Unilateral mimicking bilateral BPPV- a forgotten entity? Characteristics of a large cohort of patients, comparison with posterior canal BPPV and clinical implications

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Abstract

Objective: Unilateral mimicking bilateral benign paroxysmal positional vertigo (umb-BPPV) was attributed to inappropriate head positioning during testing of the posterior canal. Despite its inclusion in the Diagnostic criteria for the classification of vestibular disorders of the Bárány Society, the clinical characteristics and treatment responsiveness of this BPPV subtype have not been intensively studied.

Methods: Records of patients with BPPV seen at a single outpatient dizziness clinic during the years 2000–2020 were reviewed. Eighty seven patients with umb-BPPV and 86 random patients with posterior canal BPPV (p-BPPV) were retrieved. Their demographics and BPPV characteristics were analyzed.

Results: Patients’ and BPPV characteristics were similar in umb- and p-BPPV except for the prevalence of males in the umb-BPPV group. No differences were found between treatment responsiveness and recurrence in both groups. The recurrence rate of umb-BPPV was not influenced by age, gender, BPPV side, duration of symptoms or treatment responsiveness during the first attack.

Conclusions: In accordance with our hypothesis about mixed canal- and cupulolithiasis as the underlying mechanism of umb-BPPV, patients did not differ in characteristics and treatment responsiveness from p-BPPV patients. Recognition of umb-BPPV is important since inappropriate treatment can cause an unnecessary delay in therapy success.

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1. Introduction

Posterior canal BPPV (p-BPPV), the most common type of BPPV, is caused by canalolithiasis [von Brevern et al., 2007]. Otoconia displaced from the macula of the utricle into the posterior semicircular canal move accordingly to gravity and cause inappropriate stimulation of the vestibular end organ during head movements, resulting in vertigo. During the diagnostic Dix-Hallpike maneuver posterior canal containing otoliths is placed by 45° head rotation in the vertical plane to achieve maximal flow velocity of the endolymph during head repositioning. Centrifugal endolymph flow then activates ampullar receptors producing nystagmus that beats to the down most ear [von Brevern et al., 2015; Hain et al., 2005; Honrubia et al., 2001; Five et al., 2008].

We often see patients with a mildly asymmetric, bilaterally positive Dix Hallpike test suggestive of bilateral p-BPPV. However, after treatment of the more prominent side, symptoms and nystagmus disappear on both sides. This phenomenon has been reported in the past as unilateral mimicking bilateral BPPV (umb-BPPV) [Steddin et al., 1994]. It was attributed to inappropriate head positioning of the tested posterior canal, leading to gravitation of the otoliths on the cupula and causing ampullolpetal flow and geotropic nystagmus on Dix-Hallpike manoeuvre of the opposite ear. Other authors were able to distinguish true bilateral BPPV from umb-BPPV by measuring the rotation vector of nystagmus in three dimensions and its time constant [Imai et al., 2008]. Patients with umb-BPPV had a single rotation axis indicating involvement of a single posterior canal. Short time constant of the nystagmus in one ear corresponded to canalolithiasis on this side while long time constant in the opposite ear reflected transient cupulolithiasis of the opposite, firstly tested, ear.

Despite the inclusion of the umb-BPPV in the Diagnostic Criteria
Table 1: Characteristics of patients with umb-BPPV and p-BPPV.

| Characteristics                  | p-BPPV | umb-BPPV | P-value |
|----------------------------------|--------|----------|---------|
| Age (years) mean ± SD            | 63.51 ± 14.90 | 60.63 ± 16.53 | 0.265   |
| Gender                           |        |          |         |
| females n (%)                    | 62 (72.1) | 48 (55.2) | 0.021   |
| males n (%)                      | 24 (27.9) | 39 (44.8) |         |
| BPPV characteristics             |        |          |         |
| duration of symptoms before diagnosis (months) | 38.98 ± 53.30 | 36.17 ± 40.31 | 0.825   |
| left n (%)                       | 41 (47.4) | 43 (49.4) | 0.818   |
| right n (%)                      | 45 (52.3) | 44 (50.6) |         |
| treatment maneuvers (n)          | 2.20 ± 3.49 | 2.33 ± 2.69 | 0.419   |
| minimum treatments (n)           | 1.98 ± 3.52 | 1.65 ± 1.63 | 0.933   |
| maximum treatments (n)           | 2.68 ± 3.68 | 3.22 ± 3.96 | 0.395   |
| Recurrence characteristics       |        |          |         |
| number of recurrences per year   | 2.57 ± 1.63 | 2.11 ± 1.34 | 0.206   |
| follow up (years)                | 3.49 ± 5.54 | 5.05 ± 13.21 | 0.037   |

