Diagnostic and treatment strategy of Lateral Semicircular Canal Canalolithiasis

Strategia diagnostica e terapeutica della Canalolitiasi del Canale Semicircolare Laterale

G. ASPRELLA LIBONATI
Unit of Audiology-Vestibology and Phoniatrics, Department of Otorhinolaryngology and Head-Neck Surgery, "Madonna delle Grazie" Hospital, Matera, Italy

Key words

Lateral Semicircular Canal • Benign Paroxysmal Positional Vertigo • Liberatory Manoeuvre • Otoliths • Lateral Semicircular Canal

Parole chiave

Vertigine Parossistica Posizionale del canale semircicolare laterale • Manovra liberatoria • Otoliti • Canale semicircolare laterale

Summary

A new strategy for the diagnosis and treatment both of geotropic and apogeotropic Lateral Semicircular Canal Benign Paroxysmal Positional Vertigo is proposed. To this end, a new strategy of approach to Lateral Semicircular Canal Benign Paroxysmal Positional Vertigo is described in order to rapidly highlight both the side and the affected canal. Thus, in the first treatment session, using the so-called "strategy of the minimum stimulus", a large percentage of cases are successfully treated, with the lowest number of vertigos for the patient. Following a review of the literature, 269 case studies, personally observed over a 4-year period, are described. The diagnostic strategy is performed by a single manoeuvre to determine whether the posterior semicircular canal or the lateral canal is affected. In the latter case, it is possible to highlight the affected sides both of the geotropic and apogeotropic forms. The therapeutic strategy comprises several liberatory manoeuvres, barbecue rotation techniques (Vannucchi-Asprella, Lempert), and Gufoni manoeuvre by continuously monitoring the ampullofugal movement of the otoliths. Almost 98% of cases are successfully treated at the first treatment diagnostic-therapeutic session. This approach to Lateral Semicircular Canal Benign Paroxysmal Positional Vertigo allows a two-fold goal to be achieved, i.e., to effect both diagnosis and treatment at the first examination. Furthermore, thanks to the philosophy of the approach to Benign Paroxysmal Positional Vertigo, called the "Strategy of the minimum stimulus", patient compliance is very good since a very small number of vertigos are produced, and few neuro-vegetative disorders.

Riassunto

Lo scopo del lavoro è quello di illustrare una nuova strategia per la diagnosi e la terapia della vertigine parossistica posizionale benigna (VPPB) del canale semicircolare laterale (CSL), sia nella forma geotropa che in quella apogeotropa. Viene descritta una metodologia di approccio alla VPPB del CSL che consente di individuare rapidamente il lato ed il canale affetto, portando già nel corso della prima seduta ad immediata risoluzione una elevata percentuale di casi, con il minimo disagio per il paziente. Infatti con la metodica illustrata si consegue il risultato terapeutico sottoponendo il paziente al minor numero di vertigini indispensabili: "strategia del minimo stimolo". Dopo una disamina della letteratura viene riportata la propria esperienza relativa a 269 casi osservati in 4 anni. La strategia diagnostica utilizza una manovra unica, finalizzata a distinguere l'interessamento del canale semicircolare posteriore dal laterale, consentendo, in quest'ultimo caso, di individuare il lato affetto sia nelle forme geotrope che apogeotrope. La strategia terapeutica utilizza la combinazione di diverse manovre liberatorie, tecniche di barbecue rotation (Vannucchi-Asprella, Lempert), e la manovra di Gufoni, monitorizzando sempre l'effettiva progressione in senso ampullifugo dell'ammasso otolitico. Il controllo videonistagmoscopico step by step del nistagmo evocato nell'esecuzione delle varie fasi della terapia, consente, infatti, di rilevarne l'efficacia, testimoniata dalla comparsa di un nistagmo diretto verso l'orecchio sano, da deflessione ampullifuga della cupula ampollare dell'orecchio coinvolto, quindi inibitorio. La percentuale di risoluzioni della patologia nel corso della prima seduta diagnostico/terapeutica è elevata, raggiungendo il 98%. Con tale strategia di approccio alla VPPB del CSL si consegue dunque l'obiettivo di effettuare sia la diagnosi che la terapia già alla prima osservazione. Inoltre la compliance da parte del paziente è elevata essendo limitata al minimo indispensabile la stimolazione di vertigini e del corredo neurovegetativo associato, con una filosofia di approccio alla VPPB definita come "Strategia del minimo stimolo".

