Journal of Otology 17 (2022) 46–49

Contents lists available at ScienceDirect

Journal of Otology

journal homepage: www.journals.elsevier.com/journal-of-otology/

A possible objective test to detect benign paroxysmal positional vertigo. The role of the caloric and video-head impulse tests in the diagnosis

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ARTICLE INFO

Article history:
Received 31 October 2021
Received in revised form
10 November 2021
Accepted 12 November 2021

Keywords:
Caloric test
Video-head-impulse test
Benign paroxysmal positional vertigo
Objective diagnosis

ABSTRACT

Background: Benign paroxysmal positional vertigo (BPPV) is characterized by vertigo lasting from seconds to minutes, induced by head movements.
Objectives: Our study aimed to investigate the clinical significance of the caloric vestibular and video head-impulse tests (vHIT) diagnosing the disorder.
Methods: 68 patients suffering from posterior canal BPPV (25 male, 43 females, mean age ± SD, 54.5 ± 13.2 years) and 56 patients with a normal functioning vestibular system as control were investigated. Bithermal caloric test and vHIT was performed during the same medical check-up. Canal paresis (CP%), gain (GA) and asymmetry (GA%) parameters were calculated.
Results: The Dix-Hallpike manoeuvre was only positive in 4% of this population. The CP% parameter was only pathologic in two patients, and there was no significant difference between control and BPPV patients ($p = 0.76$). The GA value was never under 0.8 in this population, but GA% was abnormal in 63.2%. A significant difference comparing the GA% values to the control group was seen ($p = 0.034$). There was no correlation detected between the CP% and GA% values in BPPV. Regarding the GA% value, 61% sensitivity and 76% specificity was seen.
Conclusion: The Dix-Hallpike manoeuvre was not often positive in the non-acute phase of BPPV; therefore, objective testing is essential. The caloric test does not have clinical significance in BPPV, but vHIT can be helpful based on the GA% parameter.

1. Introduction

Benign paroxysmal positional vertigo (BPPV) is the most common peripheral vestibular disorder (Seidel, 2019), clinically characterized by episodes of vertigo lasting from seconds to minutes, induced by head movements and accompanied by vegetative symptoms (von Brevern, 2017). The pathological background of BPPV is the dislocation of the calcium carbonate crystals (i.e. otoconia) in the inner ear, resulting in canalo- or cupulolithiasis (Schuknecht, 1969; Hall, 1979). In most cases (80–90%), canalolithiasis occurs in the posterior semicircular canals (p-BPPV) because it is the most gravity-dependent part of the vestibular end-organ (Anagnostou, 2015). BPPV diagnosis is based on the typical clinical history and on provocative positional testing, which – in the case of p-BPPV – is the so-called Dix-Hallpike manoeuvre (von Brevern, 2015; Argaet, 2019). However, the specificity and sensitivity of the manoeuvre were identified as 79% and 75% in a previous study (Halker, 2008). The video-head impulse (vHIT) and caloric tests are the most common objective methods used in everyday neurotologic practice. Both of them evaluate the vestibular function based on the measurement of the vestibulo-ocular reflex (VOR). The vHIT test allows the examination of all six semicircular canals at physiologic higher frequencies during high-velocity impulses induced by the examiner. It is easy to carry out in everyday practice (Mangabeira Albernaz, 2014). The bithermal caloric irrigation test can examine the function of the horizontal semicircular canals and the superior parts of the vestibular nerve at non-physiologic low frequencies. It can be time-consuming and also stressful for the patients (Mahringer and Rambold, 2014).

The presented study aimed to examine the possible role and clinical significance of the two tests in diagnosing BPPV. The

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Peer review under responsibility of PLA General Hospital Department of Otolaryngology Head and Neck Surgery.

https://doi.org/10.1016/j.joto.2021.11.001

Table 1
Based on the control group's results, the normal value of the GA% parameter, according to the mean ± SD parameters, and the lower and upper 95% ranges. The GA% was defined as normal under 16%.

	Mean	SD	Lower 95% range	Upper 95% range
GA%	13.52	1.24	11.04	15.76

correlation between the results of the two examinations was also contrasted.

