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RESEARCH ARTICLE

Benign paroxysmal positional vertigo: Pathophysiology, Causes, Canal Variants and Treatment.

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Abstract

Benign paroxysmal positional vertigo is the most common cause of recurrent vertigo which last for a few seconds usually managed head positioning maneuvers. The most common form of BPPV occurs when otoliths from the macula of the utricle fall into the lumen of the posterior semicircular canal responding to the effect of gravity. BPPV appeared to be associated with previous trauma (6.7% of all patients), ipsilateral Meniere's disease (6.5%/), ipsilateral vestibular neuritis(5.6%),history of BPPV affecting the same ear(5.2%),a severe systemic disease(4.6%) and history otologic surgery(1%). The effectiveness of the maneuvers depending on correct diagnosis of canal affected, cupula involved or not, single or multiple canal affected and sidedness of structures. The important question of whether repeated maneuvers during one session are more effective than just one remains to be examined systematically.

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INTRODUCTION

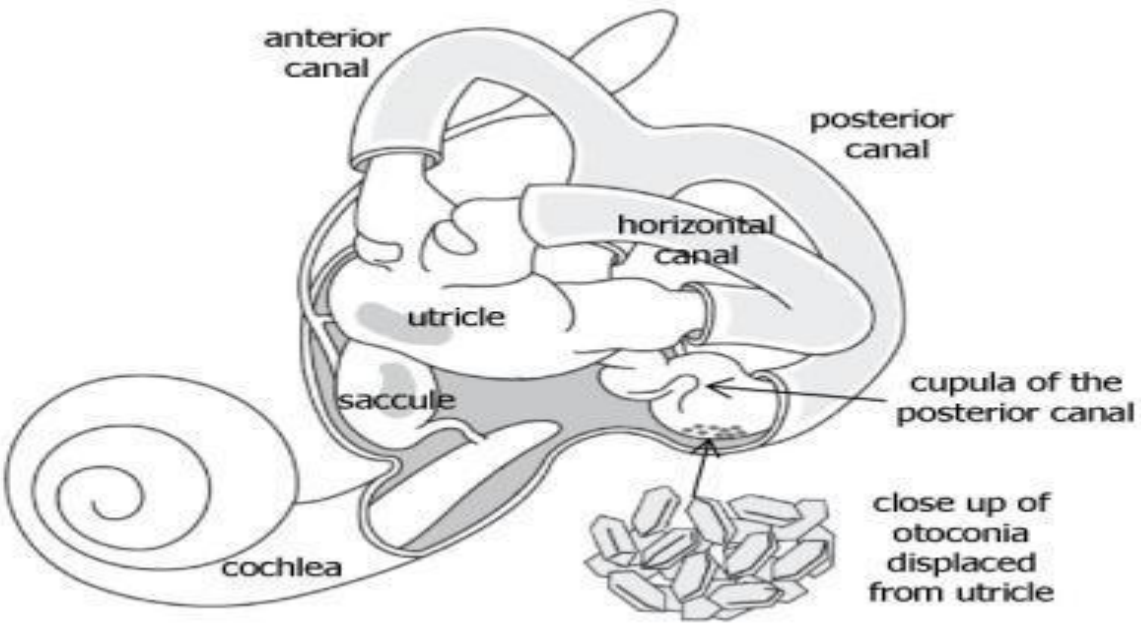
Dizziness is a common complaint in patients presenting to the clinic. Vertigo was found to be most common cause of dizziness. Vertigo is defines as an illusion of motion and is most commonly caused by BPPV[1] .Benign paroxysmal positional vertigo (BPPV) is the most common disorder of the inner ear vestibular system, which is a vital part of maintaining balance. BPPV is benign, meaning that it is not life-threatening nor generally progressive. BPPV produces a sensation of spinning called vertigo that is both paroxysmal and positional, meaning it occurs suddenly and with a change in head position. BPPV is the most common vestibular disorder; 2.4% of all people will experience it at some point in their lifetimes[2]. BPPV accounts for at least 20% of diagnoses made by physicians who specialize in dizziness and vestibular disorders, and is the cause of approximately 50% of dizziness in older people[3]. In 1952 hallpike and Dix described the classic characteristic of BPPV: affected ear dependency, rotatory nystagmus, latency, fatigability on repeated provocative positioning. It is characterized by rotational vertigo induced by head position changes. Patients typically complain about attacks of vertigo when extending or turning the neck, getting up or lying down, or rolling over in bed. The attacks often are accompanied by a feeling of unsteadiness and loss of confidence while walking[4]. Other charaterstic of BPPV include rotational vertigo(in 86%),oscilloscopia(31%),nausea(33%),vomiting(14%),imbalance(49%),fear of falling(36%), and falls(1%).[5]
Benign paroxysmal positional vertigo can occur through the lifespan from childhood to elders[6] The prevalence of BPPV in this young adult population was a surprising 9%[7]. It can affect the quality of life of elderly patients and is associated with reduced activities of daily living, falls, and depression. Patients with BPPV experience delays in diagnosis and treatment, the mean delay being 92 weeks, and they frequently are inappropriately treated with vestibular suppressant medications[7]. BPPV is more prevalent in women (2 times more) as compared to men. Patients with BPPV are 5 times more likely to have relations with BPPV compared to other dizzy patients suggesting a familial tendency.[5]
BPPV is found in isolation and termed primary or idiopathic BPPV in approximately 50% to 70% of all cases. The most common cause of ''secondary'' BPPV is head trauma, representing 7% to 17% of all cases. Other causes of

