Anterior Canal Lithiasis: Diagnosis and Treatment

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Abstract

Objective. To describe the clinical and oculographic features in patients with anterior semicircular canal benign paroxysmal positional vertigo and to determine the efficacy of a canalith repositioning procedure for its management.

Study Design. Case series with chart review of patients presenting positional vertigo and positional downbeating nystagmus during a 2-year period.

Setting. Outpatients’ tertiary referral center for balance disorders.

Subjects and Methods. Eighteen patients suffering from positional vertigo and presenting positional downbeating nystagmus were treated with a maneuver based on a modification of the procedure proposed by Crevits. Mean outcome measure: disappearance of positional downbeating nystagmus.

Results. Positional downbeating nystagmus was elicited unilaterally with the Dix-Hallpike maneuver in 6 cases. In 4 patients, it was triggered by both left and right Dix-Hallpike tests. In 8 patients, the positional nystagmus was elicited by a straight head-hanging maneuver. The positional nystagmus was purely downbeating in 12 patients. In the remaining, a torsional component was detected. After the treatment, only 1 patient showed positional nystagmus at 30 days.

Conclusion. In anterior canal benign paroxysmal positional vertigo, the presence of a positional downbeating nystagmus in response to positional tests is key for diagnosis. In a significant number of patients, the affected side may not be detected because of the inconstant presence of a torsional component. Treatment with a simplified maneuver based on Crevits’s technique can be considered an effective method for the treatment of anterior canal lithiasis, especially when the affected side cannot be detected clearly.

Keywords

positional vertigo, anterior semicircular canal, canalith repositioning maneuver, otolith

Among the pathologies of the ear that cause vertigo, benign paroxysmal positional vertigo (BPPV) is by far the commonest. In its most common form, it regards a rotatory type of vertigo associated with nystagmus, the characteristics of which have led to hypothesizing the involvement of the posterior semicircular canal (PSC) where basophilic particles have been found either adhering to the cupula (cupulolithiasis)¹ or free floating in the nonampullary portion of the canal (canalolithiasis).²

More recently, involvement of the horizontal semicircular canal (HSC) has been pointed out by virtue of a positional paroxysmal nystagmus in a purely horizontal direction.³ The existence of a canalolithiasis of the anterior semicircular canal (ASC) is much more debatable. This canal is located in the higher portion of the inner ear, and as such, it would clearly seem unlikely that otolithic material could penetrate as far into the interior. Nevertheless, in the literature, a variable incidence of ASC-BPPV is reported: values of under 2%⁴,⁵ compared to up to 12%⁶, 17%,⁷ and even 21% in other reports.⁸

The ASC projects to the ipsilateral superior rectus and to the contralateral inferior oblique muscle. As such, a lithiasis of the ASC should produce a torsional nystagmus with a downbeating vertical component, in contrast with what occurs with the PSC, where the vertical component is upbeat.⁹ The torsional component will be directed toward the affected ear: a correct assessment of this nystagmic aspect is the best way of establishing the injured side.¹⁰ However, the torsional component often does not clearly appear, and so the ASC-BPPV
nystagmus presents exclusively as vertical downbeating.10,13,14 Nevertheless, positional downbeating nystagmus (pDBny) is considered a sign of central nervous system (CNS) involvement15: for this reason, in the absence of clinical or oculographic signs indicating pathology of the CNS and in the presence of positional vertigo symptomatology, it is necessary to keep in mind a possible diagnosis of ASC-BPPV.

Although some authors consider ASC-BPPV a transitory result of “canal switch” that occurs in the course of treating other more common forms of BPPV,16,17 there have also been reported refractory cases that require specific treatment.

The position of the ASC on one side is diametrically opposite to that of the PSC on the other side. Starting from this premise, a “reverse” version of the Epley maneuver has been proposed, which consists simply of performing a canalith repositioning procedure (CRP) starting from the healthy side.4,18 A modification of this maneuver is the one proposed by Jackson et al19 reporting therapeutic success in 100% of cases. Further modifications of the Epley “reverse” maneuver were described.19,20

Lately, borrowing the movement performed in Crevits’s technique,21 another maneuver has been proposed that boasts the noteworthy advantage of not needing to first identify the injured side.22 It consists of 4 steps with intervals of 30 seconds: the patient is brought from a sitting position to a supine position with the head extended backwards by 30°. Then the head is tilted forward while the patient is still supine. Finally, the patient is brought back to a sitting position.

In this study, we aim to describe the clinical and oculographic features in patients with ASC-BPPV and to determine the efficacy of a modified CRP for its management.

