Subjective Visual Vertical in Various Vestibular Disorders by Using a Simple Bucket Test

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Abstract Subjective Visual Vertical (S.V.V.) assesses the ability to perceive verticality which depends on visual, vestibular and somatosensory inputs. The judgment of verticality is altered when there is otolith dysfunction. Objective of our study was to present a simple method to assess S.V.V. and to analyze S.V.V. changes in various vestibular disorders. 100 subjects presenting with vestibular disorders in period of 1 year 2 months were subjected to Neurotological history and examination. Patients with non-vestibular causes were excluded. S.V.V. was tested with a simple innovative device—a specially designed bucket. The angle of deviation from vertical was noted in degrees. Normal deviation is $0 \pm 2^\circ$. Out of 23 patients with vestibular neuritis 83 % showed abnormal S.V.V. Amongst 11 patients of Meniere's disease, 55 % and 42 patients of BPPV, 71 % had abnormal S.V.V. Amongst 24 patients with other causes 15 % showed abnormal S.V.V. S.V.V. is a reliable screening tool in assessment of vestibular dysfunction along with other clinical tests. It has a prognostic value during recovery following vestibular damage. The modified 'Bucket' is a simple, easy to use and cost-effective device to do the S.V.V. in daily practice.

Keywords Subjective visual vertical · Bucket test · Otolith dysfunction · Vestibular vertigo

Introduction

Subjective Visual Vertical (S.V.V.) is the ability of a person to perceive verticality. The purpose of S.V.V. test is to detect abnormal subjective tilt. In normal persons, the ability to perceive verticality is quite good. This ability is dependent on input from visual, vestibular and somatosensory systems. The otolithic organs in the vestibular system sense gravity. Both the utricle and saccule contribute to the sense of verticality. After injury to the otoliths, or to the nerve that transmits impulses from the otoliths and other parts the ear to the brain, judgement of vertical may be altered, which literally tilts ones vision.

A person with vestibular disease may not perceive a vertical line as vertical resulting in deviation from normal which, can be measured in degrees. A commercial method of measuring S.V.V. is a device that projects a laser line onto a screen. The angle of the line with respect to a reference can be read out by the tester. By allowing a subject to repeatedly set the line to vertical, one can measure S.V.V. Tests for S.V.V. are many viz; Maddox rod, vertical beam projected on screen, motor driven hemisphere with dots, etc. which are used in most research labs across the world.

Despite being easy to perform and interpret, the evaluation of S.V.V. is not routinely carried out in vertigo clinics across India. This is probably because of lack of expensive equipment in clinics and the motivation to carry out the test due to time constraints in a busy out-patient department. The bucket test, first described by Zwergal [1], used in our study is simple and quick to perform routinely in daily

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OPD. In our study we have assessed the results of S.V.V. in various vestibular disorders, its value in diagnosis and prognosis of the disease.

Objectives

1. To present a simple inexpensive clinical test to assess S.V.V. in patients of vertigo. 2. To analyze the results of S.V.V. values in various vestibular dysfunctions.

Material and Methods

A prospective cross sectional cohort study was carried out in 100 patients in age group of 18–77 years, presenting to a private vertigo clinic of an E.N.T. hospital with complaints of rotatory vertigo of vestibular cause over 1 year, 2 months (Nov 2012–Dec 2013). Inclusion criteria: 1. Patients with history of rotatory vertigo. 2. Patients diagnosed with vestibular cause viz; B.P.P.V., Meniere's syndrome, Vestibular Neuritis, Vestibulopathy, labyrinthitis, Migrainous vertigo, vestibular paroxysmia and semicircular canal dehiscence. Exclusion criteria: 1. Patients with non vestibular cause for vertigo. 2. Patients with poor uncorrected vision.

All the patients presenting with vertigo were subjected to Neurotological history taking & examination, including the Unterbergers stepping test, Head Impulse Test, Dix-Hallpike test, E.N.G with Caloric tests, Audiometry & MRI in indicated cases and all underwent S.V.V. measurement by "Bucket test".

Patients were given conventional treatment for the underlying disease and asked to follow up at 1 week, 2 weeks and one month intervals and reassessed clinically by above tests.

The patients were classified into definite diagnosis of vestibular disease based on clinical findings and investigations. Criteria for vestibular neuritis were acute vertigo with spontaneous nystagmus or old history of the same, a viral prodrome, canal paresis on caloric test and no hearing loss. Criteria for Meniere's disease according to the A.A.O.O. guidelines were followed viz, episodes of rotatory vertigo, lasting for at least 20 min, documented sensorineural hearing loss and tinnitus with aural fullness. B.P.P.V. was confirmed with history of rotatory vertigo lasting for few seconds in changes of head position and a positive Dix- Hallpike test. Migrainous vertigo was diagnosed in patients with vertigo of variable durations with past history of migrainous attacks and who improved on treatment protocol for migraine. Patients suspected with labyrinthitis, perilymph fistula and semicircular canal dehiscence were placed in a group termed "others".

