CLINICAL PRACTICE

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Benign Paroxysmal Positional Vertigo

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This Journal *feature begins with a case vignette highlighting a common clinical problem. Evidence supporting various strategies is then presented, followed by a review of formal guidelines, when they exist. The article ends with the authors' clinical recommendations.*

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A 58-year-old woman seeks care from her primary physician after the occurrence of sudden vertigo and imbalance with nausea and vomiting, which began that morning when she got out of bed. The vertigo lasted less than a minute but recurred when she lay back down in bed, rolled over in bed, or got up again. She reports no tinnitus or hearing loss. How should this patient be evaluated and treated?

THE CLINICAL PROBLEM

Benign paroxysmal positional vertigo (BPPV) is by far the most common type of vertigo, with a reported prevalence between 10.7 and 64.0 cases per 100,000 population and a lifetime prevalence of 2.4%.[1,2] The condition is characterized by brief spinning sensations, usually lasting less than 1 minute, which are generally induced by a change in head position with respect to gravity.[3,4] Vertigo typically develops when a patient gets in or out of bed, rolls over in bed, tilts the head back, or bends forward.[3] Even though patients with BPPV occasionally report persistent dizziness and imbalance, a careful history taking almost always reveals that their symptoms are worse with changes in head position.[4] Many patients also have nausea, sometimes with vomiting. Attacks of BPPV usually do not have a known cause, although cases may be associated with head trauma, a prolonged recumbent position (e.g., at a dentist's office or hair salon), or various disorders of the inner ear.[3] Spontaneous remissions and recurrences are frequent; the annual rate of recurrence is approximately 15%.[5] Patients with BPPV are at increased risk for falls and impairment in the performance of daily activities.[6]

An audio version of this article is available at NEJM.org

The prevalence of idiopathic BPPV is increased among elderly persons and among women, with peak onset between 50 and 60 years of age and a female-to-male ratio of 2:1 to 3:1.[2,3] BPPV has also been reported to be associated with osteopenia or osteoporosis and with decreased serum levels of vitamin D — associations that are not explained by age or sex.[7,8] The fundamental pathophysiological process in BPPV involves dislodged otoconia from the macula of the utricular otolith that enter the semicircular canals. When there is a change in the static position of the head with respect to gravity, the otolithic debris moves to a new position within the semicircular canals, leading to a false sense of rotation. BPPV usually arises from the posterior semicircular canal, which is the most gravity-dependent canal; this type of BPPV accounts for 60 to 90% of all cases.[4] However, the proportion of patients with BPPV that involves the horizontal semicircular canal may have been underestimated, since involvement at this site is more likely to remit spontaneously than involvement in the posterior semicircular canal.[9] BPPV rarely involves the anterior semicircular canal, probably because of its uppermost position in the labyrinth, where otolithic debris is unlikely to become trapped.[10]

key Clinical points

benign paroxysmal positional vertigo

- Benign paroxysmal positional vertigo (BPPV), by far the most common cause of vertigo, is characterized by brief spinning sensations, which are typically induced by a change in head position with respect to gravity.
- BPPV involving the posterior canal (the most common type) is diagnosed on the basis of nystagmus beating in an upward and torsional direction, with the top poles of the eyes beating toward the lower ear, as observed when the patient is lying on one side during the Dix–Hallpike maneuver.
- BPPV involving the horizontal canal is characterized by nystagmus that is either geotropic (beating toward the ground) or apogeotropic (beating toward the ceiling) when the head is turned to either side while the patient is in a supine position.
- Canalith-repositioning maneuvers (e.g., Epley's and Semont's maneuvers for the posterior canal) are effective treatments for BPPV.

STRATEGIES AND EVIDENCE

BPPV must be distinguished from other, more serious causes of acute or episodic vertigo (Table 1). A history taking and neurologic examination often allow for differentiation among stroke, vestibular neuritis, and BPPV. The examination should include the testing of eye movements for sustained nystagmus, vertical ocular misalignment, and a pattern of vestibular responses that is suggestive of a central cause. Such testing has been reported to be more accurate for the diagnosis of stroke than computed tomography or early use of magnetic resonance imaging.[10,11] The diagnosis of BPPV is supported if changes in head position with respect to gravity provoke the symptoms and elicit the patterns characteristic of BPPV. Because most physicians are not familiar with the precise anatomical relationships of the semicircular canals in the skull, it can be a challenge to interpret the different patterns of positional nystagmus and perform the correct maneuvers. (Videos available with the full text of this article at NEJM.org show the patterns of nystagmus that are diagnostic of the two most common types of BPPV and demonstrate the movements of the body that should be performed to treat each type.)

BPPV sometimes involves multiple canals in one ear or is bilateral, making it difficult to identify the patterns of nystagmus and choose the best treatment. Generally, such cases should be referred to a specialist, as should cases of positional downbeat nystagmus and cases that are resistant to treatment.

Diagnosis

Physical examination reveals positional nystagmus in more than 70% of patients with BPPV.[12] This finding is elicited by performing specific maneuvers, depending on which canal is affected.