Introduction

Benign paroxysmal positional vertigo (BPPV) due to canalolithiasis of the lateral semicircular canal (LSC) has been known for over 15 years and described in the literature for the first time in 1985 [1 2]. The typical clinical picture of LSC-BPPV is a bidirectional horizontal geotropic nystagmus which is bipositional on the right and left sides.

In 1989, Pagnini et al. [3] reported 15 cases of LSC-BPPV, hypothesizing that the endolymphatic current induced by the floating of otoconial debris on the posterior arm of the LSC causes the nystagmus. When the patient lies supine, after rotating the head on the impaired side, the otoliths settle along the canal, towards the ampulla, due to gravity, generating an ampullopetal, and, therefore, an excitatory, endolymphatic current, and the consequent geotropic nystagmus (Ny) beating to the impaired ear. If the patient's head is turned on the healthy side, the otoliths float towards the utricular orifice generating an ampullofugal, thus inhibitory, endolymphatic current (Figs. 1, 2). Consequently, the Ny will be geotropic once again and, therefore, beating to the healthy side. The Authors stress a greater intensity of the nystagmus on the impaired side explained by Ewald's second law [4] which postulates that the response to an excitatory stimulus is always more intense than that following an inhibitory stimulus. This was also the first report of forms originating as apogeotropic paroxysmal positional nystagmus that transformed spontaneously into geotropic.

In 1994, Pagnini et al. [5] reported an additional ten cases of LSC-BPPV with bidirectional horizontal PP-Ny originating as apogeotropic. The transformation of the paroxysmal positional nystagmus into the geotropic form occurred in all patients during the first or later treatment sessions. The Authors suggest that this change of the Ny may be related to a different position of the otoconial mass inside the LSC. In fact, if one considers the LSC divided into two halves, the simple or posterior arm and the ampullary or anterior arm, it is not difficult to imagine the different direction the otolithic mass will follow in its gravitational sedimentation in the lateral position depending on the original position of the otoliths inside the canal. If the patient lies on the impaired side, the debris in the ampullary segment will move away from the cupula, resulting in an inhibitory ampullofugal endolymphatic current causing apogeotropic paroxysmal positional nystagmus beating to the healthy ear. When the head is turned to the opposite side, the otoliths will drop towards the ampulla with an excitatory discharge and an apogeotropic paroxysmal positional nystagmus beating to the affected side will be observed. The transformation of the nystagmus from an apogeotropic to a geotropic form is explained by the migration of the otoconial mass to the posterior arm of the LSC (Figs. 1, 2). Accordingly, the otoliths will float to an opposite direction compared to the cupula, due to gravity occurring with the lateral rotations of the head. The most intense apogeotropic paroxysmal positional nystagmus is observed in the supine position with the head turned on the healthy ear according to Ewald's second law, in that the excitatory stimulation from an ampullopetal endolymphatic current occurs on the uppermost ear.

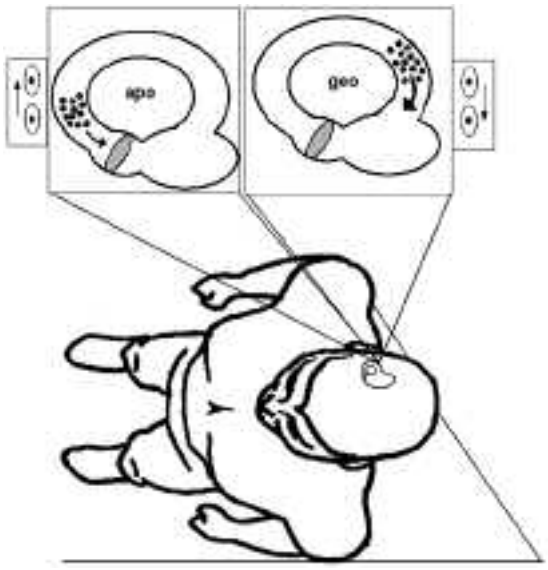

Fig. 1. Patient lies on side of healthy ear: in geotropic forms, otoliths found in posterior arm of LSC settle along canal, towards utricle, generating an ampullofugal, inhibitory current and, therefore, geotropic nystagmus beating to healthy ear. In apogeotropic forms, otoliths found in anterior arm settle along canal, towards ampulla, causing an excitatory, ampullopetal endolymphatic current and consequent apogeotropic nystagmus beating to impaired side.

