REPOSITIONING MANOEUVRES AS KINESIOTHERAPY-BASED TREATMENT FOR BENIGN PAROXYSMAL POSITIONAL VERTIGO (BPPV)

Mădălina Gabriela GEORGESCU[1*], Daniela VRÎNCEANU[2]

[1] "Carol Davila" University of Medicine and Pharmacy, Department of Audiology, Bucharest, Romania
[2] "Carol Davila" University of Medicine and Pharmacy, Department of ENT, Bucharest, Romania
*Corresponding author: madalina.georgescu@gecad.com

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Abstract. *Dizziness is a very common symptom in general medical practice (5% of family doctor appointments, according to the data provided by the World Health Organization). Therefore, the patient with dizziness needs to be approached very carefully, their medical history being the key element for the correct evaluation of each patient. The primary purpose of the medical consultation is not to establish the aetiology of the disease, but to find the main cause of dizziness - vestibular/inner ear, neurological or other pathological conditions. It is thus essential to know very well the clinical and paraclinical information in order to make a correct differential diagnosis and apply the most beneficial treatment. More than 40% of peripheral vestibular pathology is represented by benign paroxysmal positional vertigo (BPPV), a disease characterised by the displacement of the otolithic structure from the macular region to the semicircular canal. Patients will have the sensation of true vertigo when rolling in bed, getting up from the bed or bending forward. Specialised bedside examination with a specific magnifying glass or infrared camera allows the physician to establish the precise location and mechanism of the disease. Once the affected semicircular canal is established by the ENT or neurologist, treatment usually consists of repositioning manoeuvres. These could be performed by trained physicians, audiologists and physiotherapists. The most used manoeuvres will be described in this paper.*

Keywords: *otoliths, semicircular canal, benign paroxysmal positional vertigo (BPPV).*

Introduction

Dizziness is a very common symptom in general medical practice (5% of general practitioner consultations) (Neuhauser, 2007; Roberts, Gans, Kastner et al., 2005), with a significant incidence in the elderly population (over 65%), which might lead to falls with hip fracture and possible death (Jönsson et al., 2004).

The aetiology of this symptomatology is extremely varied. Therefore, the patient with dizziness needs to be approached very carefully, their medical history being the key element for the correct evaluation of each patient (Baloh et al., 1987; Brandt et al., 1994).

The primary purpose of the medical consultation is not to establish the aetiology of the disease (basically, the aetiology can be determined only in 50% of cases of damage to the vestibular system), but to find the main cause of dizziness - vestibular, neurological or other pathological conditions. It is thus essential to know very well the clinical and paraclinical information in order to make a correct differential diagnosis. (Rosenfeld & Shiffman, 2006)

Benign paroxysmal positional vertigo (BPPV) is a mechanical disorder of the labyrinth, which is clinically manifested by episodes of rotatory vertigo triggered by changes in head and/or body position in space (Kentala & Pyykko, 2000; Riga et al., 2011).

The main symptom is the sudden appearance of vertigo (the feeling of self-rotation or the feeling that the surrounding objects are spinning) when changing the position of the head in

relation to gravity. This paroxysmal and severe symptom hinders daily activity and job efficacy in patients with BBPV, with significant repercussions upon their quality of life. (López-Escamez et al., 2000)

The vertigo and nystagmus that accompany it (commonly towards the side to which the head is turned) usually have a short latency period (a few seconds), are exhausted if the position is maintained and come back each time the head is returned to the trigger position but with a much lower intensity, this return of the head being accompanied by the appearance of nystagmus in the opposite direction (Shepard & Telian, 1995; Bhattacharyya et al., 2017). Nystagmus is an involuntary conjugate movement of the eyeballs triggered by the appearance of a functional asymmetry between the two inner ears.

Benign paroxysmal positional vertigo is the most common cause of vertigo, a true "headliner" of diseases of the vestibular system. The disease generally affects patients aged 50-70 years and is considered one of the leading causes of falls in the elderly.

Vertigo may occur during sleep when the person turns to one side or the other, lies horizontally, looks up, takes an object from a shelf above the head, bends over or makes any other sudden movement of the head. About 80% of patients describe a feeling of rotating vertigo, and 47% also have a feeling of floating (Hornibrook, 2005).

Although it lasts no more than 30 seconds, BPPV attacks are accompanied by anxiety and can be followed by malaise and a feeling of imbalance, empty head and sensitivity to head movements in any direction. Anxiety occurs for two reasons: on the one hand, patients think that the symptoms they experience may be due to an intracranial tumour or stroke, and on the other hand, the fact that they reflexively adopt avoidance behaviours in order to prevent the vertigo-triggering position (Hotson & Baloh, 1998; Kentala & Pyykko, 2000).

The spectrum of severity is highly variable, from minor symptoms represented by episodes of positional vertigo and periods of inter-critical calm to moderate symptoms represented by frequent attacks of positional vertigo with states of imbalance between attacks. Symptoms can go away spontaneously without treatment or can last for days, weeks, months, even years with recurrence over time.

