cervical VEMP (cVEMP)
  - Ocular VEMP (oVEMP)

Tests of utricular function
- Static Subjective Visual Vertical (SVV)
- SVV with Dynamic unilateral centrifugation (UC)
- Off-Vertical Axis Rotation (OVAR)
Difficulties in evaluating the utricles

- Limited availability of equipment in many clinics
- Uncertainty of clinical symptoms and manifestations
History of SVV testing

- Started in the field of psychology in 1950’s
  - (e.g., Wapner et al. 1951)

- Numerous studies on SVV performed by military & NASA

- Perception of verticality attributed to vestibular system by Friedmann in 1970
Techniques of SVV testing

- Rod technique
  - Manual manipulation
  - In hemispheric dome
  - Rod & Frame technique

Vibert, Häusler & Safran (1999)

Techniques of SVV testing (cont’d)

- modified Maddox glasses
- Reflected light
- LED array
- Laser

Protocol for SVV

- Regardless of technique used, the protocols have some consistencies
  - Performed in dark room
  - Line starts off of true vertical
  - Subject makes the manipulation of the stimulus
Static SVV at Bloomsburg University

- Performed in darkness – in our clinic, within the rotational chair suite
- Patient instruction very clear to not inject bias
- Foil trial included in each set
SVV Norms

- Normals adjust the SVV to within a few degrees from the gravitational vertical.
  - $\pm 2.0^\circ$ (Akin & Murnane, 2009; Bohmer, 1999; Friedmann, 1970; Murray, et al. 2007; Tabak, et al. 1997; Vibert & Häusler, 2000)
  - $\pm 2.5^\circ$ (Tribukait, et al. 1996; Tribukait, & Bergenius, 1998; Tribukait, & Eiken, 2005; Tribuikait, et al. 2004)
  - $\pm 3.0^\circ$ (Hafstrom, et al. 2004; Karlberg, et al. 2002)

- The reported variances for these normative studies differ between 0.5 and 1°

- No significant change in SVV with aging (Kobayashi, et al. 2002)
Observed SVV in patients

- Patients with abnormalities will deflect the top of the line (SVV) or the lowest part of the line (SVH) toward the dysfunctional side
  - Weakness of right utricle
    - Line > +2.5 degrees (more positive than +2.5 degrees)
  - Weakness of left utricle
    - Line < -2.5 degrees (more negative than -2.5 degrees)
  - Bilateral utricular weakness
    - There may be no detectable difference if the loss is symmetrical
    - The SVV may be < ±2.5° or the results may be random
Abnormally functioning utricles at rest

Perception of tilt due to asymmetric neural firing.

Effects of vestibular pathology on SVV

- Acute Ménière’s Disease (Kumagami, et al. 2009)
  - Pre-attack: $<\pm 2.5^\circ$
  - During attack: abnormal SVV
    - Towards lesion (92.9%)
    - Away from lesion (7.1%)

- Unilateral vestibular neuritis (Min et al. 2007)
  - Mean: $\pm 3.51^\circ$ ($SD=2.49$)
Effects of vestibular pathology on SVV (cont’d)

- Surgical deafferentation (Vibert et al. 1999)
  - 10 - 30° with vertical frame
  - 5 - 15° with Maddox rod

- Vestibular labyrinthitis (Vibert et al. 1999)
  - SVV > 2°
Limitations of SVV

- Currently, there is no literature discussing precision of verticality
  - Important since norms can range from 2 to 3
- The typical protocol for SVV is based on methods of adjustment
  - Examiner has little control over responses
  - Possible subject bias, inter-subject and inter-trial variability
- Electromechanical manipulation of angle may be imprecise

- Within a year, many patients demonstrate an improved SVV (Takai et al. 2006)
  - Tabak and colleagues (1997) suggested possible permanent change
Limitations of SVV (cont’d)

- Within a year, many patients demonstrate an improved SVV (Takai et al. 2006)
  - Tabak and colleagues (1997) suggested possible permanent change