secondary BPPV are viral neurolabyrinthitis or ‘‘vestibular neuronitis’’ (which is involved in up to 15% of BPPV cases), Me´nie`re’s disease (5%), migraines, otologic and nonotologic surgery, and prolonged bed rest [4].

Subtypes of BPPV are distinguished by the particular semicircular canal involved and whether the detached otoconia are free floating within the affected canal (canalithiasis) or attached to the cupula (cupulothiasis). BPPV is typically unilateral, meaning it occurs either in the right or left ear, although in some cases it is bilateral, meaning both ears are affected. The most common form, accounting for 81% to 90% of all cases, is canalithiasis in the posterior semicircular canal.[2]
Particle repositioning maneuvers are effective treatment for BPPV, leading to the resolution of the positioning nystagmus in 70% to 100% of cases . The reported recurrence rate of BPPV is 20% to 30%, but there are series with as much as a 50% recurrence rate. Aspects such as age, sex, the presence of residual instability after the repositioning maneuvers, complexity of primary BPPV treatment, and cause have been related to the development of recurrences, sometimes with controversial results[4].The most common “complication” of BPPV repositioning treatment is canal conversion. Considering the population age in which it is usually performed there is a surprising sparsely of literature on cervical spine and neurological complications.

PATHOPHYSIOLOGY

BPPV occurs as a result of otoconia, tiny crystals of calcium carbonate that are a normal part of the inner ear’s anatomy, detaching from the otolithic membrane in the utricle and collecting in one of the semicircular canals. When the head is still, gravity causes the otoconia to clump and settle . When the head moves, the otoconia shift. This stimulates the cupula to send false signals to the brain, producing vertigo and triggering nystagmus (involuntary eye movements). The cupular excitatory response is usually related to movement of otoliths (calcium carbonate crystals) that create a current of endolymph within the affected semicircular canal. The most common form of BPPV occurs when otoliths from the macula of the utricle fall into the lumen of the posterior semicircular canal responding to the effect of gravity. These ectopic otoliths, which have been observed intraoperatively, are referred to as *canaliths*. The canaliths are dense and move in the semicircular canal when the head position is changed with respect to gravity; the canalith movement ultimately deflects the cupula, leading to a burst of vertigo and nystagmus. In some cases, canaliths adhere to the cupula, causing cupulolithiasis, which is a form of BPPV less responsive to treatment maneuvers.[8]