Although classified as a benign disorder, BPPV can become dangerous in certain conditions or occupations, such as for tall workers or heavy machinery operators.

BPPV is the most common cause of vertigo, with a prevalence of 2.4% and an annual incidence of 0.6%. This means that about 1 million adults suffer from BPPV each year in Germany, for example. (Von Brevern et al., 2007)

Japanese epidemiological studies estimate that the actual incidence would be between 10.7 and 17.3 per 100,000 inhabitants per year, although it is very possible that these figures are underestimated, as most cases resolve spontaneously within a few months (Imai et al., 2005).

In the United States, of the 5.6 million patients who go to the clinic for dizziness, 17 to 42% are diagnosed with BPPV, which is diagnosed twice as often as Menière's disease.

The average duration of the active phase in patients who do not receive treatment is about 15 days.

The recurrence rate is about 15% per year (Nunez et al., 2000), and about one in two patients is prone to recurrence (Von Brevern et al., 2007). The highest recurrence rate (80%) is recorded in the first year after the diagnosis of the disease, while 5 years later, the recurrence rate decreases to 5%.

BPPV commonly affects a single semicircular canal, most often the posterior one. In a study conducted on a large population of patients, almost 70% were diagnosed with posterior canal BPPV (Korres et al., 2002; Caruso & Nuti, 2005).

The right semicircular canal is much more commonly affected, the right-left ratio being 1.5:1, probably due to the habit of most patients to sleep on the right side (Von Brevern et al., 2004), the position during sleep usually favouring sliding and aggregation of otoconia in the posterior semicircular canal.

Bilateral posterior canal impairment occurs in 7.5% of patients and approximately 90% of bilateral disorders are post-traumatic (Marzo et al., 2004). Cases of concomitant impairment of the posterior and lateral semicircular canals have also been reported.

In more than half of the cases, the origin of BPPV remains a mystery, this condition being discovered in isolation, thus being classified as primary or idiopathic BPPV. In fact, its aetiology is multifactorial. The rest of the cases are classified as secondary BPPV and vary considerably between 3% and 25.2% of all patients with BPPV.

In most cases, the probable aetiology is the pathological condition that causes otoconia detachment, macular degeneration or alterations in endolymph metabolism.

The causes that could lead to secondary BPPV are (Norré, 1994; Parnes et al., 2003; Atacan et al., 2001; Bertholon et al., 2002):

- head injuries;
- viral infections and inflammation of the vestibular-cochlear nerve;
- Menière's disease;
- migraine attacks;
- repetitive head movements, such as working in front of the computer;
- prolonged dorsal decubitus;
- cephalic extremity surgery;
- minor strokes affecting the vascularisation of the inner ear;
- chronic otitis;
- vitamin D3 deficiency.

Schucknecht (1962) differentiates three forms of BPPV:

- Self-limiting form, which is the most common and resolves spontaneously within a few weeks;
- Recurrent form, with numerous relapses after periods of remission;
- Permanent form, which persists for more than one year and does not respond to the correct repositioning treatment performed.

The condition is easily diagnosed by the clinician, without requiring costly investigations such as computed tomography or nuclear magnetic resonance and, moreover, can actually be treated with a simple manoeuvre performed in the doctor's office.

The characteristic features of the disease as well as its diagnosis were first clarified by Dix and Hallpike (1952), who noted the following symptoms: the patient's medical history showed that the feeling of dizziness occurred when lying in bed or turning from side to side in bed or if this position was taken during the day, for example, when lying under a car to fix something or turning the head to paint the ceiling of a house. As a diagnostic test, the above authors note the following: the patient is initially placed on a treatment bed with their head

turned to one side so as to stare at the examiner's forehead. At that moment, the examiner firmly grabs the patient's head between two hands and suddenly leans the patient to their back in a critical position. It was also noted the appearance of torsional nystagmus with the upper pole of the eye beating towards the ground and disappearing when the manoeuvre was repeated. In addition, the two authors observed that this nystagmus had a latency period of about 5 seconds until it appeared, its intensity initially increased and then decreased, and when bringing the patient into a sitting position, the nystagmus changed its direction.

The occurrence of BPPV is due to an excess of otoconial fragments in the vestibular endolymph, which is formed either post-traumatically or by excessive fragmentation of otoliths or the inability of dark cells to phagocytise these physiologically produced fragments.

The presence of otoliths in the endolymph is followed by their displacement at the most declining point of the endolymph system; when moving the head and turning to that side, they will reach the posterior semicircular canal, usually where there should be no otoliths. Thus, hydrodynamic changes will appear in the endolymph of the canal, followed by the bending of the cilia under the action of the endolymphatic current and the triggering of some action potentials in the vestibular nerve. This stimulation of a single vestibular nerve explains the informational imbalance in the vestibular nuclei on the right and left sides, the consequence being the appearance of nystagmus and vertigo. (Parnes & McClure, 2015)

Currently, it is universally accepted that endolymph particles originate in the utricle, being in fact otoconia that, spontaneously or due to direct damage (infections, circulatory disorders) or indirect damage (trauma), get fragmented and become free in the endolymph (Figure 1).