In 1996, Nuti et al. [6] reported data emerging from a study on 123 patients suffering from LSC-BPPV, highlighting 5 typical cases to illustrate possible clinical variants of the syndrome, examining the physiologic aspects of the nystagmus observed and suggesting further physiopathological explanations based on the canalolithiasis theory.

In 2001, von Brevern et al. [7] described the case of a patient with BPPV of right LSC who showed spontaneous Ny beating to the left which disappeared after the rehabilitation technique. The Authors explained spontaneous nystagmus with plugging the horizontal canal by means of otoconial particles, with a negative endolymph pressure between plug and cupula.

Vannucchi et al. [8] stressed the rules to identify the impaired side for LSC-BPPV.

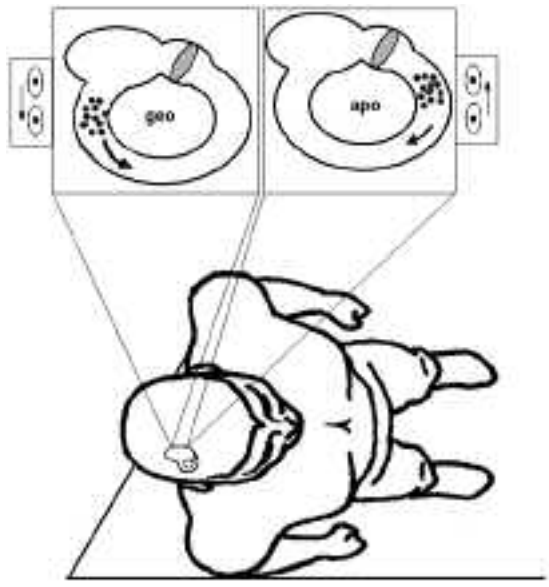

Fig. 2. Patient lies on impaired side: in geotropic forms, otoliths found in posterior arm of LSC settle along canal, towards ampulla, generating an excitatory, ampullopetal endolymphatic current and, consequently, geotropic nystagmus beating to affected side. In apogeotropic forms, otoliths found in anterior arm move away from ampulla, generating an inhibitory ampullofugal endolymphatic current and, consequently, apogeotropic nystagmus.

The affected side of the geotropic forms is:
- the side on which the nystagmus is more intense;
- the side on which spontaneous inversion occurs or is more evident;
- the side opposite the direction of the nystagmus when the patient is brought from the seated position to the supine position.

The affected side of the apogeotropic forms is:
- the side on which the nystagmus is less intense;
- the side opposite that on which spontaneous inversion occurs, although this phenomenon is not frequent;
- the side to which nystagmus beats when the patient is brought from the seated position to the supine position.

This study was performed to examine the efficacy of a step-by-step approach to the identification and treatment of LSC-BPPV in a large cohort of patients. The identification of the involved side is, indeed, important in choosing effective treatment manoeuvres. Therefore, a specific approach strategy is described, involving minimal stimulus diagnosis and treatment, and resulting in a successful outcome in the first treatment session with the lowest number of vertigos: the "strategy of the minimum stimulus".

Material and Methods

From January 2001 to December 2004, we observed 269 BPPV due to LSC canalolithiasis, of which 196 were geotropic and 73 apogeotropic.

Overall 66% of LSC-BPPV were associated with a spontaneous stationary nystagmus which disappeared after the rehabilitation treatment.

Our diagnostic-therapeutic approach aimed at resolving the BPPV during the first treatment session with the lowest number of vertigos through the "*strategy of the minimum stimulus*".

The therapeutic approach took into account the patient's physical and psychological conditions; e.g. arthrosis, obesity, recent injuries, plaster casts, several neurovegetative disorders, anxiety, depressive phobic status.

The diagnostic techniques adopted were Pagnini-McClure and "Asprella Single Manoeuvre", the latter being performed to diagnose both LSC and posterior semicircular canal (PSC) BPPV.

Anxious or phobic patients with several neuro-vegetative symptoms not wishing to undergo a diagnostic-therapeutic procedure causing repeated vertigos, are submitted to the "Asprella Single Manoeuvre" (Fig. 3) consisting in a brisk change from the seated to the supine position under videonystagmoscopic (VNS) control.