Bucket test: A simple plastic bucket is modified for the test. On the inside of its bottom is a vertical line drawn with Radium ink. On the outside of the bottom is a protractor print (showing angles in degrees) pasted, so that the zero of this scale is in line with the vertical line drawn inside. A string with a weight is fixed in a way that it hangs from the centre outside over the scale. As the bucket is rotated the string with the weight moves over the scale indicating the degree of deviation from vertical. (Fig. 1). The subject looks into the bucket holding it in his hands. The examiner rotates the bucket clockwise and anticlockwise for six trials and fixes at one position, asking the subject to re-rotate it till he perceives that the radiant line is vertical. The angle of deviation is measured on the outside indicated by the string on the scale as in degrees away from 0°. A mean of the result of six trials is taken as absolute value. Normal range of deviation is $0 \pm 2^\circ$ [1].

Observations

The distribution of the 100 patients as per their etiology is shown in Table 1.

Out of 23 patients diagnosed as Vestibular Neuritis (Fig. 2) 19 had abnormal deviation of S.V.V. at first visit, four did not show any deviation. S.V.V. value of more than two degrees to the right or the left was considered abnormal. More 85 % of the patients with abnormal S.V.V. (range was from >2 to 7°) showed deviation to same side as hypoactive labyrinth on caloric test, whereas in 15 %, the deviation was to opposite side as that of hypoactive labyrinth on calorization. On follow up after 2 weeks, 15 patients still had abnormal S.V.V. and eight had normal values. All the patients were on vestibular rehabilitation therapy. At 1 month follow up 18 patients showed a normal S.V.V. where as only three had abnormal S.V.V., two patients did not follow up.

Meniere's disease was diagnosed in 11 patients (Fig. 3), six of whom showed abnormal values of S.V.V. and in five it was normal. Amongst patients with abnormal S.V.V. values, three patients showed deviation to same side as the disease, one to opposite side and two of patients had bilateral disease.

Out of 44 patients of B.P.P.V. (Fig. 4), 36 had unilateral B.P.P.V. of posterior semicircular canal and six had Lateral Semicircular Canal involvement. 30 patients had abnormal S.V.V. to the same side, four to opposite side and in eight patients it was normal. They were all subjected to repositioning maneuvers. On follow up after 1 month out of 32 patients, 30 had a normal S.V.V. and two still had abnormal value. Ten patients did not follow up.

Other causes of vestibular dysfunction included Migraine related Vertigo (10), Idiopathic vestibulopathy

Fig. 1 S.V.V. measurement done with the bucket

Table 1 Distribution of subjects with vestibular dysfunction $N = 100$

Vestibular disorder	Number of patients
B.P.P.V	42
Vestibular neuritis	23
Meniere's disease	11
Others	24

(5), Vestibular paroxysmia (2), Labyrinthitis (3) and Superior Semicircular Canal dehiscence (1). 20 of these patients had normal S.V.V. values and four had abnormal

values which included all three patients of labyrinthitis and one of idiopathic vestibulopathy.

Discussion

Various test batteries to assess vestibular system are usually limited to the assessment of semicircular canal functions. Nowadays VEMP is being widely used for testing saccular function. Utricular function can be tested by S.V.V. In our study we used a simple plastic bucket which was modified very easily to measure the S.V.V. Research has shown that there is no difference between results using

Fig. 2 The findings of S.V.V. in patients of Vestibular Neuritis ($N = 23$)

Fig. 3 The findings of S.V.V. in patients of Meniere's disease ($N = 11$)

Fig. 4 The findings of S.V.V. in patients of B.P.P.V. ($N = 42$)

the bucket test and more expensive testing apparatus [1]. We found this method though not very sensitive, is quick, inexpensive, easy to replicate, re-test and comfortable for the patients in our routine assessment.

In humans, the perception of vertical is provided by input from various sensorineural organs and pathways: vision, eye-movements, and proprioceptive and vestibular cues, particularly from the otolithic organs and graviceptive pathways. Friedman, in 1970, studied subjective vertical in a variety of clinical situations. Normal subjects can adjust an illuminated rod in an otherwise completely dark room to vertical within a mean error of less than 2° . Friedman concluded that severe derangement of this test is confined to brainstem lesions and the immediate postoperative period of peripheral vestibular lesions. The S.V.V. tilts toward the side of lesion [2].