Figure 1. Otoconial fragmentation (electron microscopic image) (Baloh et al., 1987)

In this environment, otoconia tend to slide with the movements of the head in one of the semicircular canals, most often in the posterior semicircular canal due to its position and orientation. From this moment on, there are two possibilities: either the particles aggregate giving rise to a larger particle that reaches a critical mass, which can cause specific BPPV symptoms (canalithiasis), or the particles adhere to the cupula of the semicircular canal in which they are (cupulolithiasis).

Canalithiasis is most common in current practice: otoconial fragments tend to gravitate inside the posterior semicircular canal, usually being in the most sloping part of the labyrinth during both orthostatic and dorsal decubitus positions. Once inside the canal, the cupula barrier at the ampullary end of the canal blocks the exit of particles to the utricle and thus

they become trapped, being able to leave the canal only through the non-ampullary end (Figure 2) (Kentala & Rauch, 2003).

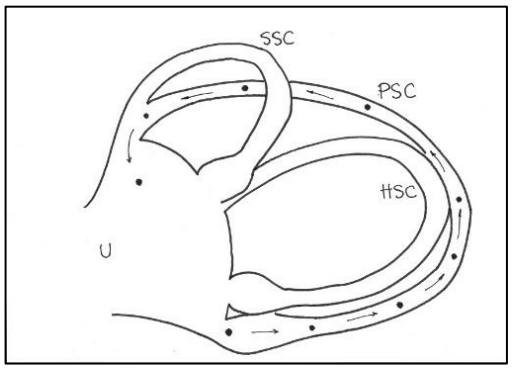

Figure 2. Displacement of the otoconial fragments into the posterior semicircular canal (BPPV of the posterior semicircular canal)

Benign paroxysmal positional vertigo is classified according to the following criteria:

- laterality:
  - right
  - left
- number of semicircular canals involved:
  - one canal
  - multicanals

If several semicircular canals are affected at the same time, the posterior and lateral ones are usually impaired.

The particles can also be temporarily located in the common arm of the posterior and anterior canals. In this case, it is about pure torsional nystagmus that, during the Dix-Hallpike manoeuvre, will beat towards the healthy ear, and when the patient returns to the sitting position, it will beat towards the affected ear.

Positive diagnostic

The Dix-Hallpike manoeuvre has been the "gold standard" of diagnosis for posterior canal BPPV for almost 50 years.

The suspicion of BPPV is confirmed by clinical examination: in the Dix and Hallpike position on the respective side (Figure 3), after a latency period of 2-20 seconds, intense horizontal rotatory geotropic nystagmus appears, accompanied by vertigo. This nystagmus, as well as the sensation of vertigo, disappears if the head position is maintained for about 1 minute (fatigue). When returning to the sitting position, the patient may experience nystagmus with the opposite direction or lower, less severe and exhaustible nystagmus. Repetition of the trigger manoeuvre demonstrates the adaptability of benign paroxysmal positional nystagmus, a pathognomonic feature of this condition.

Paraclinical audio-vestibular investigations usually reveal normal results.

Clinical examination establishes the BPPV diagnosis and identifies the affected semicircular canal (Table 1).

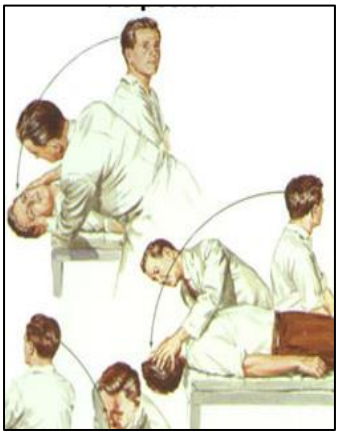

Figure 3. Dix-Hallpike diagnostic manoeuvre (From Bernard Ars' personal iconography)

Table 1. *Lesion-side diagnostic of BPPV*

Clinical characteristic	PSC	HSC	ASC
Incidence	90%	6%	4%
Provocative manoeuvre	Dix & Hallpike, affected ear down	Dorsal decubitus with rapid lateral head turn	Dix & Hallpike, affected ear up
Nystagmus	geotropic, upwards torsional	horizontal, direction-changing	apogeotropic, downwards torsional
Latency	3-15 sec	< 5 sec	3-15 sec
Duration	< 45 sec	< 2 min	< 30 sec
Fatigability	YES	NO	YES
Treatment	APPROPRIATE REPOSITIONING MANOEUVRE		

In the practice of family physicians in the United States, the positive predictive value of the Dix-Hallpike manoeuvre was found to be 83%, and its negative value, 52%. Therefore, a negative Dix-Hallpike test does not definitively rule out the diagnosis of posterior canal BPPV. Due to the low negative predictive value, it was suggested that the manoeuvre should be repeated in two separate visits to the clinician to confirm the diagnosis and avoid false-negative results. (Norré, 1995)

Factors that may affect the accuracy of the method are:

- the speed of movements performed during the test;
- the time of day when the test is performed;
- the angle between the plane of the occiput and the horizontal;
- the examiner's experience.