When a rotatory nystagmus is evoked the head is turned 45° to the right if the nystagmus is counterclockwise and to the left if it is clockwise; therefore, the bed head is lowered rapidly so that the patient goes to the Dix-Hallpike position.

If the nystagmus persists or becomes more intense, then the diagnosis of the PSC-BPPV is confirmed and Epley manoeuvre is performed.

Should a horizontal nystagmus occur, LSC-BPPV will be diagnosed: e.g. a right nystagmus may indicate either a left geotropic form or a right apogeotropic form. In fact, in the supine position, the LSC is on a vertical plane and, therefore, due to the brisk deceleration caused by the manoeuvre, the otoliths are pushed downwards; if they are in the posterior arm, they float towards the utricle, but if they are in the anterior arm, they float towards the ampulla (Fig. 4).

Therefore, the head is briskly turned 90° towards the side the nystagmus beats to; if the nystagmus increases, a geotropic form may be diagnosed; on the contrary, if it decreases, stops or reverses direction, an apogeotropic form may be diagnosed.

The rehabilitation manoeuvres used in geotropic forms were the Vannucchi-Asprella manoeuvre (Fig. 5) and the Lempert manoeuvre (Fig. 6); in several cases of the apogeotropic form, the first step of the Gufoni manoeuvre (Fig. 7) was also performed: the patient was briskly tilted onto the impaired side with the head in axis with the body.

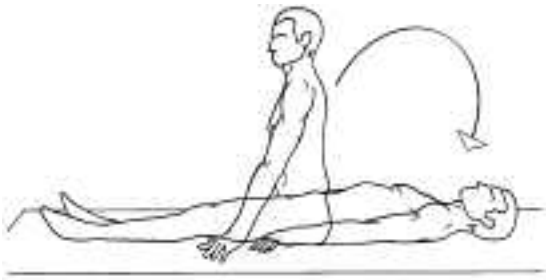

Fig. 3. Asprella Single Manoeuvre performed to diagnose both LSC and PSC BPPV: a brisk change from seated to supine position, under videonystagmoscopic control.

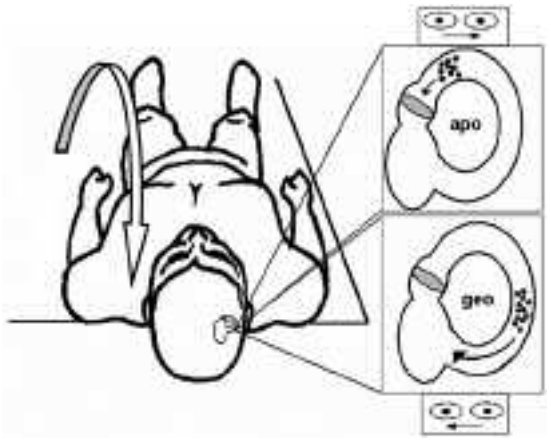

Fig. 4. Asprella Single Manoeuvre: when patient lies supine, LSC is on vertical plane; therefore, due to brisk deceleration caused by manoeuvre, otoliths are pushed downwards: if they are in posterior arm, they float towards utricle, if they are in anterior arm, they float towards ampulla.

The rehabilitation manoeuvres were always carried out under VNS control, in order to monitor the migration of the otolithic mass in an ampullofugal direction, which is confirmed by a nystagmus beating to the healthy side, irrespective of position, i.e., inhibitory due to the ampullofugal deflection of the cupula when carrying out the single steps of the therapy.

Results

Out of 196 geotropic forms, 166 (85%) were first treated with the Vannucchi-Asprella manoeuvre. The manoeuvre was then repeated until no horizontal nystagmus beating to the healthy side was evoked, either

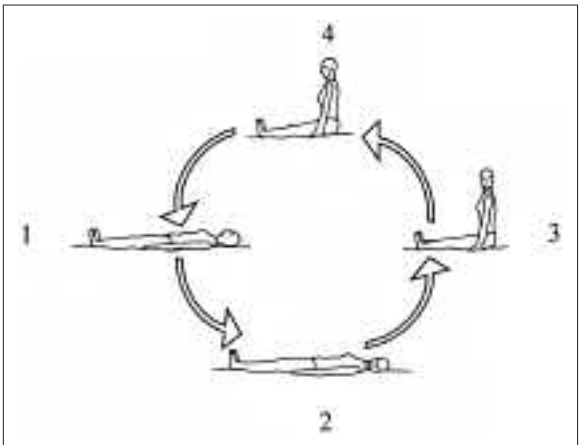

Fig. 5. Vannucchi-Asprella manoeuvre for right LSC-BPPV: 1. patient lies in supine position, 2. his/her head is briskly turned 90° towards healthy side, 3. while keeping head turned, he/she is returned to seated upright position, 4. his/her head is slowly brought back in axis with body; 1. he/she is returned to supine position.