2. Materials and methods

2.1. Patients

In this study, a total of 68 patients suffering from p-BPPV (25 male, 43 females, mean age± SD, 54.5± 13.2 years) were investigated, and 56 patients with a normal functioning vestibular system as control were also enrolled. The studied BPPV patients were included based on the previously positive Dix-Hallpike manoeuvre taken from the patients' medical data. All patients were diagnosed as having p-BPPV based on international recommendations as follows:

(1) Recurrent attacks of positional vertigo or positional dizziness provoked by lying down or turning over in the supine position.
(2) Duration of attacks <1 min.
(3) Positional nystagmus elicited with a latency of one or a few seconds by the Dix-Hallpike manoeuvre or side-lying manoeuvre (Semont diagnostic manoeuvre). The nystagmus is a combination of torsional nystagmus, with the upper pole of the eyes beating toward the lower ear, combined with vertical nystagmus beating upward (toward the forehead), typically lasting <1 min.
(4) Not attributable to another disorder (von Brevern M, 2017).

The control patients did not complain about vertigo and had no history of vestibular disorders in the anamnestic data. The physical examinations did not show vestibular aberrations either.

The study had the consent of Semmelweis University Regional and Institutional Committee of Science and Research Ethics: 48/2018.

2.2. Examinations

Initially, all patients were tested for spontaneous nystagmus, optokinetic eye movements and horizontal tracking. The caloric test was performed using the CHARTR air caloric stimulator, NCA-200, and the eye movements were recorded using a MUC-100 electronystagmography system (1990, ICS Medical Corporation, Schaumburg, Illinois). Bithermal caloric test was performed with a constant airflow at 25 and 50 °C for 40 s, with the patient supine on both sides. Canal paresis (CP%) parameter was calculated based on the modified Jongkees' formula.

The vHIT test was carried out using an ICS Impulse System (Otometrics 1085). The patients were asked to wear a pair of lightweight goggles with a digital camera system to detect their eye movements. The patient was asked to focus their vision on a point located about 1.5 m in front of them. After calibration, high-velocity head impulses with low amplitude in the horizontal plane were applied by the examiner. The patients underwent at least 20 unpredictable impulses. The system calculated the gain (GA) and gain asymmetry (GA%) parameters. The GA parameter was defined normal as 0.8<, as per the recommendation of the manufacturer. GA% normal value was calculated according to the result of the investigated normal subjects, as shown in Table 1 below. For all patients, all three semicircular canals (including the anterior and posterior ones) were tested, but for data analysis (i.e., to contrast the results with caloric test), the GA and GA% values of the horizontal canals were included. Both tests were performed during the same medical check-up.

2.3. Statistical analysis

The IBM SPSS V24 software was applied for data processing. The data were tested for normal distribution using the Shapiro-Wilk test. Since the parameters were not normally distributed, the Mann-Whitney *U* test was used. The simple linear correlation, Spearman correlation, and Kappa tests were applied to detect correlation. Moreover, ROC curves were drawn to define sensitivity and specificity parameters. A statistically significant difference was set at $p < 0.05$.

3. Results

In the diagnosis of BPPV, the diagnostic test considered the most sensitive is the Dix-Hallpike manoeuvre; however, in this population, it was positive only in 3 subjects (4%). Therefore, it is essential to find another objective test to verify the diagnosis. Table 2 summarizes the results of caloric and vHIT tests, analyzing by correlation tests.

As shown in Table 2., the caloric test was not often pathologic in BPPV. Only two patients had significant canal paresis; these patients suffered from secondary BPPV, combined with Ménière's disease or vestibular neuritis. In 97% of the cases, the caloric test showed normal results. As shown in Fig. 1, there is no apparent difference between control patients' boxes and those suffering from BPPV in terms of CP%, indicating that canal paresis is not characteristic of BPPV. GA parameter of vHIT was never defined as pathologic in this disorder, suggesting a normal function of the horizontal canals. However, the GA% parameter was over 16% in 63.2% of the cases. When the parameters of BPPV patients and control patients regarding GA% were contrasted, a statistically significant difference was detected (Fig. 1.).

The possible correlation between the GA% and CP% values was also calculated. The results are shown in Table 2 and Fig. 2. As shown in Fig. 2, no linear correlation was detected between the two parameters, and Spearman correlation did not indicate a non-linear correlation either. The outcome suggests that an increasing tendency in either of the values does not increase the other as well. Categorical analysis (Kappa test) indicates a non-significant correlation, which means that pathologic outcome of one of the tests does not mean a similar outcome in the other one (Table 2).