Patients with obesity class III are difficult to examine by a single clinician and, in this case, help is needed. Those with various physical limitations benefit from special examination tables (Stryker circle beds) that make the manoeuvre easier and safer.

Diagnostic manoeuvres should be avoided in certain circumstances. Although no cases of vertebrobasilar insufficiency have been reported during the manoeuvre, clinicians need to consider the risk of stroke in patients with risk factors. For these patients (cervical stenosis, severe kyphoscoliosis, Down syndrome, advanced rheumatoid arthritis, low back pain, ankylosing spondylitis, severe obesity, elderly people), some authors recommend performing

the Vertebral Artery Test before placing the patient in the trigger position to ensure that there is no risk of compression of the vertebral artery (Norré & Beckers, 1988; Angeli et al., 2003; Bergin et al., 2010). The possibility of a stroke should not be underestimated.

Roll test ("Supine roll test")

Horizontal semicircular canal BPPV ranks second in frequency of occurrence after posterior canal BPPV (Hornibrook, 2005).

The supine roll test is a manoeuvre imagined by McClure and Pagnini, which detects horizontal semicircular canal lithiasis (Figure 4) (McClure, 1985).

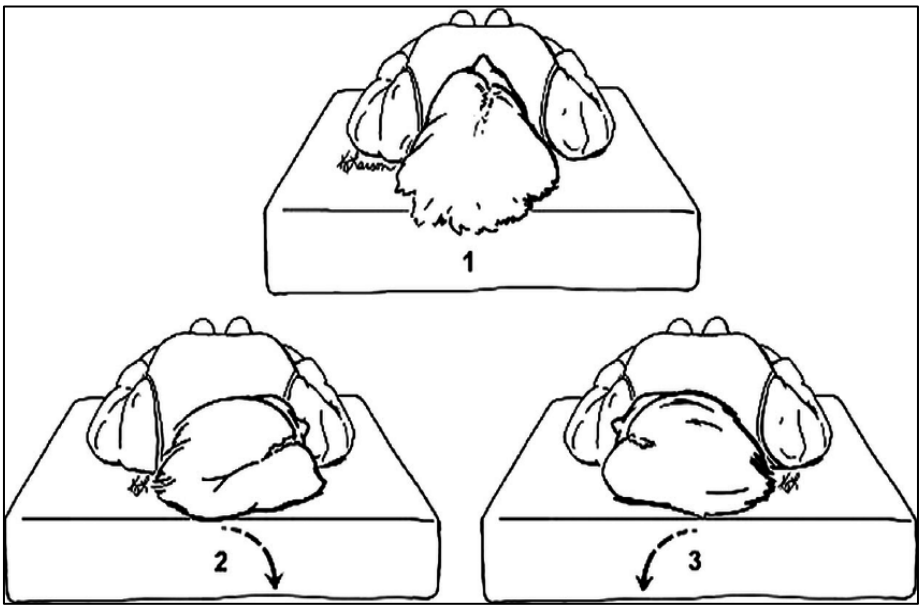

Figure 4. Roll test

The patient is brought from sitting to a supine position, with the head raised 30 degrees. The head is then quickly rotated to the right, and then 90 degrees to the left, passing through the initial position so that the patient's ear rests on the examination table. During this time, the examiner observes the appearance of nystagmus. The head is rotated to the other side only after the nystagmus has disappeared.

In the case of lateral canal BPPV, nystagmus is purely horizontal without any rotating component, begins after a short period of latency, increases in magnitude as the trigger position is maintained, is less susceptible to fatigue when the test is repeated, is more intense and lasts longer, but does not exceed one minute. Due to the coplanarity of the two horizontal semicircular canals, nystagmus will be present no matter on which side the patient will be turned, but will be more intense on the affected side in cases of canalithiasis and more intense when returned to the healthy ear in cases of cupulolithiasis.

Otolithic repositioning manoeuvres

BPPV is a disease of the peripheral vestibular system, which is characterised, in pathophysiological terms, by the abnormal movement of otoconial fragments in the semicircular canals. The treatment methods aim at bringing the fragments back into the utricle, their place of origin, and the otolithic repositioning manoeuvres must take into account the anatomy of the affected semicircular canal in order to allow, under the action of gravity, the movement of otoconial fragments.

The inner ear has the three semicircular canals arranged perpendicular to each other, with one semicircular canal in each plane of space (Figure 5), coplanar two by two - the upper (anterior) semicircular canal is coplanar with the posterior semicircular canal in the opposite ear, and the two horizontal (lateral) semicircular canals are coplanar with each other (Figure 6). It should also be mentioned that the two horizontal canals are inclined upwards by 30 degrees from the horizontal (Figure 7).