Though well known in several types of brainstem lesions, S.V.V. abnormalities may also be observed after peripheral vestibular lesions, such as surgical de-afferentation, with a deviation directed toward the operated ear. Subjective Visual Vertical abnormalities are presumably related to a lesion of the otolithic organs and/or to changes in the afferent graviceptive pathways. Vibert et al. in their prospective study, measured the S.V.V. and defined the influence of the otolithic organs in patients suffering from various types of peripheral vestibular diseases: unilateral sudden cochleo-vestibular loss, so-called “viral labyrinthitis”, sudden idiopathic unilateral peripheral vestibular loss, so-called “vestibular neuritis” [3]. Data were compared with findings after unilateral surgical deafferentations such as vestibular neurectomy and labyrinthectomy. Subjective Visual Vertical was measured with a binocular test (vertical frame) and a monocular test (Maddox rod). Their results demonstrated that S.V.V. is frequently tilted in acute peripheral vestibulopathies. These findings suggested that otolithic function is implicated in the deficit

Table 2 Percentage of cases with abnormal S.V.V. in various vestibular disorders in our study

Vestibular disease	Percentage of cases with abnormal S.V.V. (%)
Vestibular neuritis	81
B.P.P.V	71
Meniere's disease	52
Labyrinthitis	100

depending on the extent and/or the localization of the peripheral vestibular lesion [3].

In our study of S.V.V. in vestibular disorders we found that 83 % of patients with Vestibular Neuritis had abnormal S.V.V., 71 % of B.P.P.V. cases, 52 % of Meniere's disease, 100 % of patients with acute labyrinthitis did have abnormal S.V.V. frequently towards the side of lesion (Table 2). We did not have any cases of operated Vestibular neurectomy or Labyrinthectomy.

Amongst the 23 patients of vestibular neuritis, we found that 83 % had tilting of subjective vertical, in 85 % towards side of lesion, i.e. a hypoactive labyrinth on calorization and Unterberger's stepping test. In most of patients compensation occurred with vestibular exercises, S.V.V. being abnormal in only 64 % at 2 weeks and at 1 month follow-up, 79 % showed no deviation. Three patients who still had S.V.V. tilt were those who were non compliant with the vestibular rehabilitation therapy. The improvement in S.V.V. tilt correlated very well with the improvement of symptoms in our patients. However, Heil Noh and Sayong Chae in their study of 62 patients with vestibular neuritis found that there was no relation between the canal paresis and the tilt of S.V.V. Yet their results showed that S.V.V. correlated with clinical improvement of dizziness symptoms in vestibular neuritis, thus help evaluate vestibular neuritis during the follow up [4]. S.V.V.

is useful in clinical practice in persons with vestibular neuritis [5]. The range of abnormal tilt on either side in our cases was from more than 2 to 7°. Literature mentions that persons with vestibular lesions may orient the bar tilted as much as 10° [6]. The S.V.V. reverts to normal in labyrinthectomy by 1 year. In vestibular nerve section, a small deviation may persist after neurectomy even after 4 years [7].

Literature search was not fruitful in case of S.V.V. done on patients with active or remitted Meniere's disease except for those who underwent labyrinthectomy or neurectomy. In patients with Meniere's disease, operated with labyrinthectomy, a marked deviation toward the operated side was found acutely, with resolution over weeks [7]. Our study included 11 cases of diagnosed Meniere's syndrome, in varying stages of the disease, two of who had bilateral disease. 55 % of these patients had abnormal S.V.V. amongst which again in 50 % the tilt was to same side as the disease. This correlated with the hypoactive labyrinth on caloric test and Unterberger's stepping test. In bilateral Meniere's disease S.V.V. is insensitive to lateralization hence of little value.

S.V.V. is slightly biased during eccentric rotation in persons with B.P.P.V. This probably reflects unilateral utricular disturbance [8]. Amongst our 42 patients diagnosed as BPPV. 86 % had posterior SCC BPPV and 14 % had lateral SCC BPPV. At first visit, 71 % did show abnormal S.V.V. towards affected side, 19 % had normal S.V.V. and in rest, the tilt was to opposite side. After treatment by canal repositioning maneuvers, at one month follow up, 17 % showed a normal S.V.V. Amongst the patients grouped as "other causes", all three patients of labyrinthitis had tilt to affected side, one patient with idiopathic vestibulopathy showed abnormal S.V.V., whereas the patients diagnosed as Vestibular Migraine, Vestibular paroxysmia and Superior canal dehiscence showed normal S.V.V. None of our patients diagnosed as vestibular migraine showed abnormal S.V.V. though literature mentions that S.V.V. maybe altered in vestibular migraine [9].

Conclusion

Static S.V.V. is a useful measure of utricular dysfunction in acute peripheral disorders especially vestibular neuritis. It has a potential use in measuring compensation, prognosis and recovery in various peripheral vestibular conditions. The bucket test though not very sensitive is a simple, cost effective, easy and quick method to assess S.V.V. in daily practice. It should be made a part of routine neurotological examination while evaluating a patient of vertigo.

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