CAUSES

Soto-varela and colleagues reported that the origin of BPPV remained unknown in 61.9%, but in remainder ,BPPV appeared to be associated with previous trauma(6.7% of all patients), ipsilateral Meniere’s disease(6.5%/),

ipsilateral vestibular neuritis(5.6%),history of BPPV affecting the same ear(5.2%),a severe systemic disease(4.6%) and history otologic surgery(1%)[9].The most common cause of BPPV in people under age 50 is head injury and is presumably a result of concussive force that displaces the otoconia. In people over age 50, BPPV is most commonly idiopathic, meaning it occurs for no known reason, but is generally associated with natural age-related degeneration of the otolithic membrane or less physical activity. BPPV is also associated with migraine[10] and ototoxicity. Viruses affecting the ear (such as those causing vestibular neuritis) and Ménière's disease are significant but unusual causes. Occasionally BPPV follows surgery as a result of the trauma on the inner ear during the procedure combined with a prolonged supine (laying down face-up) position[11]. BPPV may also develop after long periods of inactivity. Prolonged lying may facilitate the deposition of otoconia on the cupula or contribute to their loosening from the utricle. Consequently it has been hypothesizes that mild to moderate physical activity might relocate the particle from the canal thus preventing the accumulation of an adequate number of otoconia necessary for forming an agglomerate[7]. Other conditions that have been associated with BPPV including diabetes, thyroiditis, hypertension, hyperlipidemia, stroke and osteoporosis.[7]

CANAL VARIANTS

BPPV may affect the posterior, anterior, and horizontal semicircular canal and in some cases it may even involve more than one canal at a time. Due to gravity dependent position the most commonly affected semicircular canal is the posterior canal. The horizontal semicircular canal is positioned within the membranous labyrinth such that it may also be affected by the same mechanism. The anterior canal (because of superiorly located) and polycanalicular forms are the least common[12]. In a study of 614 BPPV patients over an 11 year period, the PC BPPV (Posterior canal) was affected in 543 patients (88.45%), the horizontal in 39(6.4%) and the superior (Anterior) canal in 32(5.2%) [9]. The nystagmus of horizontal canal BPPV is horizontal and changes direction when the head is turned to the right or left while supine (direction changing paroxysmal positional nystagmus). The direction-changing positional nystagmus may be either geotropic or apogeotropic. The geotropic form, which is thought to result from free-moving otoconial debris in the long arm of the semicircular duct, is generally more responsive to treatment. The apogeotropic form is likely due to otoconial material in the short arm of the canal or attached to the cupula (cupulolithiasis).Hence, one seeks to convert the more treatment-resistant apogeotropic to the more treatment-responsive geotropic nystagmus form of horizontal canal BPPV. The nystagmus and vertigo of horizontal canal BPPV may be provoked by the Dix–Hallpike maneuver but are more reliably induced by the supine head roll test or so-called Pagnini–McClure maneuver[13]. The bow and lean test can be used as diagnostic test in horizontal canal test. In a prospective study, the test shows significant result for both canalithiasis and cupulolithiasis of lateral canal against supine head roll test[7].

Table1: Nystagmus features by canal affected in BPPV.[12]

Canal affected	Direction of Paroxysmal Positional Nystagmus (fast phase).
Posterior canal	Upbeating+Torsional top pole beating toward downward ear.
Horizontal canal	Horizontal geotropic direction changing(right beating in head right position, left beating in head left position) or horizontal apogeotropic direction changing(left beating in head right position, right beating in head left position).
Anterior canal	Downbeating possibly with a slightly torsional

	component.

TREATMENT

The effectiveness of the maneuvers depending on correct diagnosis of canal affected, cupula involved or not, single or multiple canal affected and sidedness of structures.

Maneuvers for Posterior Canal BPPV

Particle repositioning head maneuvers are considered to be more effective than medication or other forms of exercise-based therapy[14] in treating posterior canal BPPV. However, even with successful treatment with such maneuvers, BPPV reoccurs in about one-third of patients after one year, and in about 50% of all patients treated after five years [15, 16, 17].