Figure 5. Perpendicular semicircular canals

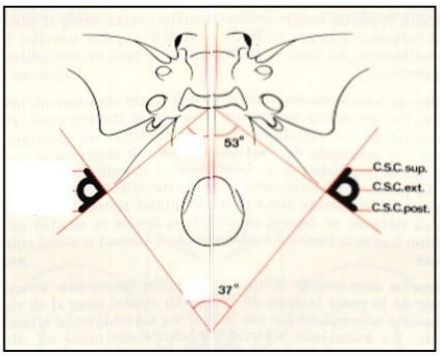

Figure 6. Coplanarity of the semicircular canals

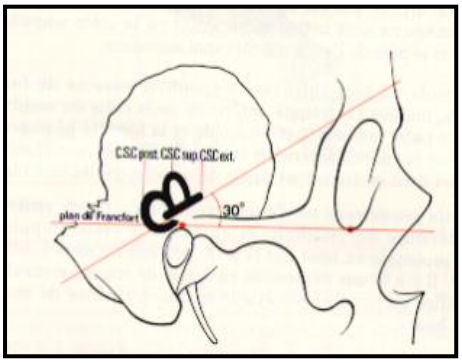

Figure 7. Elevated horizontal semicircular canal

The return of otoconial fragments is the purpose of physical methods used to treat BPPV, the only treatment that removes the disease.

Repositioning methods differ depending on the affected semicircular canal. Therefore, diagnosis is essential in choosing the right treatment. Using an inadequate repositioning method (incorrect diagnosis of the affected ear or semicircular canal) can worsen the condition of the patient, who can no longer sleep in any position due to the dissemination of otoconial fragments in all semicircular canals.

However, the correct diagnosis and the choice of the appropriate treatment method bring satisfaction to both the therapist and the patient because the physical method of otolithic repositioning instantly eliminates the symptoms (Appiani et al., 1997; Asawavichianginda et al., 2000).

The most used otolithic repositioning options are the following:

- For posterior semicircular canalithiasis, the Epley and Semont manoeuvres.
- For horizontal semicircular canalithiasis, the method of prolonged rest (12 hours) on the healthy side, Barbeque and Gufoni manoeuvres.

Of course, side effects might occur, such as the displacement of otoconial fragments in another semicircular canal (usually in the lateral one during the Epley manoeuvre) or residual dizziness (usually in multicanal BPPV), which is why follow-up after the repositioning manoeuvre is mandatory to solve the remaining symptoms if any (Seok et al., 2008) and restore balance (Blatt et al., 2000).

Patients with BPPV are frequently referred to the emergency unit, where a thorough medical history and bedside evaluation are mandatory for proper diagnosis and management (Koelliker et al., 2001; Korres & Balatsouras, 2004; Lawson et al., 2005).

Epley manoeuvre

Based on his own models, Epley proposed a controlled set of head movements, which he called the canalith repositioning procedure (CRP) - the Epley manoeuvre. Thus, under the action of gravity, the free particles in the posterior semicircular canal are moved to the utricle, where they will have to be maintained for being destroyed by cells specialised in this regard. The Epley manoeuvre is a reliable treatment method for BPPV of the posterior semicircular canal, with a very high success rate (more than 95%) after one manoeuvre (Hilton & Pinder, 2004; Munoz et al., 2007).

The Epley manoeuver begins with the vertigo-triggering position (Dix-Hallpike position on the side of the affected ear) and continues with the slow movement of the head and body towards the affected ear, in steps of 90 degrees. Each position is maintained for 2 minutes or until the feeling of vertigo disappears completely. At the end of the rotation, the patient is seated and the head is returned to the middle position with the chin on the chest in order to direct the otoconial particles towards the utricle.

When raising the head in the upright position, a significant imbalance to the back may occur, so we must be prepared to support the patient. After repositioning, the patient is advised not to lie below 45 degrees from the vertical and not to turn their head in any direction for 48 hours (Figure 8). (Epley, 1980; Roberts, Gans, & DeBoodt, 2005; Massoud & Ireland, 1996)