Posterior Semicircular Canal

In patients with BPPV that involves the posterior canal, nystagmus is typically induced with the use of the Dix–Hallpike maneuver (Table 2 and Fig. 1, and Video 1).[13] When there is movement of otolithic debris (canalolithiasis) in the posterior canal away from the cupula, the endolymph flows away from the cupula, stimulating the posterior canal. The resulting nystagmus is upward-beating and torsional, with the top poles of the eyes beating toward the ear in the lower position (as the patient's head is turned to one side) (Video 1).[13] The nystagmus usually develops after a brief latency period (2 to 5 seconds), resolves within 1 minute (typically within 30 seconds), and reverses direction when the patient sits up.[13] With repeated testing, the nystagmus diminishes owing to fatigability.[13] If the otoconia become attached to the cupula (cupulolithiasis), the evoked nystagmus is similar to that observed in canalolithiasis but is usually longer in duration.[14]

A positive response to the Dix–Hallpike maneuver, in which the nystagmus beats in the correct direction, is the standard for diagnosing BPPV involving the posterior canal. However, approximately one fourth of symptomatic patients have little or no nystagmus. Treating these patients may still be beneficial if their symptoms conform to the usual clinical picture.[12]

Videos showing patterns of nystagmus and treatment maneuvers are available at NEJM.org

Table 1. Differential Diagnosis of Acute Vertigo.

Cause	Onset and Course	Nystagmus	Auditory Symptoms	Other Features
BPPV*	Recurrent, transient, positional; usually provoked by turning over or getting in and out of bed	Positional, with mixed vertical torsional nystagmus in BPPV involving posterior canal and horizontal nystagmus in BPPV involving horizontal canal	None	Recent inciting event possible (e.g., recumbent position at dentist's office or hair salon, prolonged bed rest, head trauma); history of similar episodes
Stroke	Spontaneous, usually sustained; may be worsened by positional change	Spontaneous, with beating in various or changing directions	Occasional	Neurologic symptoms or signs may include headache and vertical misalignment of eyes; results of head-impulse test typically normal†
Vestibular neuritis	Spontaneous, sustained; may be worsened by positional change	Spontaneous, predominantly horizontal	None	May be preceded by viral illness; results of head-impulse test abnormal†
Vestibular migraine	Recurrent, spontaneous; duration for minutes to hours; may be positional	Rare, but when present usually positional	Occasional	Migrainous headaches, motion sickness, family history
Meniere's disease	Recurrent, spontaneous; typical duration for hours	Spontaneous, horizontal	Fluctuating hearing loss, tinnitus	Ear pain, sensation of fullness in ear

* BPPV denotes benign paroxysmal positional vertigo.
† In the head-impulse test, the result is considered abnormal when a corrective movement (saccade) is required to maintain straight-ahead fixation after the head has been rotated to the side.[11]

Horizontal Semicircular Canal

BPPV involving the horizontal canal is usually diagnosed by means of the head-roll test (also called the log-roll test), in which the head is turned approximately 90 degrees to the left and to the right with the patient lying supine (Table 2).[9,15] Horizontal nystagmus occurs with the head turned in either direction, and in both positions it beats either toward the ground (geotropic nystagmus, Video 2)[9,15] or toward the ceiling (apogeotropic nystagmus, Video 3).[16]

Proper treatment of BPPV involving the horizontal canal requires knowledge of which ear is involved.[17-20] When the nystagmus is more intense with the head turned to one side than with the head turned to the other side, the nystagmus beats toward the affected ear.

Anterior Semicircular Canal

BPPV involving the anterior canal is extremely rare, and its pathophysiology is poorly understood.[21,22] Its hallmark is a positional downbeat nystagmus with a torsional nystagmus in which the top poles of the eyes beat toward the involved ear. Patients with this type of nystagmus should be evaluated for central lesions, although such lesions are rarely found.

Treatment

BPPV typically resolves without treatment. A prospective longitudinal study showed that the median interval between the onset of symptoms and spontaneous resolution in untreated patients was 7 days when the horizontal canal was affected and 17 days when the posterior canal was affected.[23] However, canalith-repositioning maneuvers can be used to treat BPPV promptly and effectively.[24-27] Medications are primarily used to relieve severe nausea or vomiting. Surgeries such as transection of the posterior ampullary (singular) nerve and plugging of the involved canal are rarely required and should be considered only for patients whose symptoms are intractable and incapacitating and in whom there has been no response to repositioning maneuvers.[25]

Posterior Semicircular Canal

Epley's canalith-repositioning maneuver was designed to flush mobile otolithic debris out of the posterior canal and back into the vestibule (Fig. 2).[26] The otoconia move around the canal with each step of the maneuver and eventually drop out

Table 2. Diagnosis and Treatment of Benign Paroxysmal Positional Vertigo According to the Affected Canal.

