Benign Paroxysmal Positional Vertigo: Updated Review of Its Diagnosis and Treatment

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ABSTRACT

Objective: This review summarizes the key findings of literature regarding Benign Paroxysmal Positional Vertigo (BPPV), including its pathomechanism, diagnosis, and management.

Background: BPPV is a pathological problem in the vestibular system characterized by brief and repeated periods of a spinning sensation triggered by certain head movements. BPPV is the most common cause of vertigo and is characterized by positional nystagmus.

Diagnosis: BPPV is diagnosed through pathological history along with diagnostic maneuvers, such as the Dix-Hallpike maneuver. In most cases, the etiology of BPPV is considered idiopathic; however, older age and minor head injuries are considered risk factors associated with BPPV.

Management: The treatment of BPPV can be achieved through many therapeutic repositioning maneuvers, which, in turn, return the floating otoconia that cause vertigo from the semicircular canals, mostly the posterior semicircular canal, to their original place in the utricle. While most individuals with BPPV respond well to repositioning maneuvers, a small section of population with incurable BPPV undergoes surgical treatment.

KEY WORDS

vestibular, nystagmus, dizziness, semicircular canals, repositioning maneuvers

INTRODUCTION

Benign paroxysmal positional vertigo (BPPV) is the most frequent disorder of the vestibular system1). This disorder affects about 1.6% adults annually. It was found that during the symptoms associated with the disease, 86% of the people with BPPV restricted their daily activities, while 18% avoided going out of their homes2). Moreover, BPPV was reported to be the most frequent disorder among peripheral vestibular disorders to occur among in children under the age of 15, with a prevalence rate of 10 cases in every 100,000 healthy child3). BPPV is characterized by positional episodic vertigo, which is associated with positional nystagmus and elicited by sudden head movements such as looking upward, lying down on one side, or turning over in bed4). In 1921, Barany was the first researcher to clearly describe paroxysmal vertigo as being associated with nystagmus and following the changes in the head positions in relation to gravity5), whereas in 1952, Dix and Hallpike were the first researchers to use the descriptive term "benign paroxysmal positioning vertigo" and define its signs and symptoms in detail. In addition, they presented a test to provoke the vertigo attack, which is known as the Dix-Hallpike test, where a patient quickly moves from a long sitting to a supine position, turning their head to either the right or the left side at an angle of 45°6). The aim of this review is to provide a brief overview of the anatomical structures and the physiology of the vestibular system as well as an overview of the BPPV—which is the most frequent disorder of the peripheral vestibular system—along with its pathomechanism, diagnosis, and management.

ANATOMY AND PHYSIOLOGY OF THE SYSTEM

The vestibular system is located in the inner ear, deep in the temporal bone. The vestibular system consists of two main structures, the otolith organs (i.e., the utricle and saccula) and three semicircular canals (i.e., the posterior, horizontal, and anterior canals). The otolith organs detect and respond to the changes in the head position with respect to gravity (i.e., linear acceleration) as the utricle detects horizontal movements and sacculae detects vertical movements. The otolith organs include the macula, which is the region of the otolith organs that perceives the head linear acceleration. The macula consists of hair cells that are covered with a gelatinous layer. Above this layer lie calcium carbonate crystals, which are called otoconia. Otoconia are relatively heavy, which makes them easily susceptible to be influenced by the longitudinal movements of the head. The head movements cause otoconia to move and bend the hair cells, which converts the mechanical movements into electrical signals, which are transmitted to the brain through the vestibulocochlear nerve. The semicircular canals, which detect and respond to rotational movements, consist of three canals that are perpendicular to each other and filled with an endolymph fluid. At one end of each canal, there is a widened area called ampulla that contains hair cells. The angular head movements cause the fluid to move inside the semicircular canal that is concerned with the movement that pushes the hair cells, which transduce the angular head movements into neural signals. Moreover, the vestibular system detects linear and angular head movements and sends neural signals to the central nervous structures in order to control eye movements during the head and body movements so as to keep them focused on the target through the vestibulo-ocular reflex (VOR) as well as to control the neck and lower limb muscles so as to maintain the body balance7).
PATHOMECHANISM OF BPPV