There is currently two practice guideline for diagnosing and treating for BPPV, one is American Academy of Neurology and another is American Academy of Otolaryngology –Head & Neck surgery, both validate the effectiveness of Epley maneuver in the treatment of PC BPPV[7]. A more recent Cocharane review validate the effectiveness of post Epley restrictions(using a neck brace, head movement restrictions and sleeping upright) and conclude that in the experimental group 88.7% versus 78.2% in the control group converted from a positive to negative hall-pike test[18]. Occasionally, when CRP (canalith repositioning maneuver) is being performed, neurological symptoms (e.g., weakness, numbness, and visual changes other than vertigo) occur, caused by compression of the vertebral arteries[19]. In this case, persisting with the maneuver can lead to stroke. However, medical professionals can modify the exercises or use special equipment so that the positions are attained by moving body and head simultaneously, thereby avoiding the problematic compression.

The Semont Liberatory Maneuver (SLM) involves a procedure whereby the patient is rapidly moved from lying on one side to lying on the other. Although many physicians have reported success treating patients with the Semont Maneuver[20] and support its use, more studies are required to determine its effectiveness.[2]

Maneuvers for Horizontal Canal BPPV

Because of the relative rarity of horizontal canal BPPV, there are no best practices established for treatment Maneuvers; however, the most widely studied is the Lempert maneuver or barbecue maneuver [18, 21]. This maneuver entails moving the head through a series of 90˚ angles and pausing between each turn for 10 to 30 seconds. Other techniques such as the Gufoni maneuver and the Vannucchi-Asprella liberatory maneuver have also been used to treat horizontal canal BPPV (both the geotropic and apogeotropic nystagmus forms), but additional well-supported clinical studies are needed to assess their effectiveness[2].CRP or modified Epley maneuvers are usually ineffective for horizontal canal BPPV, so a number of alternative maneuvers have been devised. Variations of the roll maneuver (Lempert maneuver or barbecue roll maneuver) are the most widely published treatments for horizontal canal BPPV. Success in treatment, based on all studies, is probably 75% but ranges from approximately 50% to nearly 100%[18,21]. Casani et al and Appiani et al. review other techniques used with success in the treatment of both the geotropic and apogeotropic forms of horizontal canal BPPV. Another treatment reported as effective is referred to as forced prolonged positioning. With this method, the patient lies down laterally to the affected side, and the head is then turned 45 degrees toward the ground and maintained in that position for 12 hours before the patient is returned to the starting position. Some authors advocate this technique for refractory horizontal canal BPPV. Using this approach, one study reported remission rates of 75% to 90%[2].For the management of cupulolithiasis of the horizontal semicircular canal, there are some technique like repetitieve somersaults[22] and head tilt hopping exercise[23].

Maneuvers for Anterior Canal BPPV(AC-BPPV)

There is no definitive treatment for anterior canal BPPV and no controlled studies of it have yet been completed. However, there is a logical modified maneuver for the anterior canal that is essentially a deep (exaggerated) Dix-Hallpike [24]. Other proposed treatments employ reverse versions of the maneuvers used for posterior canal BPPV; for example, the reverse Semont (starting nose down and turned to the unaffected side), or the reverse Epley (again

starting nose down). These treatments are geometrically reasonable, but require additional study to prove their efficacy.

Particle repositioning procedure: It consists of four steps, with position changes occurring at 30^0 intervals. From the head-straight sitting position (position1), a head-hanging maneuver is performed so that the head is brought to at least 30^0 below the horizontal, (position 2). During the maneuver, loose otoconia within the anterior canal should move away from the anterior canal cupula, triggering a down beating nystagmus. For patients who are unable to attain a 30^0 dependent head position, a tilting examination table or ''tilt table'' can be used to attain the same head position with respect to gravity. After 30 sec, once vertigo and nystagmus provoked by the maneuver cease and while still supine, the patient's head is moved quickly forward ''chin to chest'' (position 3), with the vertex near the vertical axis. After another 30 sec. have elapsed, head and body are brought into the sitting position (position 4), remaining there for another 30 s. In cases of failure or incomplete remission of symptoms, the same maneuver is repeated.[25]

Post-treatment considerations

After successful treatment with particle repositioning maneuvers, residual dizziness is often experienced for up to three months. Whether post-treatment activity restrictions are useful has not been adequately studied [2]. Nevertheless, many physicians recommend that their patients sleep in an elevated position with two or more pillows and/or not on the side of the treated ear, wear a cervical collar as a reminder to avoid quick head turns, and avoid exercises that involve looking up or down or head rotation (such as freestyle lap swimming). Such precautions are thought to help reduce the risk that the repositioned debris might return to the sensitive back part of the ear before it either adheres or is reabsorbed.