Materials and Methods

In our outpatients’ tertiary referral center for balance disorders, from January 2008 to January 2010, we examined 462 patients presenting BPPV; of these, 379 (82.0%) reported involvement of the PSC, 65 (14.1%) of the HSC, and 18 (3.9%) of the ASC.

All the patients were studied by the following:

Anamnesis and audiological examination
Test for spontaneous nystagmus and positional nystagmus (supine roll test, Dix-Hallpike test, head-hanging maneuver)
Caloric tests

For a better understanding of the individual patient and his or her relative nystagmic patterns, we used a computerized videonystagmographic system for recording (Hortmann GN Analyzer, GN Otometrics GmbH & Co KG, Münster, Germany).

The criterion for diagnosing ASC-BPPV was as follows: onset of paroxysmal rotatory vertigo upon execution of positioning maneuvers in association with the onset of pDBny with or without a torsional component.

All the patients with suspected ASC-BPPV underwent a complete neuroradiological examination (computed tomography [CT] scan and magnetic resonance imaging [MRI] of the brain) to exclude inner ear abnormalities (ie, superior canal dehiscence, large vestibular aqueduct) and CNS pathologies.

Once the diagnosis of ASC-BPPV was established and after signing informed consent to the treatment, the 18 patients were subjected to a maneuver based on a modification of Crevits’s technique. The sample consisted of a consecutive series of all the patients who were eligible.

Approval of the study was granted by the local ethics committee (Comitato Etico dell’Azienda Ospedaliera-Università Pisana).

The patient was quickly moved from the sitting position (Figure 1a) to an enhanced (straight) head-hanging position with the head bent backward as far as possible (Figure 1b). This position was maintained for 3 minutes, after which the patient’s head was quickly moved forward as far as possible, to the point of the chin almost touching the chest (Figure 1c). This position was maintained for 3 minutes, and then the patient was brought to a sitting position (Figure 1d). The therapeutic procedure was repeated twice at each session of treatment.

All the patients were evaluated 48 hours after treatment, and if they presented no improvement, the maneuver was repeated up to 5 times. All patients were invited to return for a checkup 30 days after the start of the treatment (final checkup on the 30th day). The mean outcome measure was disappearance of pDBny after the treatment.

Results

Table 1 summarizes the clinical and oculographic features of the patients. The age of the patients was 29 to 79 years (mean, 51.6). Clinical histories revealed a previous head trauma in 1 patient; 7 patients suffered from high blood pressure (associated with diabetes mellitus in 1 patient and ischemic heart disease in another patient). One patient suffered from migraine and depressive disorder; another presented atrial fibrillation. In 4 patients, an audiometry revealed a sensorineural hearing loss compatible with presbycusis; all the other patients showed normal hearing. Eight patients reported previous BPPV currently in remission. At the time of the examination, the symptomatology had been present from 1 to 45 days, with an average of 12.8 days. No patients presented spontaneous nystagmus. Caloric tests showed a canal paresis (>30%) in 3 cases. pDBny was elicited unilaterally with Dix-Hallpike (D-H) tests in 6 cases (4 right D-H and 2 left D-H). In 4 patients, the pDBny was triggered by both left and right D-H tests. In 8 patients, the pDBny was elicited exclusively by a straight head-hanging maneuver.

The pDBny was purely downbeating in 12 patients. In those remaining, a torsional component was detected, and its direction was used to determine the site of the lesion. The latency of the pDBny ranged from 0 to 6 seconds (mean, 2.2 seconds), and its fatigability (not tested in 2 patients because of strong neurovegetative reactions) was null or poor in 10 of the remaining 16 cases. The duration ranged from 4 to 70 seconds with a mean of 28.5 seconds. A clear paroxysmal aspect (crescendo and decrescendo) of pDBny was detected only in 7 cases. Inversion of pDBny upon returning to a sitting position...
was detected in 2 cases, whereas in 4 patients, we observed persistence for a few seconds of the same nystagmus elicited in the triggering position.

Neuroradiological examination was normal in all cases.

Eight patients were symptom free after 1 session of treatment. Seven patients needed 2 sessions of treatment to solve the positional vertigo with remission of the pDBNy. In 2 patients, remission was achieved at the third session of treatment. At the final checkup at 30 days after treatment, all the patients except 1 showed no pDBNy, although in 8 cases, a switch to posterior (6 cases) or horizontal (2 cases) canal BPPV was evident.

**Discussion**

In the presence of material of greater density than the endolymph in the vestibule, it is presumed that gravitational forces tend to cause the debris to fall into the more sloping part of the labyrinth, that is, in the region of the PSC. It is much less likely that such material involves the ASC because of its location in the highest point of the labyrinth in a standing position. For this reason, ASC-BPPV (about 4% of the patients with BPPV in our case histories) is considered a real anomaly, perhaps induced by structural changes or caused by the formation of solid structures in the lumen of the ASC.