The patients' characteristic and BPPV were assessed to assess the association between independent variables found to be associated with outcome (p-value < 0.1). The distribution of recurrences in umb-BPPV followed the Poisson distribution and enabled us to examine the association between the number of recurrences and independent variables using Negative Binomial Regressions.

**Ethical approval:** The study was approved by the Ethical review board of the institution according to the principles of the Helsinki Declaration.

2. Methods

Medical records of patients with idiopathic BPPV seen at single outpatient dizziness clinic during the years 2000–2020 were reviewed. Eighty seven patients with umb-BPPV and 86 random patients with p-BPPV were retrieved. The diagnosis of BPPV was established according to the characteristics of the nystagmus evoked by positioning testing - nystagmus guided strategy.

The diagnosis of p-BPPV was based on a history of positional vertigo and a normal neurotological examination except for a positive Dix-Hallpike test. The latter demonstrated a torsional/vertical nystagmus beating toward the lower ear with latency, had a crescendo-decrescendo course, fatigability and reversal [von Brevern et al., 2015; Shuknecht, 1969; von Brevern et al., 2015; Shuknecht, 1969]. Patients with umb-BPPV were cured after 2.20 Epley maneuvers per attack on average, similarly to p-BPPV patients cured by 2.33 maneuvers [Table 1].

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3. Results

The characteristics of patients with umb-BPPV and p-BPPV are summarized in Table 1 and were similar in both groups except for the prevalence of males in the umb-BPPV group. Male gender was also found to be independently associated with a higher probability of having umb-BPPV [Table 2].

No differences were found between the frequency of right and left side in p-BPPV vs umb-BPPV. The mean duration of vertigo prior to first treatment was comparable in both groups of patients. Patients with umb-BPPV were cured after 2.20 Epley maneuvers per attack on average, similarly to p-BPPV patients cured by 2.33 maneuvers [Table 1].

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We further searched for factors influencing recurrences in the umb-BPPV group. Age, gender, BPPV side, mean duration of symptoms until treatment or the number of treatments in the first attack were not associated with the recurrence rate in this group [Table 3].

4. Discussion

While canalolithiasis is the accepted pathomechanism of p-BPPV, pathological findings of otoliths attached to the cupula of the semicircular canal raised the theory of cupulolithiasis [von Brevern et al., 2015; Shuknecht, 1969]. Detached otoconia fall into the short arm of the posterior semicircular canal and get attached to the utricular side of cupula causing excitation of the receptors in an ampullofugal direction, similarly to the free-floating canaloliths. The co-existence of canalolithiasis and cupulolithiasis is difficult to be clinically distinguished [von Brevern et al., 2015; Shuknecht, 1969; House et al., 2003; Imai et al., 2009; Valli et al., 2008; Yatomi et al., 2017; Buckingham, 1999].
We presume that umb-BPPV is caused by mixed canal- and cupulolithiasis of the posterior semicircular canal [Fig. 2]. During positioning testing of the involved ear, geotropic nystagmus is obtained, as expected. On testing the opposite – healthy ear, ampullopetal flow of the otoliths leads to inhibitory stimulation of the vestibular receptors resulting in an apogeotropic nystagmus and mimicking a positive Dix-Hallpike test. This nystagmus lasts longer and is of smaller amplitude than in the opposite ear and is caused mainly by cupulolithiasis since the relatively low weight of canaloliths and their caudal position in the semicircular is not sufficient to evoke vestibular stimulation and nystagmus [Fig. 2]. The posterior semicircular canal cupulolithiasis alone – the heavy cupula might partly explain the pathophysiology of umb-BPPV. It is assumingly caused by density ration changes between the cupula and surrounding endolymph but the nystagmus is quite persistent with no latency [Asprella Libonati, 2012].