Location in Semicircular Canal	Diagnosis			Treatment	
	Maneuver	Method	Induced Nystagmus	Repositioning Maneuver	Method
Posterior semicircular canal	Dix–Hallpike	With head turned to one side at angle of 45 degrees, patient is moved from sitting position to supine position, with head hanging below examination table	Upbeat and ipsiversive torsional*	Epley's maneuver	After performance of Dix–Hallpike maneuver, head is turned 90 degrees toward unaffected side; head is then turned another 90 degrees, and trunk is turned 90 degrees in same direction, so that patient lies on unaffected side with head pointing toward the floor; patient is then moved to sitting position
	Side-lying	Patient is quickly placed on the side with affected ear with head turned 45 degrees in opposite direction	Upbeat and ipsiversive torsional*	Semont's maneuver	Patient is swung rapidly, through 180-degree cartwheel-like motion, from lying on the side with affected ear to lying on the side with unaffected ear
Horizontal semicircular canal					
Geotropic	Supine head roll	Head is turned approximately 90 degrees to each side while patient is in supine position	Geotropic (beats toward the ground)	Barbecue rotation	Head is rotated in three 90-degree increments, for a total of 270 degrees, from affected ear down, to supine, to unaffected ear down, to prone
				Gufoni's maneuver	Patient lies on the side with unaffected ear for 1–2 minutes; head is then rotated 45 degrees in downward direction; patient then assumes sitting position
				Forced prolonged position	The patient lies with the unaffected ear down for approximately 12 hours
Apogeotropic	Supine head roll	Head is turned approximately 90 degrees to each side while patient is in supine position	Apogeotropic (beats toward the ceiling)	Gufoni's maneuver	Patient lies on the side with affected ear for 1–2 minutes; head is then rotated 45 degrees in upward position; patient then assumes sitting position
				Head-shaking	Head is shaken from side to side at approximately two cycles per second for 15 seconds

* In ipsiversive nystagmus, the upper pole of the eyes beats toward the side of the affected (lower) ear.
† If the apogeotropic type of benign paroxysmal positional vertigo is converted to the geotropic type, treatment for the geotropic type should be provided.

into the vestibule (Video 4), where they can be resorbed.[26] Each position should be maintained until the induced nystagmus or vertigo dissipates, but always for at least 30 seconds.[27] The success rate with Epley's maneuver is about 80% after one session and increases to 92% with repetition up to four times.[28] A meta-analysis of five randomized, controlled trials showed that patients with BPPV involving the posterior canal who were treated with Epley's maneuver, as compared with patients treated with sham maneuvers and untreated controls, had significantly higher rates of improvement in symptoms (odds ratio, 4.4; 95% confidence interval [CI], 2.6 to 7.4) and in nystagmus (odds ratio, 6.4; 95% CI, 3.6 to 11.3).[29] Although some clinicians advocate the use of a hand-held vibrator on the mastoid of the involved side while Epley's maneuver is being performed or recommend that patients restrict movements of the head and body after treatment, there is