The criterion for diagnosis of ASC-BPPV includes vertical pDBNy with a torsional component directed toward the affected ear. The torsional component may manifest in an apo-geotropic direction (in cases where the affected ear is uppermost) or geotropic direction (affected ear lowermost).

Positional nystagmus from ASC-BPPV may manifest both when the affected ear is uppermost or facing down, but it may also be triggered by left and right D-H maneuvers and even present in a straight head-hanging position. In our experience, pDBNy was elicited simply with a straight head-hanging maneuver in 8 of 18 patients. The ASC is much nearer to the sagittal plane than the PSC, so vertical movement is more efficacious; to mobilize the particles in the ASC adequately, rather than use rotatory movements, it is important to position the head low down. In the D-H maneuvers, rotation of the head by 45° toward one side prevents gaining a very dependent position that may be reached, however, with a head-hanging maneuver.
In our cases, pDBny was evoked in 4 patients using both right and left D-H positioning. In these cases, it may be extremely difficult to identify the affected side. Assuming that the side affected by ASC-BPPV is the left, by performing a right D-H test, movement occurs on the plane of the affected canal, determining an ampullofugal flow that causes the pDBny (Figure 2a). If a left D-H maneuver is performed (with the affected ear facing down), the head rotates orthogonally to the plane of the canal (Figure 2b). Only during 45° rotation of the head does the movement occur on the canal plane, and gravitational forces can induce an otolithic movement causing an endolymphatic ampullofugal flow.

The variability of the positioning maneuvers that may trigger nystagmus in ASC-BPPV depends on different elements:

- The anatomical position of the ASC, which may present at different angles in relation to the sagittal plane
- The presence of areas where the membranous canal narrows, which may block extraneous matter in places that are more or less close to the ampulla
- The degree of extension that the head of the patient can reach when performing the positioning maneuvers

Analysis of the characteristics of pDBny observed in the patients studied has enabled us to point out the following aspects:

- The nystagmus in ASC-BPPV is positional downbeating, associated with a torsional component only in a limited number of cases (6 of 18).
- Latency shows to be less compared to PSC-BPPV with an average of 2 seconds compared to 2 to 15 seconds of the latter.
- Duration is very variable (from 4 seconds to more than 1 minute).
- There is no evident paroxysmal aspect; in fact, in 61% of cases, it is semi-paroxysmal, consisting of a brief initial phase of increase, which then declines slowly.
- Fatigability is not as constant as with PSC-BPPV; it has only been clearly highlighted in 33% of cases. This, along with the lack of paroxysmal activity, may be justified by the lack of dispersion of the otoliths. If, as we have hypothesized, the involvement of the ASC is supported by the presence of strictures, the debris could remain “trapped” in those narrower tracts of the canal, thus preventing dispersion.

As we have already reported, the presence of a torsional component is considered of fundamental importance in the detection of the affected side. Nevertheless, the absence of a torsional component in the case of ASC-BPPV has been widely reported in literature and it has been hypothesized that the cause can be sourced in the different angle that