- There may be an effect of preset angle on the SVV (Pargarkar et al. 2008)
  - Sometimes, pts will perceive SVV slightly to the side of the initial offset
SVV during Dynamic Unilateral Centrifugation (DUC)

- SVV estimated during rotation at high velocities
  - in both right ear & left ear eccentric conditions

- Eccentric protocols
  - Translation during rotation
  - Translation prior to rotation

- SVV testing performed multiple times during eccentric conditions
SVV during Dynamic Unilateral Centrifugation (DUC)

- Akin et al. 2011
  - Studied 24 individuals
  - Tested in on-axis CW, off-axis CW right, off-axis CW right

- Norms
  - On-axis: mean: 0 (SD = 1.2)
  - Off-axis right: mean: -3° (SD = 2.1)
  - Off-axis left: mean: -5° (SD = 2.6)

- Recommended looking at difference between eccentric & centric values
  - Differences > 4° normal
Stimulation of utricles during UC testing

Perception of tilt due to asymmetric neural firing.

Subjective Visual Horizontal (SVH)

- Corollary test to the SVV
  - patients adjust the position of a line to their perceived horizontal

- Mean SVH for normals:
  - $< 1.00^\circ$ (Chae, et al. 2000, Pinar et al. 2005, Takai et al., 2006)

- Individuals with abnormal utricular function adjust the SVH line with side of the abnormal ear lower than that of the intact ear (Min, et al. 2007, Ushio, et al. 2008).
Effect of vestibular pathology on SVH

- **Acute vestibular neuritis**
  - 2.35° (Min et al. 2007)

- **After vestibular deafferentation**
  - > 10° (Takai, et al. 2006)

- **After gentamicin**
  - *Mean*: 8.26° (*SD*: 4.45) down toward treated ear (Tribukait et al. 1998)

- **After stapedotomy**
  - *Mean*: 4.02° (*SD*: 2.53) down toward untreated ear (Tribukait & Bergenius, 1998)
Developments in SVV / SVH

- SVV bucket (Zwergal, et al. 2009)
  - Developed an inexpensive tool to assess SVV in patients
  - The bucket allows for easy bedside examination

- To build your own SVV bucket
Developments in SVV / SVH

  - Tested 30 normals & 30 pts with acute peripheral or central vestibular lesions
  - Compared hemispheric dome to bucket method
    - SVV in normals: 1.1° by dome, 0.9° by bucket
    - SVV in vestibular pts: 8.9 – 9.5° by dome, 8.3 – 8.7° by bucket
  - Recommended for use as bedside test for acute vertigo, brainstem infarcts, ocular motor disorders
Modified Rod and Frame

- Developed by Docherty & Bagust (2010) to eliminate changes in stimulus that may affect results
  - Tested 30 normals
  - Found no difference between 2 methods
  - Recommended using dots to eliminate stimulus artifact
Adaptive procedures for SVV & SVH

- We used a modified Method-of-Limits procedure for SVH in multiple tracks, based upon Jesteadt (1980).

- The mean SVV using the adaptive procedure were 0.52° ($SD = 0.42$) while the mean SVV for manual adjustment were 0.82° ($SD = 0.63$).

- These means were different ($t(29) = 2.26$, $p = 0.03$) and significantly correlated ($r = 0.72$, $p < 0.01$).

- The mean SVH deviations using the adaptive procedure were 0.60° ($SD = 0.48$) and 1.12° ($SD = 0.88$) for the manual method.

- These results were statistically significant ($t(32) = 4.48$, $p < .01$) and significantly correlated ($r = .67$, $p < .01$).
Conclusions

- SVV/SVH testing are useful tests in the diagnosis of vestibular disorders
- SVV is a test of utricular function that will show abnormalities in a number of different conditions
- SVV in both static and dynamic UC conditions provide useful clinical information
- Evaluation of utricular function can be performed reliably with basic tools
References

References (cont’d)

Questions?

Thank you.

Enjoy the rest of the conference.