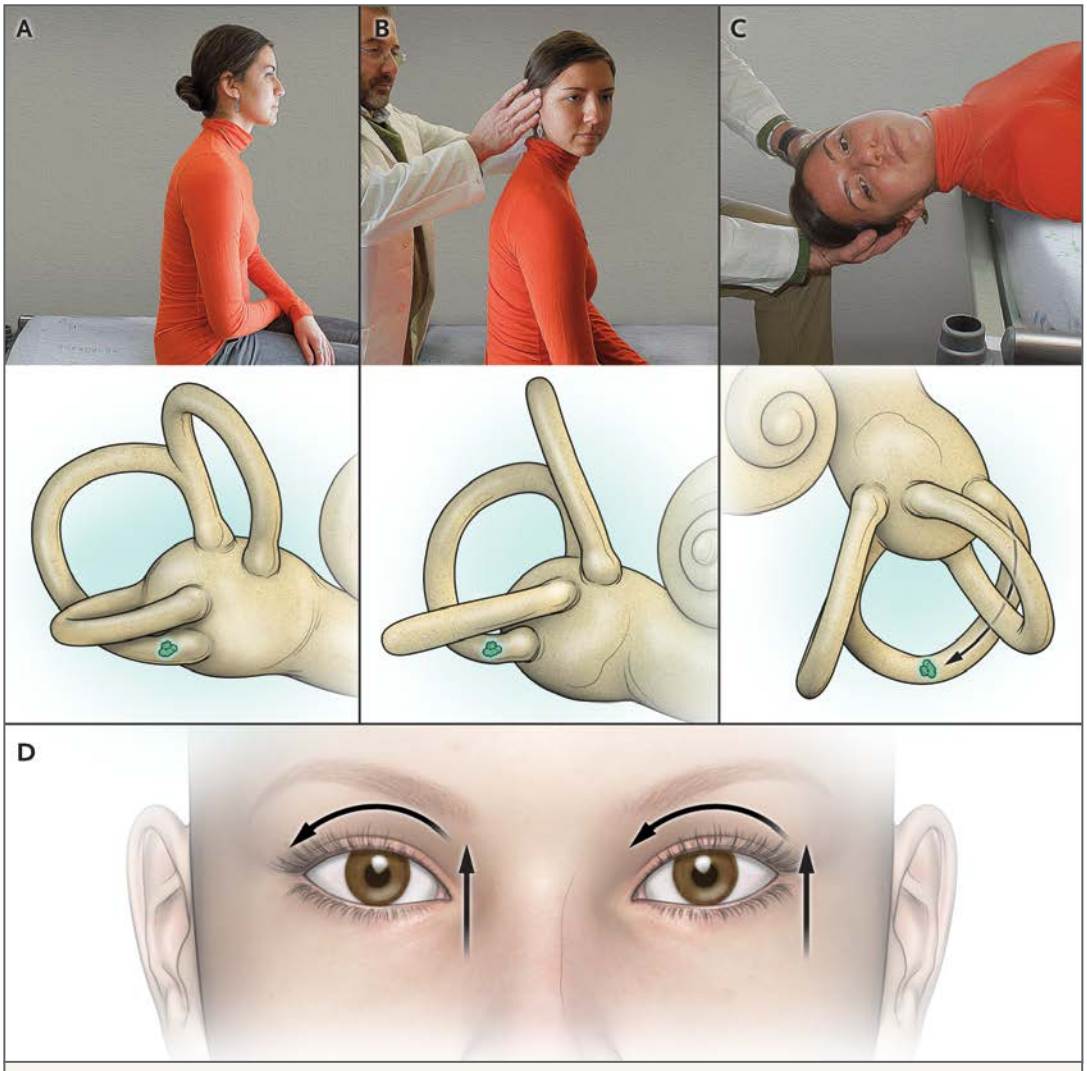

Figure 1. Use of the Dix–Hallpike Maneuver to Induce Nystagmus in Benign Paroxysmal Positional Vertigo Involving the Right Posterior Semicircular Canal.

With the patient sitting upright (Panel A), the head is turned 45 degrees to the patient's right (Panel B). The patient is then moved from the sitting position to the supine position with the head hanging below the top end of the examination table at an angle of 20 degrees (Panel C). The resulting nystagmus would be upbeat and torsional, with the top poles of the eyes beating toward the lower (right) ear (Panel D).

little evidence to support these suggestions.[27,30,31] However, it appears to be prudent for patients to sit still, in an upright position, for about 15 minutes after treatment and then to walk cautiously.

The pattern of nystagmus during Epley's maneuver helps to predict the success of treatment. When the head is turned 90 degrees away from the affected side (after being placed in the initial Dix–Hallpike position), the positioning nystagmus occasionally reappears (Video 4). According to one report, all 99 patients whose nystagmus reappeared in the same direction as the original nystagmus had resolution after one or two applications of Epley's maneuver, whereas only 3 of the 15 patients whose nystagmus shifted to the opposite direction were cured.[32] However, even in patients with nystagmus in the opposite direction, enough debris may be removed from the posterior canal to relieve symptoms.

The Semont maneuver can also be used to treat BPPV involving the posterior canal (Fig. 3).[33] To evacuate the particles, the patient is rapidly swung at high acceleration through a 180-degree cartwheel motion — from lying on the affected side to lying on the unaffected side — with the movement completed within 1.3 seconds (Video 5).[34] This maneuver can be used in lieu of Epley's maneuver in patients who have difficulties extending the neck.[35] As with Epley's maneuver, nystagmus toward the affected side in the second position of Semont's maneuver is predictive of successful treatment.[36] Both Epley's and Semont's maneuvers may be repeated several times until no nystagmus is elicited. Patients who require multiple treatments can be instructed to perform the maneuvers at home. In a randomized, controlled trial, the success rate was 95% with self-administration of Epley's maneuver and 58% with self-administration of Semont's maneuver.[37] Self-administered canalith-repositioning maneuvers may be more effective when combined with guided canalith-repositioning maneuvers performed at a clinic.[38]

Nausea or vomiting and vertigo may occur during these maneuvers, and many patients have a sensation of being off-balance and transient dizziness with head motion for several days or more, even after successful treatment. In some instances, a brief episode of vertigo occurs several minutes after performance of the maneuver. Another possible complication of the treatment maneuvers for BPPV involving the posterior canal, which occurs in less than 5% of cases,[39] is conversion to BPPV involving the horizontal canal. This condition can develop if the otoconial debris that moves out of the posterior canal falls into the horizontal canal. It can be treated with the same maneuvers used for BPPV involving the horizontal canal (geotropic or ageotropic), as described below.

Horizontal Canal

There are two types of BPPV involving the horizontal canal — one in which the nystagmus is geotropic and one in which it is apogeotropic. The former is commonly treated with the barbecue rotation. It consists of sequential 90-degree rotations of the head, first toward the affected ear and then toward the unaffected ear (Video 6).[40] With this maneuver, the otoconial debris migrates and eventually exits the horizontal canal and passes into the vestibule. Another treatment, called Vannucchi's forced prolonged position, involves having the patient lie with the unaffected ear down for approximately 12 hours.[41] This treatment is preferred for patients with severe symptoms that worsen with sequential changes in position and for those in whom it is unclear which ear is affected.[41] If lying on one side for a prolonged period is ineffective, the patient can try lying on the other side for 12 hours. An alternative treatment is Gufoni's maneuver,[42] in which the patient quickly lies down on the side of the unaffected ear and remains in this position for 1 to 2 minutes, until the evoked nystagmus subsides. The head is then quickly rotated 45 degrees toward the floor and kept in this position for another 2 minutes, after which the patient resumes an upright position (Video 7).[42]