Table 1. Clinical and Objective Characteristics in the 18 Patients with ASC-BPPV

<table>
<thead>
<tr>
<th>Duration of Vertigo Before Examination(s)</th>
<th>Provocative Maneuver</th>
<th>Type of Nystagmus</th>
<th>Latency, s</th>
<th>Duration, s</th>
<th>Fatigability</th>
<th>Crescendo/Decrescendo</th>
<th>Site of Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA 62, f</td>
<td>D-H L and R</td>
<td>pDB, no torsional component</td>
<td>No</td>
<td>6</td>
<td>Poor</td>
<td>Yes</td>
<td>NI</td>
</tr>
<tr>
<td>AV 65, m</td>
<td>H-H</td>
<td>pDB, no torsional component</td>
<td>4</td>
<td>18</td>
<td>Poor</td>
<td>No</td>
<td>NI</td>
</tr>
<tr>
<td>PM 58, m</td>
<td>D-H L</td>
<td>pDB, torsional apogeotropic</td>
<td>4</td>
<td>20</td>
<td>Poor</td>
<td>No</td>
<td>Right</td>
</tr>
<tr>
<td>MM 61, m</td>
<td>D-H R and L</td>
<td>pDB, no torsional component</td>
<td>No</td>
<td>65</td>
<td>Not tested</td>
<td>Yes</td>
<td>NI</td>
</tr>
<tr>
<td>PL 32, f</td>
<td>D-H L</td>
<td>pDB, torsional apogeotropic</td>
<td>No</td>
<td>22</td>
<td>No</td>
<td>No</td>
<td>Right</td>
</tr>
<tr>
<td>CV 29, f</td>
<td>D-H R</td>
<td>pDB, torsional geotropic</td>
<td>5</td>
<td>8</td>
<td>Yes</td>
<td>Yes</td>
<td>Left</td>
</tr>
<tr>
<td>TM 45, m</td>
<td>H-H</td>
<td>pDB, no torsional component</td>
<td>4</td>
<td>25</td>
<td>Yes</td>
<td>No</td>
<td>NI</td>
</tr>
<tr>
<td>ID 39, f</td>
<td>D-H L and R</td>
<td>pDB, no torsional component</td>
<td>No</td>
<td>70</td>
<td>No</td>
<td>No</td>
<td>NI</td>
</tr>
<tr>
<td>PG 72, f</td>
<td>H-H</td>
<td>pDB, no torsional component</td>
<td>2</td>
<td>45</td>
<td>Poor</td>
<td>Yes</td>
<td>NI</td>
</tr>
<tr>
<td>BF 60, f</td>
<td>D-H R</td>
<td>pDB, torsional apogeotropic</td>
<td>No</td>
<td>60</td>
<td>Yes</td>
<td>Yes</td>
<td>Left</td>
</tr>
<tr>
<td>BL 45, m</td>
<td>H-H</td>
<td>pDB, no torsional component</td>
<td>6</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
<td>NI</td>
</tr>
<tr>
<td>CL 48, f</td>
<td>D-H R</td>
<td>pDB, torsional geotropic</td>
<td>3</td>
<td>30</td>
<td>No</td>
<td>No</td>
<td>Left</td>
</tr>
<tr>
<td>DM 52, f</td>
<td>H-H</td>
<td>pDB, no torsional component</td>
<td>No</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
<td>NI</td>
</tr>
<tr>
<td>SC 37, m</td>
<td>H-H</td>
<td>pDB, no torsional component</td>
<td>No</td>
<td>35</td>
<td>No</td>
<td>No</td>
<td>NI</td>
</tr>
<tr>
<td>ML 47, m</td>
<td>D-H L and R</td>
<td>pDB, torsional apogeotropic</td>
<td>4</td>
<td>45</td>
<td>Not tested</td>
<td>No</td>
<td>Left</td>
</tr>
<tr>
<td>CG 79, m</td>
<td>H-H</td>
<td>pDB, no torsional component</td>
<td>3</td>
<td>15</td>
<td>No</td>
<td>Yes</td>
<td>NI</td>
</tr>
<tr>
<td>SR 41, f</td>
<td>H-H</td>
<td>pDB, no torsional component</td>
<td>No</td>
<td>4</td>
<td>Yes</td>
<td>No</td>
<td>NI</td>
</tr>
<tr>
<td>DG 57, f</td>
<td>D-H R</td>
<td>pDB, no torsional component</td>
<td>5</td>
<td>25</td>
<td>Poor</td>
<td>No</td>
<td>NI</td>
</tr>
</tbody>
</table>

The letters and numbers in the first column represent the patient’s initials and age. Abbreviations: D-H, Dix-Hallpike maneuver; f, female; H-H, head-hanging maneuver; L, left; m, male; NI, not identified; pDB, positional downbeating; R, right.
the sagittal plane forms with the 2 vertical canals (41° for the ASC, 56° for the PSC): for this reason, the torsional component would appear to be much smaller where the ASC is involved. Another explanation could be found in the fact that in humans, the torsional gain of the vestibulo-ocular reflex (VOR) in response to a high-frequency roll head impulse is less than the vertical and horizontal components.

In our case histories, the absence of a well-defined torsional component emerged in 12 of 18 cases. Drawing on the work carried out by Crevits, we adopted the same type of movement (not requiring the knowledge of the affected side) proposed by the author (and similar to the maneuver proposed by Yacovino et al), without resorting to use of instruments and notably reducing the length of performance. As is already known, the movements of the otoliths inside the canal occur in rather short lapses of time (ie, seconds), according to variations of the position of the head. Therefore, it seemed reasonable to simplify the technique by limiting maintenance of both the initial head-hanging position (the debris migrates into the upper part of the ASC, which at this point is in a more dependent position) and the position of head bent toward the chest (where the force of gravity facilitates the passage of the otoconia toward the common crus) to only 3 minutes. Conversely, the movement with which the head is brought from the head-hanging position to that tilted toward the chest is carried out rapidly so that the force of inertia induces the debris to move toward the common crus.