Sensitivity and specificity parameters for the GA% parameter of the vHIT test were also calculated. Sensitivity was defined as 61% and specificity as 76%. (see Fig. 3).

4. Discussion

BPPV is the most common peripheral vestibular disorder. The diagnostic tests considered the most sensitive for detecting it are the case history and the provocation manoeuvres. Although, based on our data, the Dix-Hallpike manoeuvre was positive in only 4% of the cases. Because of the negative Hallpike manoeuvre, the diagnosis of our BPPV patients was based on the typical anamnestic

Table 2
Results of caloric and vHIT testswith the outcome of the correlation tests. The interpretation of CP% was the following: normal: 20%>, intermediate: 20–40%, severe: 40%<. GA normal value: 0.8<.

	CP% pathologic rate; mean ± SD	GA% pathologic rate; mean ± SD	GA pathologic rate; mean ± SD	Simple linear correlation	Spearman test	Kappa test
BPPV	2/68; 8.38 ± 5.9 SD	43/68; 16.07 ± 7.06	0/68; 1.15 ± 0.2	$R^2 = 0.013$	rho = 0.089; p = 0.578	κ = 0.197 ("slight")

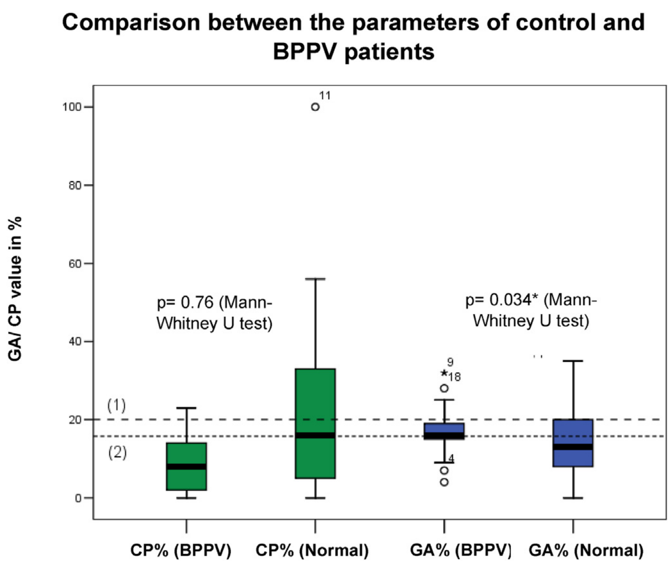

Fig. 1. Boxplot about the CP% and GA% parameters of controls and patients suffering from BPPV. (1): reference line for CP% (showing 20%), (2): reference line for GA% (showing 16%), the * sign indicates the statistically significant difference. The black lines in the boxes represent the median values; the boxes indicate the middle 50% of the data, and the whiskers the upper and lower 25%.

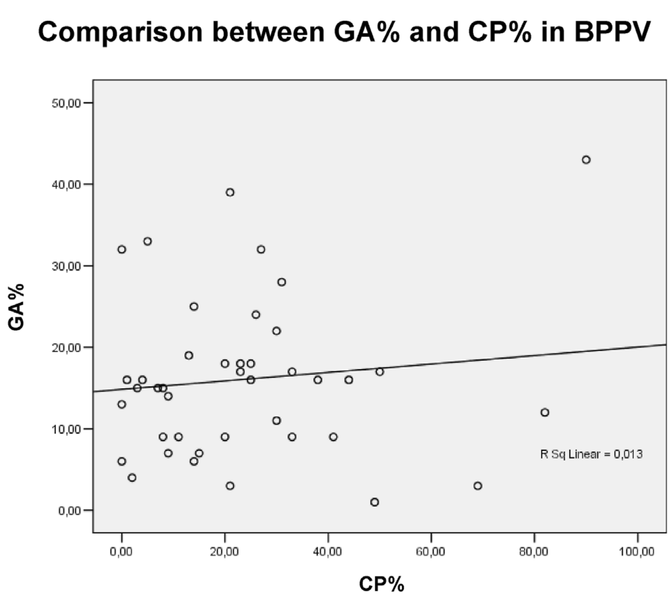

Fig. 2. Analysis of linear correlation between GA% and CP% parameters.