In a prospective observational study involving 60 patients, the effectiveness of Vannucchi's forced prolonged position did not differ significantly from that of Gufoni's maneuver; both were more effective than the barbecue rotation after a single application (with success rates of 76% and 89%, respectively, vs. 38%).[43] A recent randomized trial showed that both the barbeque rotation and Gufoni's maneuver were more effective than a sham maneuver (with success rates of 68% and 61%, respectively, vs. 35%).[44]

BPPV involving the horizontal canal with apogeotropic nystagmus is attributed to otolithic debris that is attached to the cupula (cupulo-

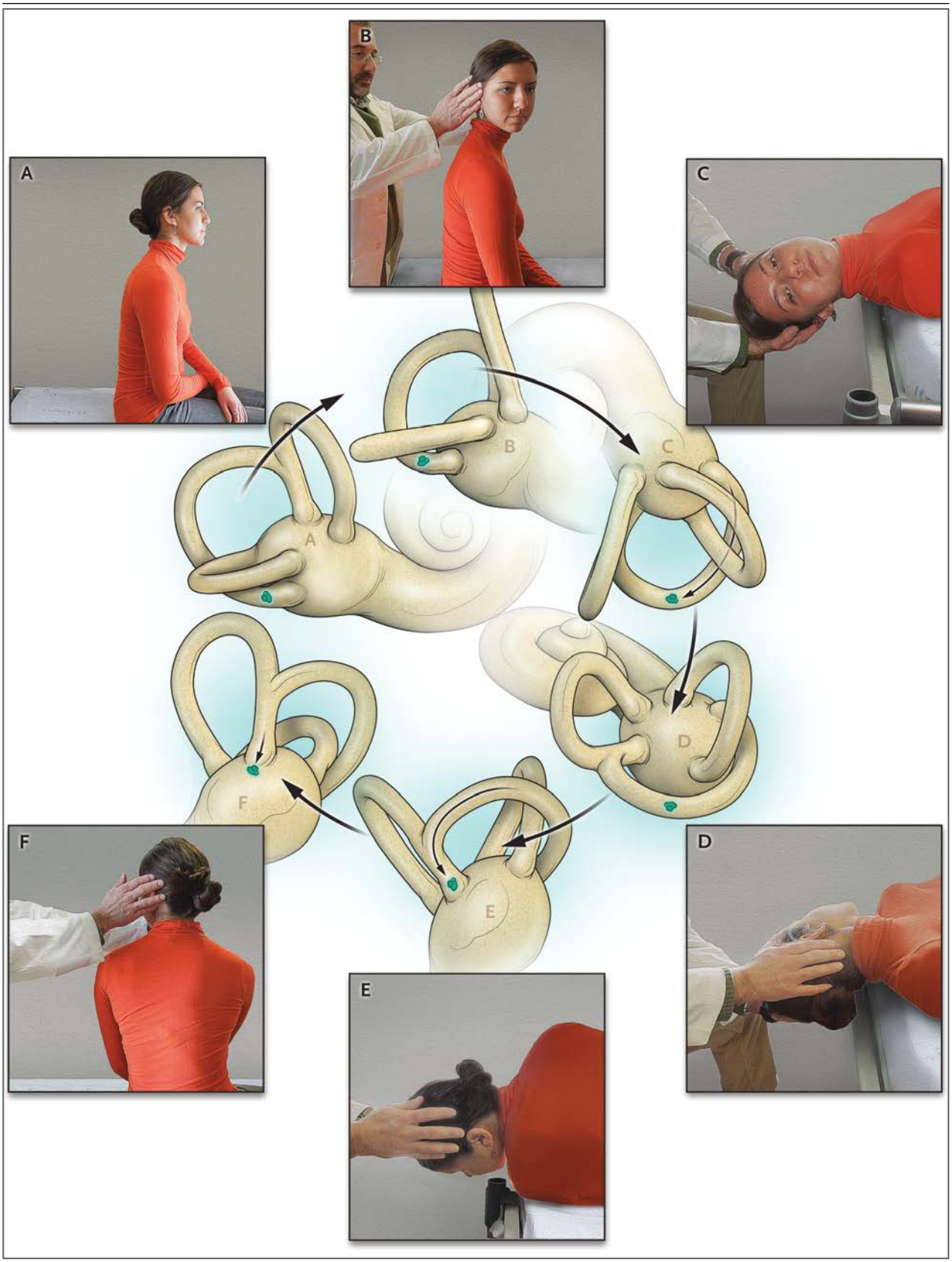
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Figure 2 (facing page). Epley's Canalith-Repositioning Maneuver for the Treatment of Benign Paroxysmal Positional Vertigo Involving the Right Posterior Semicircular Canal.