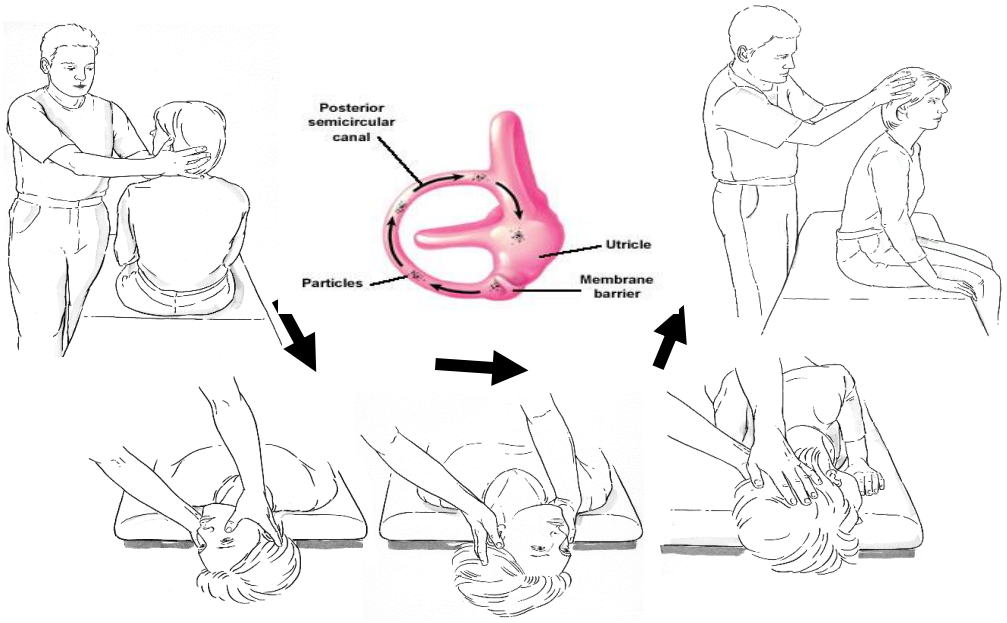

Figure 8. Epley manoeuvre

Semont manoeuvre

The Semont liberatory manoeuvre (Figure 9) is also used for the posterior canal affected by BPPV. If gravity is the factor used for repositioning in the case of the Epley manoeuvre, acceleration and gravity are used in the Semont manoeuvre. This manoeuvre involves the patient's sudden lateral lying down from a sitting position, initially towards the affected ear, and then towards the contralateral healthy ear. During manoeuvres, the head is always turned towards the healthy ear. Performing this manoeuvre requires sufficient strength from the practitioner to handle patients with different weights. (Levrat et al., 2003)

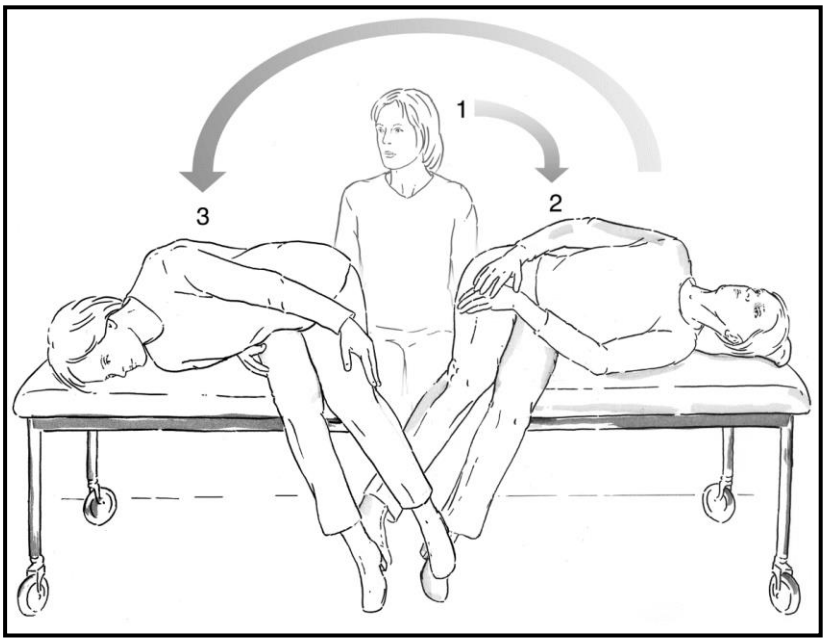

Figure 9. Semont manoeuvre

Barbeque manoeuvre

The Barbeque manoeuvre (Lempert and Tiel-Wilck) is used to reposition otoconial fragments that float freely in the horizontal semicircular canal. As in the case of the Epley manoeuvre, under the action of gravity, the particles move slowly from the affected ear to the healthy ear. Thus, from the supine position, the patient's head is turned towards the healthy ear. The patient is then rotated into lateral decubitus on the healthy side, ventral decubitus, after which the patient's head is rotated towards the affected ear, the patient is rotated into lateral decubitus on the affected side and then returns to the sitting position. Each position is held for at least 1 minute (Figure 10). (Lempert &Tiel-Wilck, 1996)