BPPV occurs when the otocnia that are originally attached to the utricle part of the vestibular system dislocate and move into one of the semicircular canals, which is commonly the posterior semicircular canal. The otocnia floating in the semicircular canal change the fluid concentration and natural movement on which these semicircular canals depend in order to detect the head circular movement, thereby causing the vestibular system to send wrong signals to the brain regarding the head position. These wrong signals from the vestibular system conflict with the signals coming from the eyes and the somatosensation which depend in order to detect the head circular movement, thereby causing vertigo. This disorder may either be unilateral or present in both sides of the labyrinths. Many theories have been formulated with the attempt to clarify the pathological mechanism of BPPV, but the two main theories that have been proposed relate to the concepts of cupulolithiasis and canalolithiasis, as described by Shuknecht in 1969 and Hall et al. in 1979, respectively. In cupulolithiasis, the degener- ated otocnia fragments travel from their original place (i.e., the utricle or saccule) and attach to the cupula of the posterior semicircular canal, which make it more sensitive to gravity. On the other hand, in the theo- ry related to canalolithiasis, it is proposed that the otocnia fragments are free-floating within the long arm of the semicircular canals, com- monly present in the endolymp of the posterior semicircular canal.

The posterior semicircular canal is the most common canal involved with BPPV (85% of the cases), which may be due to its anatomical structure, as it is the lowest canal among the semicircular canals; therefore, if the otocnia fragments dislodge from their original place, they will most likely move down to the posterior semicircular canal. While the horizontal semicircular canal is less likely to be affected in BPPV due to its orientation (17-22% of the cases), it is involved in a similar pathological mechanism as the posterior semicircular canal. However, the anterior semicircular canal is rarely involved with BPPV.

Although the etiology of BPPV is considered idiopathic in most cases (50-70%), it has been associated with certain conditions such as age, head and neck trauma, vertebrobasilar insufficiency, hormone dys- function, vestibular degeneration, vestibular neuritis, and prolonged bed-rest. A number of studies including a systematic review have failed to find a strong relationship between BPPV and osteoporosis, although people with both BPPV and osteoporosis may need to undergo canalith repositioning maneuvers more often. Although the effect of diabetes has not been reported to displace otocnia from their original location, it was found that the number of people with both BPPV and diabetes were significantly higher than those with BPPV alone. In addition, a recent study showed that diabetes mellitus increases the recurrence rate of BPPV.

DIAGNOSIS OF BPPV

Clinical diagnosis is dependent on a thorough and accurate evalua-

![Table 1: Clinical findings of affected horizontal semicircular canal BPPV](image)

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<thead>
<tr>
<th>Semicircular canals</th>
<th>Diagnostic tests</th>
<th>Therapeutic maneuvers</th>
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<tbody>
<tr>
<td>Posterior semicircular canal</td>
<td>Dix-Hallpike test</td>
<td>Epley's maneuver</td>
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<tr>
<td>Horizontal semicircular canal</td>
<td>Supine roll test</td>
<td>Lempert roll maneuver</td>
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<tr>
<td>Anterior semicircular Canal</td>
<td>Dix-Hallpike test</td>
<td>Epley's maneuver</td>
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Table 2: Diagnostic tests and therapeutic maneuvers of the affected semicircular canals.

Turning head away from the affected side

<table>
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<th>Semicircular canals</th>
<th>Diagnostic tests</th>
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<tbody>
<tr>
<td>Canalithiasis</td>
<td>Geotropic nystagmus</td>
<td>High intense nystagmus</td>
</tr>
<tr>
<td>Cupulolithiasis</td>
<td>Low intense nystagmus</td>
<td>Apogeotropic nystagmus</td>
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![Table 2](image)
The affected side is commonly the side with the largest horizontal nystagmus. However, in horizontal semicircular canal BPPV, nystagmus can either be geotropic (i.e., beating toward the lower ear) or apogeotropic (i.e., beating toward the upper ear), depending on the location of the otoconial fragments within the horizontal semicircular canal. The geotropic nystagmus indicates that the otoconial fragments are located within the long arm of the horizontal semicircular canal away from the cupula (canalolithiasis), whereas the apogeotropic nystagmus indicates that the otoconial fragments are located within the ampullary segment of the horizontal semicircular canal or possibly attached to the cupula (cupulolithiasis). Table 1 summarizes the clinical findings of the affected horizontal semicircular canal BPPV based on the direction of head movement and the location of the otoconia within the horizontal semicircular canal.