In accordance with the above hypothesis are the similarities between BPPV characteristics in patients with umb-BPPV and p-BPPV found in this study. The treatment responsiveness in the umb-BPPV group was comparable with that of the p-BPPV group. We assume that during testing of the opposite ear cupuloliths get easily removed from the short arm of the semicircular canal due to their proximity to the utricle and do not influence the treatment.
outcome.

Similarly, the characteristics of patients were comparable between umb-BPPV and p-BPPV except for gender differences. Males had a predisposition for umb-BPPV as compared to females. This is rather surprising since vestibular disorders in general, and BPPV specifically, were reported to be more common in women [von Brevern et al., 2007; von Brevern et al., 2015]. In a recent study about sexual dimorphism in vestibular function female preponderance was attributed to hormonal and neurochemical differences, female reporting bias or comorbidity such as migraine or depression [Smith et al., 2019]. Osteoporosis and associated changes in otoconia production have also been related to female preponderance of BPPV [Yang et al., 2017; Rhim et al., 2019]. Moreover, anatomical differences in the vestibular system, such as anterior-posterior dimension differences between both sexes, have been recognized [Le Maitra et al., 2017; Cox et al., 2010; Bhattacharya et al., 2008; Welker et al., 2009]. Larger size of some parts of the vestibular system in men could be associated with a predisposition for otoliths displacement into the short arm of the posterior semicircular canal accounting for the prevalence of umb-BPPV in men.

The shortcoming of this study is its retrospective character with related flaws such as possible information and selection bias. The diagnosis and treatment responsiveness were based on clinical findings without objective measurements such as videoculography which is not applied in our daily clinical practice. The recurrence rate was established only if confirmed by a positive Dix-Hallpike test while undocumented recurrences were not considered, therefore the real recurrence rate might be higher. Finally, p-BPPV patients were randomly chosen from a large group of about two

The difference between the time from second to third recurrence in the two types of BPPV is not significant (log-rank P-value = 0.554, $\chi^2 = 0.351$).

Fig. 1. (continued)
thousand patients and were not matched according to the follow up period with umb-BPPV patients. However, the mean number of recurrences did not differ between both groups and the average time period between the first and second as well as the second and third BPPV attack were similar in both groups.

It is important to recognize and differentiate umb-BPPV from bilateral BPPV. In umb-BPPV the more prominent side should be treated as long as necessary until disappearance of nystagmus. Treatment maneuvers for the pseudo-positive ear can lead to insufficient clearing of canaloliths from the long arm of the canal.

**Table 3**

Negative Binomial regression shows independence of umb-BPPV recurrences on the first attack age, gender, BPPV side and treatment responsiveness of the first attack.

| Characteristics                        | B   | S.E  | P-value | OR   | CI 95% low | CI 95% high |
|----------------------------------------|-----|------|---------|------|------------|-------------|
| Age                                    | -0.01 | 0.012 | 0.411 | 0.99 | 0.967      | 1.014       |
| Gender                                 |      |      |         |      |            |             |
| males                                  | 0.501 | 0.426 | 0.239 | 1.65 | 0.716      | 3.799       |
| females                                |      |      |         |      |            |             |
| BPPV side                              |      |      |         |      |            |             |
| right                                  | 0.275 | 0.393 | 0.484 | 1.317 | 0.61       | 2.844       |
| left                                   |      |      |         |      |            |             |
| Symptons and treatment                 |      |      |         |      |            |             |
| duration of symptoms until first treatment (days) | -0.004 | 0.004 | 0.339 | 0.996 | 0.987      | 1.004       |
| number of treatments in the first attack | -0.081 | 0.089 | 0.361 | 0.922 | 0.775      | 1.097       |

**Fig. 2.** Umb- BPPV of the right posterior semicircular canal.

A- Right Dix-Hallpike maneuver: ampullofugal flow of canaloliths and cupuloliths causes excitation of vestibular receptors and geotrophic nystagmus.