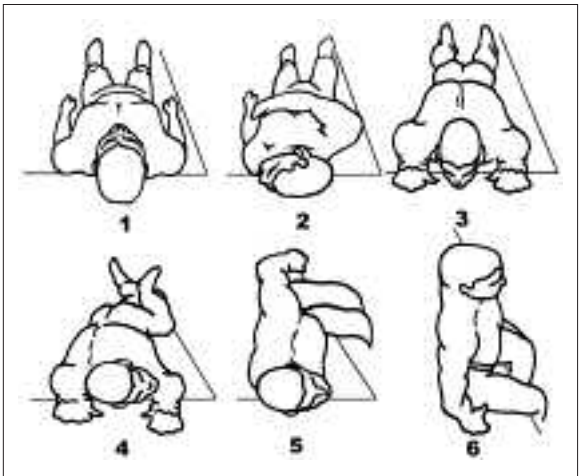

Fig. 6. Lempert barbecue rotation technique for right LSC-BPPV. Head is rotated 90° three times towards healthy side, thus applying an overall 270° rotation.

when the patient was returned to the supine position or immediately after the brisk lateral rotation of the head towards the healthy side in a supine position. Therefore, the disappearance of the nystagmus beating to the healthy side was interpreted as the solution of the canalolithiasis. Although a minimum of 5 manoeuvres were carried out as a precaution, in 50% of cases 3-4 manoeuvres were adequate, in 25% of cases 5-6 manoeuvres were sufficient, while 8-10 manoeuvres were required for the remaining 25% of patients.

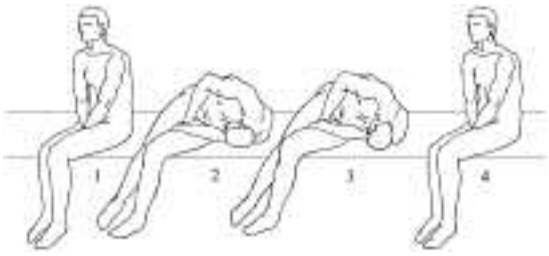

Fig. 7. Gufoni manoeuvre for right geotropic/left apogeotropic LSC-BPPV: 1. patient sits upright on examination table with his/her legs downwards; 2. he/she is then tilted rapidly on one side on the healthy side, in geotropic form, on the impaired side, in apogeotropic form; 3. head is then turned 45° downwards after which examiner waits 2-3 minutes; 4. patient is returned to original position.

In 15% of cases, the horizontal nystagmus beating to the healthy side disappeared after 3-4 manoeuvres; however, a horizontal nystagmus beating to the impaired side was evoked after returning the patient to the supine position. We assume that this inversion of the nystagmus was due to an ampullopetal reflux of the otoconial mass brought closer to the utricular orifice by the rotatory steps without crossing it. In this case, we continue with a Lempert barbecue rotation technique by performing three successive 90° rotations steps towards the healthy side. In our opinion, during this manoeuvre, the recurrence of a horizontal nystagmus beating to the healthy side after each step indicates the ampullofugal movement of the otoliths. At the end of the treatment, the diagnostic Pagnini-McClure manoeuvre was carried out to check whether the BPPV had been solved.

After the Vannucchi-Asprella manoeuvre performed towards the healthy side, 65% of the apogeotropic forms changed into geotropic forms. In these cases, after briskly rotating the patient's head towards the healthy side, a geotropic nystagmus beating to the unaffected ear can indicate the change from an apogeotropic to a geotropic form. In these patients, the Vannucchi-Asprella manoeuvre was repeated, at least 5 times, until no nystagmus was observed immediately after returning the patient to the supine position and after the brisk lateral rotation of his/her head. Therefore, in our opinion, disappearance of the geotropic nystagmus can indicate the solution of the BPPV, as confirmed later by the diagnostic Pagnini-McClure manoeuvre. Sometimes, in 8% of patients, in whom the geotropic nystagmus persisted after 10 Vannucchi-Asprella manoeuvres, the Lempert technique was performed to solve the BPPV. The head was rotated 90° three times towards the healthy side, thus applying an overall rotation of 270°.