The involvement of the anterior semicircular canal with BPPV is extremely rare, often occurring as an incidental side effect when treating one of the other types of BPPV. This side effect is known as canal switch. The Dix-Hallpike maneuver (i.e., the head hanging maneuver) is used to confirm the diagnosis of BPPV of the anterior semicircular canal as well as the posterior semicircular canal.

High scores on the Dizziness Handicap Inventory may help in the identification of people with BPPV. A study found that getting a score of 50 out of 100 on the DHI is significantly associated with the diagnosis of BPPV when compared to having a score of less than 50. This indicates that the DHI is a good predictor of having BPPV. Moreover, a study found that the mean score of the DHI for people with BPPV was significantly higher than that of healthy people, indicating that the DHI was a strong predictor of BPPV.

SYMPTOMS OF BPPV AND DIFFERENTIAL DIAGNOSIS

BPPV is the most common cause of vertigo; therefore, the American clinical practice guideline recommends that the clinicians should be aware of the associated symptoms with BPPV and the differential diagnoses that can cause vertigo, such as vestibular neuritis, vestibular migraine, vestibulocerebellar, Meniere's disease, or vascular disease. Classically, BPPV is categorized by acute, short and episodic positional vertigo and positional nystagmus. Other associated symptoms such as tinnitus, hearing loss and motor, sensory, or cerebellar deficits suggest diagnoses other than BPPV. Although BPPV accounts for the majority of nystagmus cases, there are other disorders that may cause nystagmus, such as cerebellar damage, which may resemble horizontal semicircular canal BPPV, making the distinction between them difficult. Fortunately, this situation is very rare. A systematic review study was conducted to differentiate between the clinical features of central and peripheral positional nystagmus and found that the main feature of the diagnosis is that the nystagmus moves in an atypical direction for the stimulated canal.

Moreover, a study found that the symptoms experienced by older people with BPPV differed from those suffered by young adults. In the study, older adults were found to suffer more from the loss of balance and unsteadiness, while the young people suffered more from vertigo. Another study found that people, especially the elderly, who had the symptoms of BPPB for a long time before the diagnosis and treatment had higher anxiety levels. Additionally, another study found that older people and people with a head injury or vestibular neuropathy had a significantly higher recurrence rate when compared to younger adults.

THE MANAGEMENT OF BPPV

There are many methods of treating BPPV depending on which canal is affected. All of these methods aim to reposition the displaced otoconia back into the utricle. The treatment of the posterior semicircular canal BPPV was first described by in 1992 by Epley, who described canalith repositioning. Epley's maneuver immediately resolves BPPV from posterior semicircular canal in more than 85% of all the cases. A randomized control trial of 44 subjects with posterior semicircular canal BPPV of at least a 1-month duration compared the long-term effect of the Epley maneuver versus a sham intervention. It was found that the Epley maneuver resulted in a recovery in 91% of the cases after one year, while the sham intervention led to the recovery of only 46% of the cases within the same timeframe. Additionally, a retrospective study looked at the number of times the Epley maneuver was needed to resolve the symptoms of BPPV and found that 47% of the cases became asymptomatic after performing Epley maneuver once. In contrast, 16% of the cases needed Epley maneuver twice and 21% needed the maneuver three times. Several studies have pointed out the merit of the effect of the post-procedure restriction of postural movements using a neck collar after applying the Epley maneuver versus applying the Epley maneuver alone. Although there was a statistically significant difference between the two procedures in some studies, using a neck collar after applying the Epley maneuver added only a small benefit to the effect of the Epley maneuver. In addition, a meta-analysis looked at the effect of applying a vibration to the mastoid bone while performing the Epley maneuver and found no significant difference when compared to when the Epley maneuver is performed alone.

Another treatment of the posterior semicircular canal is the Semont maneuver. The Epley and Semont maneuvers are both equally effective in resolving BPPV. A prospective study of 102 people with posterior semicircular canal BPPV investigated the effect of the Epley and Semont maneuvers on the induction of the BPPV canal switch from the posterior to the horizontal semicircular canal. Although both the maneuvers contributed to resolving the posterior semicircular canal BPPV equally, the study found that the Epley maneuver induced ipsilateral horizontal semicircular canal BPPV in 4 cases out of the 51 (7.8%) in the Epley maneuver group, while the Semont maneuver did not induce any canal switch.