After resolution of the induced nystagmus with the use of the right-sided Dix–Hallpike maneuver (Panels A, B, and C), the head is turned 90 degrees toward the unaffected left side (Panel D), causing the otolithic debris to move closer to the common crus. The induced nystagmus, if present, would be in the same direction as that evoked during the Dix–Hallpike maneuver. The head is then turned another 90 degrees, to a face-down position, and the trunk is turned 90 degrees in the same direction, so that the patient is lying on the unaffected side (Panel E); the otolithic debris migrates in the same direction. The patient is then moved to the sitting position (Panel F), and the otolithic debris falls into the vestibule, through the common crus. Each position should be maintained until the induced nystagmus and vertigo resolve, but always for a minimum of 30 seconds.

lithiasis) or that is free-floating within the anterior arm of the horizontal semicircular canal near the cupula (canalolithiasis).[16,45] Treatment involves maneuvers designed to detach the otolithic debris from the cupula or to move the debris from the anterior arm of the horizontal canal to the posterior arm (Table 2).[45] Possible adjunctive strategies for this type of BPPV include head-shaking in the horizontal plane for 15 seconds[46] and modified versions of Semont's maneuver[46,47] and Gufoni's maneuver.[48]

In Gufoni's maneuver for BPPV involving the horizontal canal with ageotropic nystagmus, the patient sits upright, looking straight head, and then quickly lies down on the affected side and remains in this position for 1 to 2 minutes after the nystagmus has stopped or has been markedly reduced. Then the head is quickly turned 45 degrees toward the ceiling and is held in this position for 2 minutes, after which the patient slowly resumes the sitting position (Video 8).[42,48] This maneuver was designed to move otolithic debris that is lying near or is adherent to the cupula in the long arm of the horizontal canal to a more posterior position in the canal, where the debris may fall into the vestibule or can be removed with the use of Gufoni's maneuver for BPPV involving the horizontal canal with geotropic nystagmus, in which the head is turned toward the floor, as described above (Video 7).[49]

A randomized trial showed significantly higher rates of immediate resolution of symptoms with the head-shaking and Gufoni maneuvers (62% and 73%, respectively) than with a sham maneuver (35%); outcomes with these maneuvers (up to two repetitions of each maneuver at the time of the initial treatment) remained superior to the outcome with the sham maneuver at 1 month.[50] Another head-to-head trial showed that after a single treatment session, the head-shaking maneuver was more effective than the modified version of Semont's maneuver (resolution of vertigo in 37% of patients vs. 17%).[46]

AREAS OF UNCERTAINTY

Although randomized trials have compared the effectiveness of various maneuvers for specific types of BPPV, it is not clear which maneuver is the most effective for each type. It is also unclear what strategy should be pursued if the initial maneuver is not effective. Should the same maneuver be repeated, or should a different maneuver be performed; if the same maneuver is repeated, how many repetitions should be performed? In addition, the diagnostic criteria and repositioning maneuvers for BPPV involving the anterior canal require validation. Finally, although reduced vitamin D levels have been reported among persons with BPPV as compared with controls,[7,8] it is not known whether vitamin D supplementation reduces the risk of incident or recurrent BPPV.

GUIDELINES

Practice guidelines published in 2008 independently by the American Academy of Neurology[27] and the American Academy of Otolaryngology–Head and Neck Surgery[1] recommend only the use of Epley's maneuver for BPPV involving the posterior canal. Recommendations in this article include other maneuvers (Semont's maneuver for BPPV involving the posterior canal and several other maneuvers for BPPV of the horizontal canal); these recommendations are based on data from more recent randomized trials.[35,44,46,50]

CONCLUSIONS AND RECOMMENDATIONS

The patient described in the vignette has vertigo and nystagmus provoked by a change in head position, without other symptoms or signs, findings that are highly suggestive of BPPV. Patients who report vertigo provoked by head movements should first undergo the Dix–Hallpike maneuver (Table 2 and Fig. 1, and Video 1). The development