In the other 35% of apogeotropic cases, other techniques were unsuccessful; consequently, the first step of the Gufoni manoeuvre was performed: the patient who was in a seated position, was briskly tilted onto the impaired side with the head in axis with the body. Immediately after tilting the patient on the impaired side, the consequent horizontal apogeotropic nystagmus indicates an ampullofugal movement of the otolithic mass.

It was decided to perform, in sequence, the Lempert barbecue rotation to the good side after putting the patient's legs onto the examination table. In these cases, at every 90° step, we observed a nystagmus beating to the healthy side, indicating a further ampullofugal movement of the otoconial aggregate. Afterwards, the diagnostic Pagnini-McClure manoeuvre confirmed the success of the treatment. During the last step of the Lempert manoeuvre, when the patient lies on the impaired side, only two patients, who were affected by an apogeotropic form suddenly showed a violent nystagmus beating to the impaired side, i.e., geotropic; consequently, the change from an apogeotropic to a geotropic form was observed although it did not solve the BPPV. The canalolithiasis was then resolved after repeating the Vannucchi-Asprella manoeuvres 8-9 times.

Overall, 98% of LSC-BPPV were solved during the first treatment session; the remaining 2% were, however, solved after several therapeutic sessions.

All patients were seen at follow-up, patients being checked after 3, 7, 15 and 30 days, thus confirming the solution of the disorder.

Discussion

Over the last few years, many therapeutic approaches have been suggested for LSC-BPPV.

After early unsuccessful endeavours to remove the otolithic mass by head shaking in the supine position [9], other Authors [10-12] suggested the rehabilitation "barbecue rotation" techniques. These involve an ampullofugal push on the endocanalar otolithic mass by rotating the patient's head briskly to the healthy side in the supine position, in single 90° steps, in order to exploit the inertial lag of the otoconia that are free to float into the canal endolymph. The overall angle of rotation varies from 180° to 360°. In 1994, Vannucchi et al. [13] devised a rehabilitation technique for the LSC-BPPV. Ascribing the pathogenetic mechanism to the canalolithiasis, the Authors have set up a procedure based on a slow gravitational sedimentation of the otoliths outside the non-ampullary LSC segment. This simple method which suits any patient, consists in forcing the patient to remain immobile on the healthy side – Forced Prolonged Position (FPP) – for at least 12 hours, in order to maintain the simple segment of

the LSC in a vertical position, with the utricular orifice facing downwards; the result of the technique is checked after 72 hours. The Authors reported a 90% cure rate of LSC-BPPV, following the FPP.

In 1995 [14], Epley devised a technique of canalith repositioning for the LSC-BPPV, without supplying any case studies.

In 1998, Gufoni and Mastrosimone [15] proposed a new technique: the patient sits upright on the examination table with his/her legs downwards; he/she is then tilted rapidly on one side – on the healthy side in the geotropic form, on the impaired side in the apogeotropic form; the head is then turned 45° downwards after which the examiner waits 2-3 minutes; finally, the patient is returned to the original position. The results described in a later report show a 90% cure rate in these cases.

In 1999, Asprella Libonati and Gufoni [16] proposed a variation to the barbecue rotation manoeuvre: the patient lies in the supine position and his/her head is briskly turned 90° towards the healthy side, then, while keeping the head turned, he/she is returned to the seated upright position and his/her head is slowly brought back in axis with the body; finally, he/she is returned to the supine position.

In 2003, Asprella Libonati et al. [17] described an original therapeutic strategy for the LSC-BPPV, known as "step-by-step rehabilitation under videonystagmoscopic (VNS) control". The rationale of this strategy is to monitor whether the ampullofugal progression of the debris in the canal occurs by observing the nystagmus evoked during each step of the liberatory technique (barbecue, Vannucchi-Asprella, Gufoni or others). According to Ewald's second law, the nystagmus with the fast phase beating to the healthy side indicates an ampullofugal deflection of the cupula caused by the floating of debris, heavier than the endolymph, towards the utricle. In this way, it is possible to adopt a more flexible approach, thus changing the therapy during the performance of the manoeuvre in order to achieve complete rehabilitation in one treatment session.