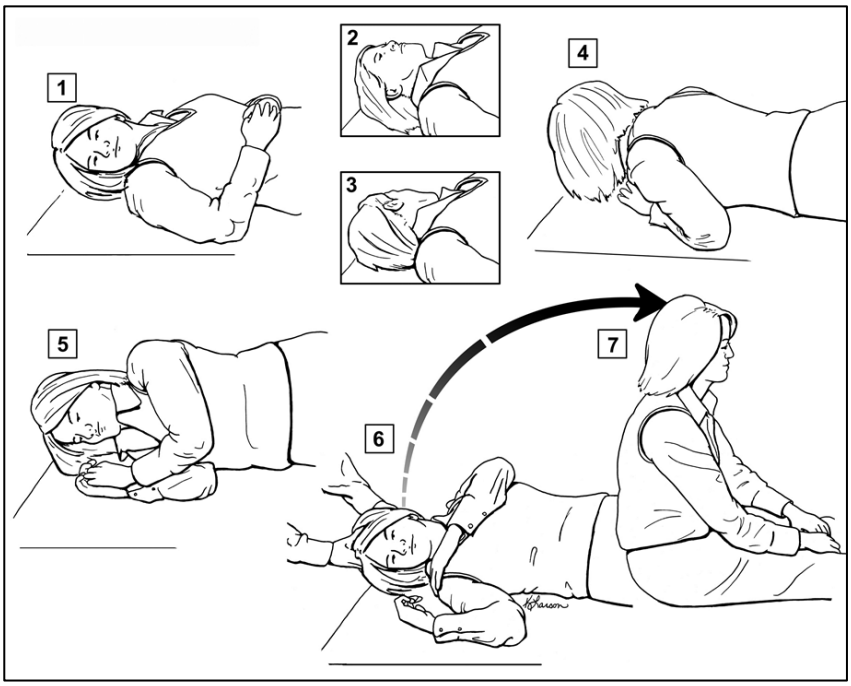

Figure 10. Barbeque (Lempert) manoeuvre

Appiani-Gufoni manoeuvre

For BPPV of the horizontal semicircular canal, the Appiani-Gufoni manoeuvre has become more and more used due to the ease of performing it. It also uses gravity as the driven factor of particle movement from the affected semicircular canal towards the utricle. Again, 1 minute-time should be respected for each position. From the sitting position, the patient is inclined laterally towards the affected part and, when reaching the table, the patient's head is turned nose up. Then the patient gets to the sitting position with the head turned straight ahead (Figure 11). (Asprella Libonati, 2005)

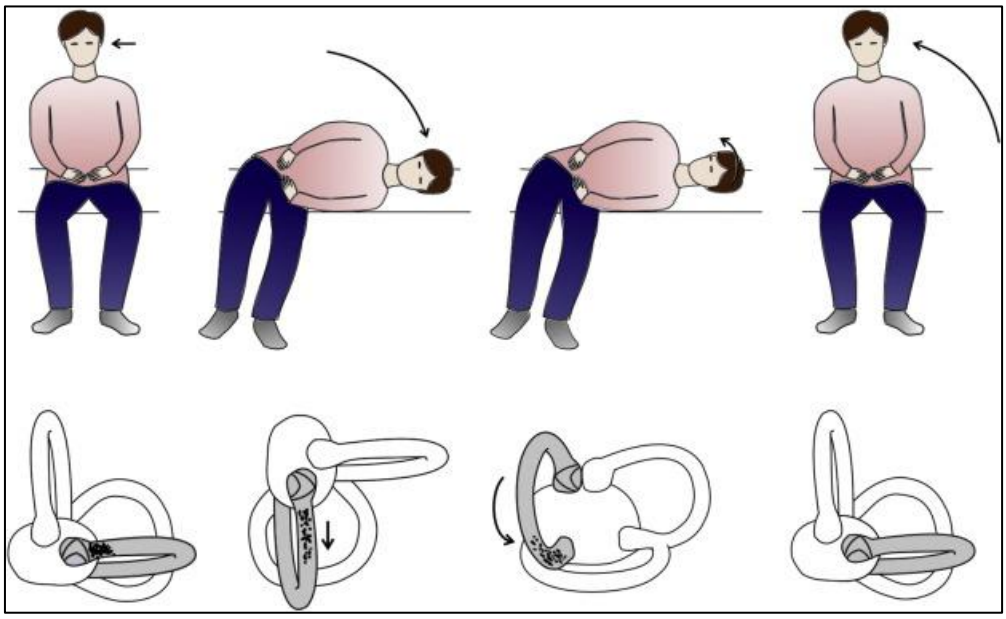

Figure 11. Appiani-Gufoni manoeuvre

BPPV is sometimes caused by the otoconial particles attached to the cupula, which do not move freely in the semicircular canal. This form of BPPV is called cupulolithiasis and is more difficult to treat. We should first try to convert it into a canalithiasis form (possible by detaching the particles with a vibrator applied to the skull) (Li, 1995) and then perform the appropriate repositioning manoeuvre.

For cupulolithiasis of the horizontal semicircular canal, a *modified Gufoni manoeuvre* is available (Testa et al., 2012; Hwang et al., 2015; Kim et al., 2012). In this case, the movement of the head in the lateral position is downward (Figure 12).