B - Left Dix-Hallpike maneuver: ampullopetal flow of cupuloliths causes inhibition of vestibular receptors in the right ear resulting in an apogeotrophic nystagmus that mimics a positive Dix- Hallpike maneuver on the left side.
posterior semicircular canal and be the cause of treatment resistance.

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Declaration of competing interest

The authors report no conflict of interests.

References

Asprella Libonati, G., 2012. Benign paroxysmal positional vertigo and positional vertigo variants. Int J Otorhinolaryngol Clin 4, 25–40.

Bhattacharyya, N., Baugh, R.F., Orvidas, L., et al., 2008. Clinical practice guideline: benign paroxysmal positional vertigo. Otolaryngol. Head Neck Surg. 139, S47–S81.

Buckingham, R.A., 1999. Anatomical and theoretical observation on otolith repositioning for benign paroxysmal positional vertigo. Laryngoscope 109, 717–722.

Cox, P.G., Jefferey, N., 2010. Semicircular canals and agility: the influence of size and shape measures. J. Anat. 216, 37–47.

Five, T.D., Iverson, D.J., Lempert, T., et al., 2008. Therapies for benign paroxysmal positional vertigo (an evidence-based review). Report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology 70, 2067–2074.

Hain, T.C., Squires, T.M., Stone, H.A., 2005. Clinical implications of a mathematical model of benign paroxysmal positional vertigo. Ann. NY Acad. Sci. 1039, 384–394.

Honrubia, V., House, M., 2001. Mechanism of posterior semicircular canal stimulation in patients with benign paroxysmal positional vertigo. Acta Otolaryngol. 121, 234–240.

House, M.G., Honrubia, V., 2003. Theoretical models for the mechanisms of benign paroxysmal positional vertigo. Audiol. Neuro. Otol. 8, 91–99.

Imai, T., Takeda, N., Sato, G., Sekinet, K., et al., 2008. Differential diagnosis of true and pseudo-bilateral benign positional nystagmus. Acta Otolaryngol. 128, 151–158.

Imai, T., Takeda, N., Ito, M., et al., 2009. 3D analysis of benign paroxysmal positional nystagmus due to cupulolithiasis in posterior semicircular canal. Acta Otolaryngol. 129, 1044–1045.

Le Maitra, A., Schuetz, P., Vignaud, P., et al., 2017. New data about semicircular canal morphology and locomotion in modern hominoids. J. Anat. 231, 95–109.

Rhim, G.J., 2019. Serum vitamin D and long-term outcomes of benign paroxysmal positional vertigo. Clin. Exp. Otorhinolaryngol. 12, 271–278.

Schuknecht, H.F., 1969. Cupulolithiasis. Arch Otolaryngol 90, 765–778.

Smith, P.F., Agrawal, Y., Darlington, C.L., 2019. Sexual dimorphism in vestibular function and dysfunction. J. Neurophysiol. 121, 2379–2391.

Steddin, S., Brandt, T., 1994. Unilateral mimicking bilateral benign paroxysmal positional vertigo. Arch. Otolaryngol. Head Neck Surg. 120 (12), 1339–1341.

Valli, P., Botta, L., Zucca, G., et al., 2008. Simulation of cupulolithiasis and canalolithiasis by and animal model. J. Vestib. Res. 18, 89–96.

von Brevern, M., Bertholon, F., Brandt, T., et al., 2015. Benign paroxysmal positional vertigo: diagnostic criteria. J. Vestib. Res. 25, 105–117.

Welker, K.L., Orkin, J.D., Rayan, T.M., 2009. Analysis of intraindividual and intraspecific variation in semicircular canal dimensions using high-resolution x-ray computed tomography. J. Anat. 215, 444–451.

Yang, C.J., Kim, Y., Lee, H.S., et al., 2017. Bone mineral density and serum 25-hydroxyvitamin D in patients with idiopathic benign paroxysmal positional vertigo. J. Vestib. Res. 27, 287–294.

Yatomi, M., Ogawa, Y., Suzuki, M., et al., 2017. Experimental model of benign paroxysmal positional vertigo with biphasic nystagmus using isolated semicircular canals. Acta Otolaryngol. 137, 53–57.