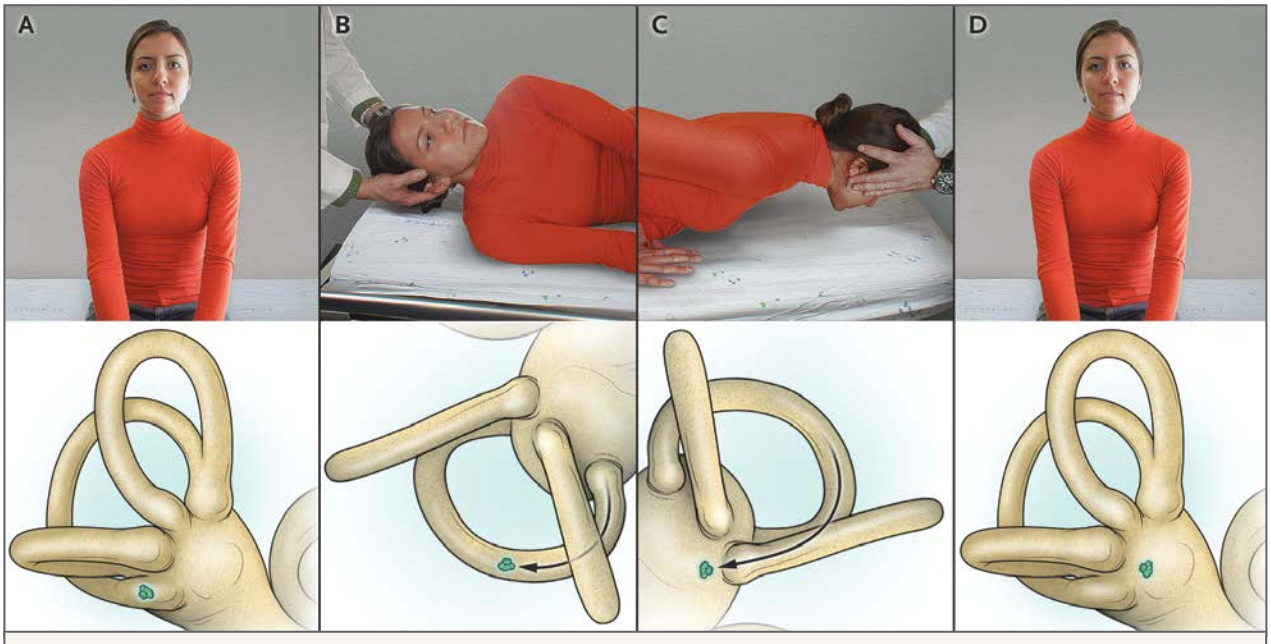

Figure 3. Semont's Repositioning Maneuver for Benign Paroxysmal Positional Vertigo Involving the Right Posterior Semicircular Canal.

The patient is asked to sit upright (Panel A) and then lies on the side of the unaffected ear (Panel B). The patient is then rapidly guided in a cartwheel pattern through the upright position (without a pause) so that he or she is lying down on the opposite side (Panel C). The head should remain turned toward the left (unaffected) side throughout the maneuver. Finally, the patient is seated and the head is returned to the neutral position (Panel D). Each position should be maintained until the induced nystagmus and vertigo resolve, but always for a minimum of 2 minutes.

of brief vertigo associated with paroxysmal upbeat and torsional nystagmus is diagnostic of BPPV involving the posterior canal (the most common type of BPPV). Given this finding, we recommend the performance of Epley's maneuver (Fig. 2, and Video 4) one or more times as needed in a given session, although Semont's maneuver (Fig. 3, and Video 5) would be a reasonable alternative. We would expect at least 80% of patients to be cured with either maneuver at the first visit. However, the patient should be informed that BPPV may recur and require retreatment.

No potential conflict of interest relevant to this article was reported.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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References

1. Bhattacharyya N, Baugh RF, Orvidas L, et al. Clinical practice guideline: benign paroxysmal positional vertigo. Otolaryngol Head Neck Surg 2008;139:Suppl 4:S47-S81.
2. von Brevern M, Radtke A, Lezius F, et al. Epidemiology of benign paroxysmal positional vertigo: a population based study. J Neurol Neurosurg Psychiatry 2007;78:710-5.
3. Baloh RW, Honrubia V, Jacobson K. Benign positional vertigo: clinical and oculographic features in 240 cases. Neurology 1987;37:371-8.
4. Furman JM, Cass SP. Benign paroxysmal positional vertigo. N Engl J Med 1999;341:1590-6.
5. Nunez RA, Cass SP, Furman JM. Short- and long-term outcomes of canalith repositioning for benign paroxysmal positional vertigo. Otolaryngol Head Neck Surg 2000;122:647-52.
6. Lopez-Escamez JA, Gamiz MJ, Fernandez-Perez A, Gomez-Fiñana M. Long-term outcome and health-related quality of life in benign paroxysmal positional vertigo. Eur Arch Otorhinolaryngol 2005;262:507-11.
7. Jeong SH, Choi SH, Kim JY, Koo JW, Kim HJ, Kim JS. Osteopenia and osteoporosis in idiopathic benign positional vertigo. Neurology 2009;72:1069-76.
8. Jeong SH, Kim JS, Shin JW, et al. Decreased serum vitamin D in idiopathic benign paroxysmal positional vertigo. J Neurol 2013;260:832-8.
9. McClure JA. Horizontal canal BPV. J Otolaryngol 1985;14:30-5.
10. Nuti D, Zee DS. Positional vertigo and benign paroxysmal positional vertigo. In: Bronstein A, ed. Oxford textbook of vertigo and imbalance. Oxford, England: Oxford University Press, 2013:217-30.
11. Kattah JC, Talkad AV, Wang DZ, Hsieh YH, Newman-Toker DE. HINTS to diagnose stroke in the acute vestibular syndrome: three-step bedside oculomotor examination more sensitive than early MRI diffusion-weighted imaging. Stroke 2009;40:3504-10.
12. Balatsouras DG, Korres SG. Subjective benign paroxysmal positional vertigo. Otolaryngol Head Neck Surg 2012;146:98-103.
13. Dix MR, Hallpike CS. The pathology symptomatology and diagnosis of certain common disorders of the vestibular system. Proc R Soc Med 1952;45:341-54.
14. Steddin S, Ing D, Brandt T. Horizontal