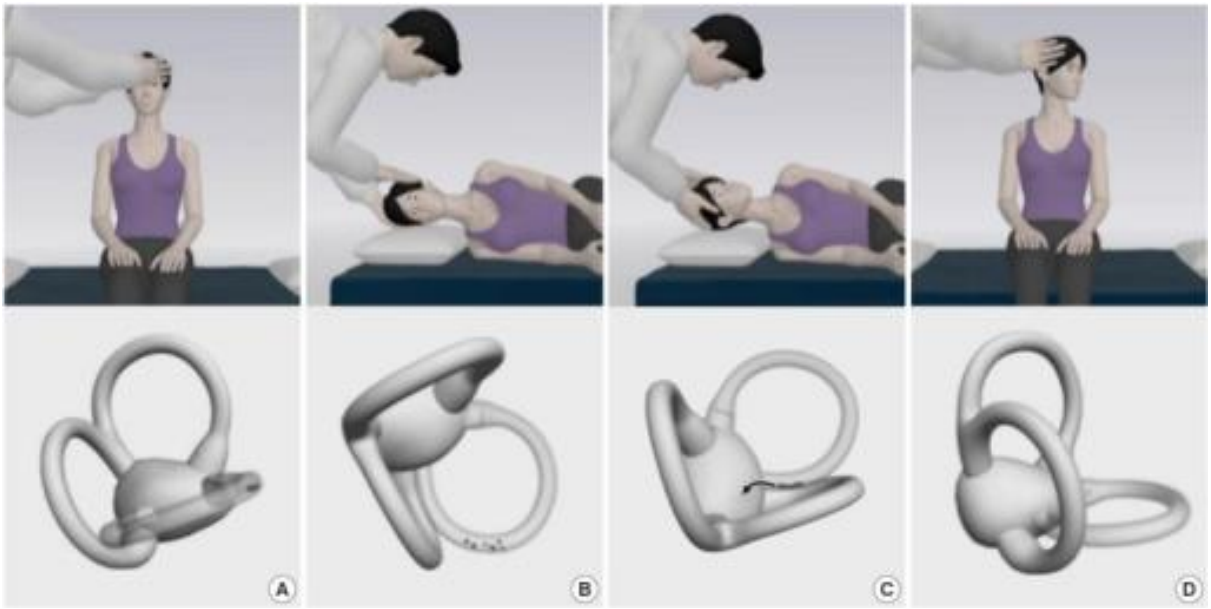

Figure 12. Modified Gufoni manoeuvre

Clinical case

We present the clinical case of a 47-year-old male with acute vertigo (lasting continuously for three hours) and right ear fullness three days ago. This first vertigo spell was followed by short attacks of vertigo (seconds) while lying down or when getting up from the bed.

Other than this, he had unremarkable personal and family medical history.

Bedside otoneurological examination revealed spontaneous left-beating nystagmus that was not influenced by bow/lean position. When positional nystagmus was examined, the patient experienced vertigo and we recorded vertical torsional nystagmus in the right Dix-Hallpike position, with changing direction after returning to the sitting position.

Based on his history and clinical evaluation, we considered two possible diagnostics – Multicanal BPPV (Right posterior canal BPPV associated with Left horizontal canalithiasis/ Right horizontal cupulolithiasis) or Multiple vestibular different pathologies (Right posterior canal BPPV plus Acute right-sided unilateral vestibulopathy).

In order to have a positive diagnostic, we continued with hearing evaluation because the inner ear has a double function: hearing and balance.

Pure tone audiometry (PTA) revealed a mild low-frequency sensorineural hearing loss on the right ear (Figure 13).

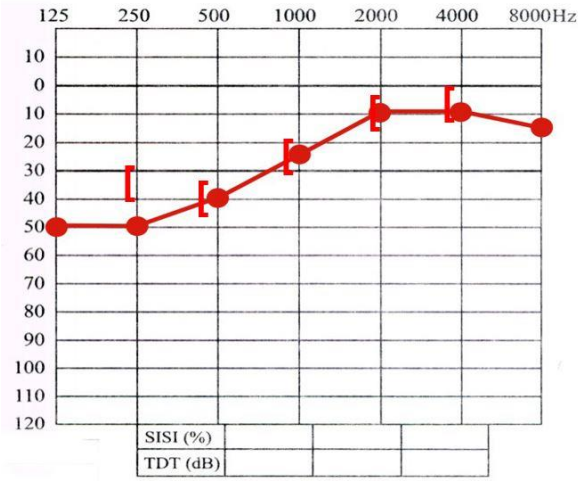

Figure 13. Mild low-frequency sensorineural hearing loss on the right ear

Our conclusion and therefore final diagnostic was Right posterior canal BPPV associated with first attack of Right-sided probable Menière's disease.

The treatment protocol chosen for our patient was the Right Epley manoeuvre. At the 7-day follow-up evaluation, the patient was free of symptoms, meaning that BPPV was completely resolved by the repositioning manoeuvre, and Menière's disease was in-between attacks, when patients are asymptomatic.

For Menière's disease, we recommended Betahistine (48 mg/day) for 30 days and low-salt diet, with follow-up evaluation after that.

Conclusion

BPPV is the most common cause of inner ear vertigo, which is caused by excessive otoconial fragmentation and free displacement of these fragments in the semicircular canals during head of body movements.

Treatment is physical and consists of repositioning manoeuvres. Once the diagnosis is made, considering the ear and canal affected, appropriate canal repositioning procedures are very rewarding for patients and therapists as well, with immediate resolution of symptoms.

Trained physicians, audiologists and physiotherapists can easily perform these manoeuvres.

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