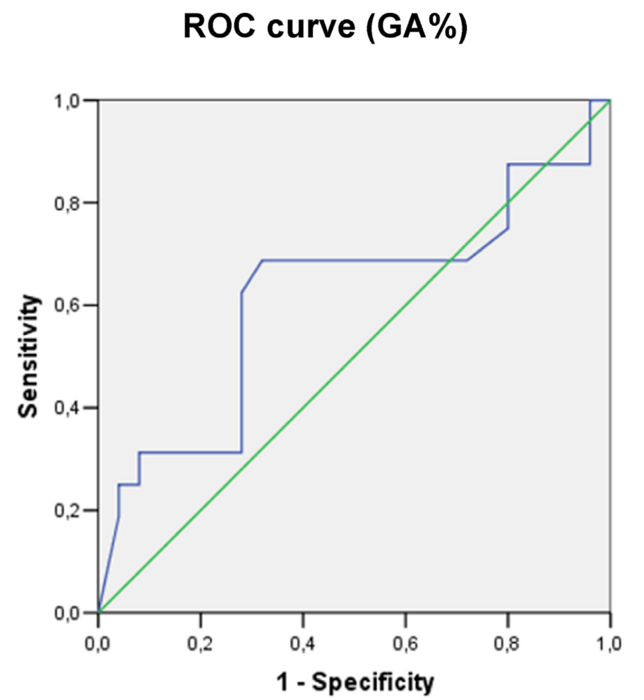

Fig. 3. ROC curve regarding GA% in BPPV. Sensitivity was calculated based on the area under the curve.

data and the previously positive manoeuvre gained from the medical documentation. This result explains that we examined the patients on an appointment basis, not immediately at the emergency department. That is the reason why it is essential to find a test that could detect BPPV. The cause of the symptoms is canalo- or cupulolithiasis, most common in the posterior canals and extremely rare in the anterior ones.

The caloric vestibular test is widely used in everyday neurotologic diagnosis; however, its clinical significance in diagnosing BPPV is questionable. Previously, some studies were undertaken to investigate the benefits of the caloric test regarding the disorder. A study stated that canal paresis was relatively common in BPPV patients; 42.8% showed abnormal caloric results. This study also concluded that canal paresis could be detected in vertical types of BPPV, too; the caloric results of 21.4% of these patients were abnormal. This fact is interesting because it is thought that caloric irrigation selectively investigates the function of the horizontal semicircular canals (Korres, 2004). Although, another investigation detected no statistically significant difference between the normal and involved ears of BPPV patients and the control group's results (Yetişer, 2017). Hence, the caloric test was not confirmed to be an ideal approach to diagnose BPPV. In another study, 156 patients suffering from BPPV were involved, and the caloric test was abnormal in 57% and normal in 43% (Bi, 2019). Regarding the possible pathophysiological background, it was suggested that the otoconia in the endolymph causes gravitational effects and results in changes in the caloric response (Korres, 2004). Based on our data, the abnormal outcome of the caloric irrigation was uncommon, and it was not statistically significant compared with the control group. Only two of the investigated patients showed significant canal paresis, but these cases were secondary BPPV types, as reported previously in the literature (Balatsouras, 2014; Zhu, 2018). Therefore, it can be concluded that the caloric test should be used to exclude other vestibular pathologies, which is also stated in the Clinical Practice Guideline for BPPV (Bhattacharyya, 2017).

The role of vHIT in the diagnosis of BPPV was investigated by some authors. For example, a study found that 35% of the examined BPPV patients had low horizontal canal gain; however, the results were not statistically significant (Saltürk, 2020). In another investigation, the abnormal rate of vertical canal GA values was 66.7%, and that of horizontal canals was 63.1%. In this investigation, all patients were in the acute phase when the vHIT examination was performed (Aslan, 2018). Previously, it was stated that 63% of the patients in the acute group, while in the non-acute, 33% showed abnormal vHIT results, so a pathologic result may depend on the stage of the disease (Mahringer and Rambold, 2014). None of the patients was in the acute phase in our population, and an abnormal GA value was not detected; however, GA% showed higher pathologic rates (63.2%). These rates are much higher than in previous studies and, especially, contrasted to the outcome of non-acute phases of BPPV. In our opinion, BPPV does not directly affect the function of the semicircular canals. A possible explanation regarding the GA% pathologic rates can be that the otoconia attached to the cupular surface might cause a VOR asymmetry between the two sides. BPPV can be categorized as a mechanical disorder; therefore, VOR gain reduction is not expected. An additional explanation of the results of the GA% value can be defined more as an artefact that the examiner often sees: the head and neck muscles of BPPV patients are rigid to prevent head movements, which are the triggers for otoconia displacement.