DISCUSSION

No treatment usually applied because the episodes of BPPV are typically self limiting, with a median duration of 2 weeks, that is why only 8% patients with BPPV receives effective treatment. Welling and colleagues prospectively examined the posterior semicircular canal of patients and without a history of BPPV for the presence of particulate matter. No particles were observed intraoperatively in any of the 13 patients undergoing labyrinthine surgery without a history of BPPV. Particulate matter was observed in only 8 of 26 patients with intractable BPPV at the time of posterior canal occlusion procedure. These observations suggest that mere presence of particulate matter is not sufficient and there are other conditions that can influence the expression of disease symptoms displaced. Based on clinical and experimental evidences, displaced fragments of otoconia into the semicircular canal are now widely accepted as a cause of BPPV symptoms. However a clinical mass appears to be needed to evoke clinical symptoms, as mere presence fragments within the semicircular canal is not always sufficient to induce a change in vestibular nerve activity. Dix and Hallpike, could not understand the pathophysiology of BPPV and they could not appropriate that positioning technique they used actually demonstrated pathology in semicircular canal rather than the utricle. They agreed with schuknecht's proposal that the dysfunction resulted from gravity dependent movement of loose or fixed dense material within semicircular canal though schuknecht's formulation were not consistent with all clinical feature of the disease but they led to the common canalithiasis theory and also the canalith repositioning or liberatory maneuver.

Hall and collegues brought clarity to mechanism underlying posterior BPPV. They explained that BPPV can be divided into two types based on presence or absence of fatigability. Specifically nonfatiuable nystagmus was result of particles being fixed on the cupula (cupulothiasis) whereas fatigable nystagmus was due th free floating particle within the body of posterior semicircular canal.(canalithiasis).

Dix-hallpike maneuver were used in these studies to elicit PC BPPV. Lateral canal type is elicited by supine head roll maneuver (pagnini mcdure maneuver). Anterior canal type diagnosis should be considered with caution because downbeating positional nystagmus related to brainstem or cerebellar lesion can produce a similar pattern. In a review of 50 patients with downbeat nystagmus, Berthen et al found that three fourth of CNS disease while atleast some of remaining one fourth of cases were thought to have a form of AC BPPV. Polycanalicular BPPV is uncommon but in this PC-BPPV combined with horizontal BPPV is common.

A rare but often frightening complication is a canalith jam is occur. This occurs when the otolith debris is unable to clear the common crus as the debris falls downwards from posterior canal into the utricle when the patients returns to a seated position following the final stage of canalith reposition maneuver of SLM . The method used to clear the jam is reverse repositioning protocol in the order in which it was performed.

Another complication is canal conversion while treating the BPPV. Canal switching is more (6%) in PC BPPV.The most common canal conversion is from PC to horizontal and PC to AC. Canal conversion appears to be more with Epley Maneuver than semont maneuver because of the higher number of steps during which the head is in dependent position [26]. Semont recurrence rate over an 8 year period was approximately 4% and 7% for the canalith repositiong maneuver.

This review evaluated the effectiveness of several particles repositioning maneuver. Our results agree with those of earlier reviews of BPPV that the CRP is more effective in PC BPPV canalthiasis, The Semont Liberatory Maneuver for cuplolithiasis, Barbecue maneuver for horizontal canal treatment; self administered CRP is more effective than self administered Liberatory Maneuver in the treatment of PC-BPPV

Clinical experience suggests that repeating Epley's maneuver during one session increases its effectiveness. A recent study however that aimed to examine the benefit of repeated against single epley's manoevures during one treatment session showed only a trend for multiple manoevers that was not statistically significant. The important question of whether repeated maneuvers during one session are more effective than just one remains to be examined systematically.

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