Unlike the maneuvers with which the head is rotated 45°, the one we used, starting from the head-hanging position, does not place the ASC on a purely frontal plane. The greater hyperextension obtained with the head-hanging (H-H) position enables the otoliths (close to the ampulla) to migrate toward the apical part of the canal, regardless of whether they are in the right or left ASC (Figure 1b), so as to then pass into the nonampullary section by means of the second phase of the maneuver (Figure 1c).

With this technique, we obtained excellent results, to the point that after 30 days, all but 1 patient was symptom free. We maintain that the elevated percentage of success may be associated with not needing to diagnose the affected side.

There are 2 major limitations in this study: the lack of a control group and the difficulty in identifying a natural history of ASC-BPPV. The 2 issues are strictly correlated, but bearing in mind the long duration of the symptomatology, before assessing the diagnosis encountered in a high number of patients, we could speculate that ASC-BPPV is characterized by a natural history with a poor tendency to recover spontaneously, as occurs, for example, in HSC-BPPV. In these latter cases, the symptomatology remits spontaneously in a much shorter time compared to the same form involving the PSC.

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**Figure 2.** Anterior semicircular canal–benign paroxysmal positional vertigo (ASC-BPPV) positional nystagmus can be evoked by both Dix-Hallpike (D-H) maneuvers. Assuming left ASC as the affected side, the right D-H positioning will provoke a more intense ampullofugal flow as the right ASC is moved along a sagittal plane (a); the left D-H positioning induces movement of the debris only during the 45° head rotation because the ASC is placed orthogonally to the sagittal plane (b). PSC, posterior semicircular canal.
This can simply be explained in view of the easier expulsion of the debris from the HSC, and the therapeutic maneuvers employed for treating HSC-BPPV simply facilitate the tendency of the HSC to clear spontaneously, thus accelerating recovery. On the contrary, in cases of ASC-BPPV, the otolithic material is probably located close to the ampulla, and only by performing a specific repositioning maneuver can we obtain clearance of the ASC.

Very often the ASC-BPPV may be considered a form of canal switch, a consequence of a CRP carried out for a BPPV affecting other canals. In these cases, it may be hypothesized that the otolithic material may penetrate into the common crus or into the nonampullary section of the ASC. The debris could be dislodged in the downward posterior canal nonampullated side, so the positioning test could produce a nystagmus triggered by ampullopetal stimuli on the PSC, which is indistinguishable from a nystagmus evoked by an ASC-BPPV of the opposite side. On that account, debris could be eliminated by virtue of simply performing positional tests when they are not extremely close to the ASC ampulla or located in the downward PSC nonampullary portion. The most refractory cases of ASC-BPPV might therefore be those in which otolithic material is found near the cupola of the ASC, thus inducing a cupolithiathia, which requires treatment using specific maneuvers.

In our sample, we did not have cases of ASC-BPPV that were consequential to CRP. In contrast, however, we verified that 6 patients presented PSC or HSC-BPPV after treatment. This eventuality may seem a disadvantageous element for the technique we adopted. However, we believe that the conversion to a more common form of BPPV may represent a further element of support toward confirming the peripheral origin of the pDBny.

**Conclusion**

In recent years, the study of the characteristics of ASC-BPPV has profoundly changed the approach to the patient presenting with pDBny, indicating in many cases the peripheral origin. The observation that, in an elevated number of patients, pDBny is elicited only following a head-hanging maneuver should induce clinicians to include this test in the battery of otoneurological tests performed. Nevertheless, the best way of verifying the peripheral origin, before resorting to implementing investigation procedures with a view to excluding CNS involvement, is that of subjecting the patient to a procedure that could be defined a modified version of Crevits’s technique. In these cases, remission of the pDBny and conversion to a more classic form of BPPV represent a simple and inexpensive way of confirming the peripheral origin of the disorder.

The maneuver used does not require identification of the affected side first, thus facilitating immediate treatment. In our study, we attained an elevated percentage of success, which is particularly worthy of note because in our sample, no cases were considered as complications of a CRP.

A mean of 1.58 sessions of treatment were required to gain complete recovery from ASC-BPPV. These values do not differ substantially from those required to attain complete remission of PSC or HSC-BPPV.

**Author Contributions**

Augusto Pietro Casani, study concept and design, acquisition of data, analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual concept, and study supervision; Niccolò Cerchiai, acquisition of data, drafting of the manuscript, administrative support, and technical and material support; Iacopo Dallan, study concept and design, critical revision of the manuscript for important intellectual conflict; Stefano Sellari-Franceschini, study concept and design, analysis and interpretation of data, and study supervision.

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