The Dix-Hallpike manoeuvre was not often positive in the non-acute phase of BPPV; therefore, objective testing is essential. The caloric test does not have clinical significance in BPPV, but vHIT can be helpful based on the GA% parameter.

5. Limitations

Our results are encouraging, although the examination of more patients is necessary, and the GA and GA% values of the vertical canals should also be analyzed. Only patients suffering from p-BPPV were investigated.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Declaration of competing interest

All of the authors declare that they have no conflict of interest.

Acknowledgements

This study was supported by EFOP-3.6.3-VEKOP-16-2017-00009 Project and by the ÚNKP-20-4-I New National Excellence Program of The Ministry for Innovation and Technology from the Source of The National Research, Development and Innovation Fund.

References

Anagnostou, E., et al., 2015. Diagnosis and treatment of anteriorcanal benign paroxysmal positional vertigo: a systematic review. J. Clin. Neurol. 11, 262–267.
Argaet, E.C., Bradshaw, A.P., Welgampola, M.S., 2019. Benign positional vertigo, its diagnosis, treatment and mimics. Clin Neurophysiol Pract 4, 97–111.
Aslan, H., et al., 2018. Our results of VHIT on BPPV. Eur. J. Rhinol. Allergy 1, 12–14.
Balatsouras, D.G., et al., 2014. Benign paroxysmal positional vertigo secondary to vestibular neuritis. Eur. Arch. Oto-Rhino-Laryngol. 271, 919–924.
Bhattacharyya, N., et al., 2017. Clinical practice guideline: benign paroxysmal positional vertigo (update). Otolaryngol. Head Neck Surg. 156, S1–S47.
Bi, J., Liu, B., et al., 2019. Caloric tests in clinical practice in benign paroxysmal positional vertigo. Acta Otolaryngol. 139, 671–676.
Halker, R.B., et al., 2008. Establishing a diagnosis of benign paroxysmal positional vertigo through the dix-hallpike and side-lying maneuvers: a critically appraised topic. Neurol. 14, 201–204.
Hall, S.F., et al., 1979. The mechanics of benign paroxysmal vertigo. J. Otolaryngol. 8, 151–158.
Korres, S.G., et al., 2004. Electronystagmographic findings in benign paroxysmal positional vertigo. Ann. Otol. Rhinol. Laryngol. 113, 313–318.
Mahringer, A., Rambold, H.A., 2014. Caloric test and video-head-impulse: a study of vertigo/dizziness patients in a community hospital. Eur. Arch. Oto-Rhino-Laryngol. 271, 463–472.
Mangabeira Albernaz, P.L., Zuma E Maia, F.C., 2014. The video head impulse test. Acta Otolaryngol. 134, 1245–1250.
Saltürk, Z., Yetişer, S., 2020. Video head impulse testing in patients with benign paroxysmal positional vertigo. Acta Otolaryngol. 17, 1–5.
Schuknecht HF. Cupulolithiasis. Arch. Otolaryngol.. 90, 765–778.
Seidel, D.U., Park, J.J., et al., 2019. Demographic data and seasonal variation in peripheral vestibular disorders in ENT practices in Germany. J. Vestib. Res. 29, 181–190.
von Brevern, M., et al., 2015. Benign paroxysmal positional vertigo: diagnostic criteria. J. Vestib. Res. 25, 105–117.
von Brevern, M., et al., 2017. Epidemiology of benign paroxysmal positional vertigo: a population based study. J. Neurol. Neurosurg. Psychiatry 78, 710–715.
Yetişer, S., İnce, D., 2017. Caloric analysis of patients with benign paroxysmal positional vertigo. J. Int. Adv. Otol. 13, 390–393.
Zhu, M., et al., 2018. Benign paroxysmal positional vertigo associated with Meniere's disease. J. Vestib. Res. 28, 359–364.