Barbecue exercises are another successful treatment option for posterior semicircular canal BPPV. Recently, a systematic review demonstrated that this type of treatment has the same recovery rate as the Epley and Semont maneuvers for treating posterior semicircular canal BPPV.

Potential treatment maneuvers for horizontal semicircular canal BPPV have been proposed, such as the Lempert roll maneuver and the forced prolonged positioning maneuver. Although the American clinical practice guideline considers the Lempert maneuver as the most commonly used for the treatment of horizontal semicircular canal BPPV, another study considered the forced prolonged positioning maneuver to be more effective and easier to apply. The Gufoni Maneuver and Barbecue maneuver are other ways of treating horizontal semicircular canal BPPV. A randomized control trial included 170 people with geotropic horizontal semicircular canal BPPV, who were randomly assigned the Barbecue, Gufoni, or sham maneuvers. The results demonstrated that both the Barbecue and Gufoni maneuvers showed better responses (69.1% and 60.9%, respectively) compared to the sham maneuver (35.4%). However, the Barbecue and Gufoni maneuvers were not significantly different in the immediate response (i.e., 1 hour after the treatment procedure) and in the long-term effect (i.e., 1 month after the treatment). In a similar study, 157 people with apogeotropic horizontal semicircular canal BPPV were randomly assigned to Gufoni, head-shaking or sham maneuvers. The Gufoni and head-shaking maneuvers demonstrated better immediate responses (73.1% and 62.3%, respectively) compared to the sham maneuver (34.7%). In another study, the efficacy of the Gufoni liberatory maneuver in treating geotropic and apogeotropic horizontal semicircular canal BPPV was investigated. The results demonstrated that, among the people with horizontal semicircular canal BPPV, 75.7% improved within an hour and 83.8% after 24 hours. However, the improvement in geotropic cases was significantly higher than in cases with apogeotropic. Baloh in 1996 and Herdman in 1997 described the canalith repositioning technique for the treatment of the posterior semicircular canal to treat the anterior semicircular canal. Table 2 summarizes the diagnostic tests and therapeutic maneuvers of the affected semicircular canals.

In a recent study, the clinical findings and treatment effect were compared in individuals with idiopathic BPPV and BPPV secondary to vestibular neuritis. The individuals with BPPV secondary to vestibular neuritis were much younger, with mainly the involvement of the posterior or semicircular canal, and they needed more treatment sessions compared to cases with idiopathic BPPV. A recent meta-analysis study showed that BPPV is associated with 8-58% of Meniere's disease cases, and the individuals with BPPV along with Meniere's disease had a more recurrence incidents and needed more repositioning maneuvers compared to the cases with idiopathic BPPV.

In addition to the role of repositioning maneuvers, a systematic review study indicated that a simulated Epley maneuver added only a small benefit to the cases to the repositioning maneuvers has a positive effect in the long term. A number of studies have looked at the effect of vestibular suppressants to reduce the remaining symptoms after performing successful canalith repositioning maneuvers with controversial results. One study
found that the group that was treated with a vestibular suppressant (dimenhydrinate 50 mg per day) did not show residual symptoms compared to the placebo and no medication groups. In contrast, another study looked at the effect of the three drugs on a group and compared it to a control group in which the subjects did not take medication. The study did not find any reduction in the residual symptoms in the former group when compared to the latter.

CONCLUSION

BPPV is a very common disorder of the peripheral vestibular system that causes a short episodic vertigo provoked by certain head movements. BPPV is caused when the otolith organ is originally attached to the otolithic organs of the vestibular system and moves into one of the semicircular canals, causing abnormal stimulation of the hair cells in the affected semicircular canal. It can be diagnosed through the patient's clinical history and confirmed with specific physical maneuvers. Moreover, BPPV is treatable with spontaneous recovery, as most individuals respond well to the therapeutic repositioning maneuvers. However, in few cases, therapists may need to redo the repositioning maneuver in order to resolve the residual symptoms.

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REFERENCES