A review of the literature, therefore, highlights a considerable variety of rehabilitation manoeuvres, each theoretically valid, aimed at achieving the ampullofugal endocanalar progression of the otoconial debris, either by angular accelerations (barbecue rotation techniques), or by sudden linear accelerations (Gufoni liberatory manoeuvre), or through slow gravitational sedimentation (Vannucchi FPP).

None of the manoeuvres proposed, so far, have been successful in almost the totality of the cases, at the first treatment, particularly, as far as concerns the apogeotropic forms.

Despite the wide range of manoeuvres available, we prefer those that are both well tolerated by the patient and give a prompt solution, thus aiming at solving the LSC-BPPV during the first treatment while causing the lowest number of vertigoes; this is the so-called *strategy of the minimum stimulus*. To this end, we use only one diagnostic manoeuvre to make a distinction between PSC-BPPV and LSC-BPPV – Asprella single diagnostic manoeuvre. We prefer the Vannucchi-Asprella manoeuvre as it can immediately solve both geotropic and apogeotropic forms as well as the transformation of some apogeotropic forms into geotropic forms. The rationale behind this technique relies on brisk, repeated angular accelerations on both the lateral semicircular canals involved and on its content – endolymphatic column and otolithic mass. Due to the inertial lag of the otoliths, which are heavier than the endolymph, a gradual movement of the otoliths in the direction opposite to the side of rotation of the head with the liberatory manoeuvre is thus obtained, both in the geotropic and apogeotropic forms. The only difference is the different endocanalar starting point of the otoconia – from the ampullary segment in apogeotropic forms, from the non-ampullary segment in geotropic forms. In other words, when the head, and, therefore, the LSC, are turned clockwise, the otoconial debris follows a counterclockwise direction and viceversa. This explains why some of the apogeotropic forms are immediately solved after several Vannucchi-Asprella manoeuvres towards the healthy side. In the other apogeotropic forms, it was necessary to perform the different liberatory techniques in various ways (Vannucchi-Asprella + Lempert; Gufoni + Lempert) under VNS monitoring of the ampullofugal progression of the otoconial mass in order to solve the BPPV at the first treatment session.

Therefore, according to our experience, we suggest that different rehabilitation techniques should be applied, the choice of the appropriate manoeuvre should take into account the physical and psychological needs of the patient – *Strategy of the Minimum Stimulus*; moreover, therapy should be performed under VNS control to check the actual ampullofugal movement of the otolithic mass "step-by-step" to be interpreted according to the well-known laws of Ewald.

In our opinion, the spontaneous nystagmus observed in 177 cases (66%) is actually a pseudo-spontaneous nystagmus. Therefore, it is a particularly long-lasting non-paroxysmal nystagmus caused by accidental horizontal rotations of the head accomplished by the patient just before undergoing the vestibular examination. In our opinion, the accidental horizontal rotations of the head accomplished by the patient can cause the slow floating of the otoliths, in that the LSC is bent 30° compared to the horizontal plane. After bringing the patient to the seated position, it might be useful to slowly rotate his/her head horizontally, in fact this manoeuvre increases the percentage of pseudo-spontaneous nystagmus (92%).

We ascribe a diagnostic meaning to this pseudo-spontaneous nystagmus since it beats to the same direction as the nystagmus evoked when the patient is brought from the seated position to the supine position. Therefore, in geotropic forms, it beats to the healthy ear, whereas in apogeotropic forms, it beats to the affected ear.

Conclusion

Application of VNS control to the diagnosis and positioning manoeuvres used for BPPV due to LSC canalolithiasis can identify the most appropriate individual rehabilitation programme, resulting in a successful outcome in the first treatment session, in a large percentage of cases. Taking into account an in-depth knowledge of the diagnostic signs of positional nystagmus, the diagnostic/therapeutic strategy for the LSC-BPPV is, in our opinion, best accomplished by following a step-by-step technique under VNS monitoring. In this way, the rehabilitation technique will suit the patient, thus reducing his/her discomfort according to the "*strategy of the minimum stimulus*".

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■ Address for correspondence: Dr. Giacinto Asprella Libonati, recinto VI Lucana 3, 5100 Matera, Italy. Fax +39 0835 243384. E-mail: giacintoasprella1@tin.it