canal benign paroxysmal positioning vertigo (h-BPPV): transition of canalolithiasis to cupulolithiasis. Ann Neurol 1996;40:918-22.
15. Baloh RW, Jacobson K, Honrubia V. Horizontal semicircular canal variant of benign positional vertigo. Neurology 1993;43:2542-9.
16. Baloh RW, Yue Q, Jacobson KM, Honrubia V. Persistent direction-changing positional nystagmus: another variant of benign positional nystagmus? Neurology 1995;45:1297-301.
17. Asprella Libonati G. Diagnostic and treatment strategy of lateral semicircular canal canalolithiasis. Acta Otorhinolaryngol Ital 2005;25:277-83.
18. Han BI, Oh HJ, Kim JS. Nystagmus while recumbent in horizontal canal benign paroxysmal positional vertigo. Neurology 2006;66:706-10.
19. Lee SH, Choi KD, Jeong SH, Oh YM, Koo JW, Kim JS. Nystagmus during neck flexion in the pitch plane in benign paroxysmal positional vertigo involving the horizontal canal. J Neurol Sci 2007;256:75-80.
20. Choung YH, Shin YR, Kahng H, Park K, Choi SJ. 'Bow and lean test' to determine the affected ear of horizontal canal benign paroxysmal positional vertigo. Laryngoscope 2006;116:1776-81.
21. Bertholon P, Bronstein AM, Davies RA, Rudge P, Thilo KV. Positional down beating nystagmus in 50 patients: cerebellar disorders and possible anterior semicircular canalithiasis. J Neurol Neurosurg Psychiatry 2002;72:366-72.
22. Cambi J, Astore S, Mandalà M, Trabalzini F, Nuti D. Natural course of positional down-beating nystagmus of peripheral origin. J Neurol 2013;260:1489-96.
23. Imai T, Ito M, Takeda N, et al. Natural course of the remission of vertigo in patients with benign paroxysmal positional vertigo. Neurology 2005;64:920-1.
24. Kerber KA, Burke JF, Skolarus LE, et al. Use of BPPV processes in emergency department dizziness presentations: a population-based study. Otolaryngol Head Neck Surg 2013;148:425-30.
25. Helminski JO, Zee DS, Janssen I, Hain TC. Effectiveness of particle repositioning maneuvers in the treatment of benign paroxysmal positional vertigo: a systematic review. Phys Ther 2010;90:663-78.
26. Epley JM. The canalith repositioning procedure: for treatment of benign paroxysmal positional vertigo. Otolaryngol Head Neck Surg 1992;107:399-404.
27. Fife TD, Iverson DJ, Lempert T, et al. Practice parameter: therapies for benign paroxysmal positional vertigo (an evidence-based review): report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology 2008;70:2067-74.
28. Gordon CR, Gadoth N. Repeated vs single physical maneuver in benign paroxysmal positional vertigo. Acta Neurol Scand 2004;110:166-9.
29. Hilton M, Pinder D. The Epley (canalith repositioning) manoeuvre for benign paroxysmal positional vertigo. Cochrane Database Syst Rev 2004;2:CD003162.
30. Hunt WT, Zimmermann EF, Hilton MP. Modifications of the Epley (canalith repositioning) manoeuvre for posterior canal benign paroxysmal positional vertigo (BPPV). Cochrane Database Syst Rev 2012;4:CD008675.
31. Devaiah AK, Andreoli S. Postmaneuver restrictions in benign paroxysmal positional vertigo: an individual patient data meta-analysis. Otolaryngol Head Neck Surg 2010;142:155-9.
32. Oh HJ, Kim JS, Han BI, Lim JG. Predicting a successful treatment in posterior canal benign paroxysmal positional vertigo. Neurology 2007;68:1219-22.
33. Semont A, Freyss G, Vitte E. Curing the BPPV with a liberatory maneuver. Adv Otorhinolaryngol 1988;42:290-3.
34. Faldon ME, Bronstein AM. Head accelerations during particle repositioning manoeuvres. Audiol Neurootol 2008;13:345-56.
35. Mandalà M, Santoro GP, Asprella Libonati G, et al. Double-blind randomized trial on short-term efficacy of the Semont maneuver for the treatment of posterior canal benign paroxysmal positional vertigo. J Neurol 2012;259:882-5.
36. Soto-Varela A, Rossi-Izquierdo M, Santos-Pérez S. Can we predict the efficacy of the Semont maneuver in the treatment of benign paroxysmal positional vertigo of the posterior semicircular canal? Otol Neurotol 2011;32:1008-11.
37. Radtke A, von Brevern M, Tiel-Wilck K, Mainz-Perchalla A, Neuhauser H, Lempert T. Self-treatment of benign paroxysmal positional vertigo: Semont maneuver vs Epley procedure. Neurology 2004;63:150-2.
38. Tanimoto H, Doi K, Katata K, Nibu KI. Self-treatment for benign paroxysmal positional vertigo of the posterior semicircular canal. Neurology 2005;65:1299-300.
39. Herdman SJ, Tusa RJ. Complications of the canalith repositioning procedure. Arch Otolaryngol Head Neck Surg 1996;122:281-6.
40. Lempert T. Horizontal benign positional vertigo. Neurology 1994;44:2213-4.
41. Vannucchi P, Giannoni B, Pagnini P. Treatment of horizontal semicircular canal benign paroxysmal positional vertigo. J Vestib Res 1997;7:1-6.
42. Gufoni M, Mastrosimone L, Di Nasso F. Repositioning maneuver in benign paroxysmal vertigo of horizontal semicircular canal. Acta Otorhinolaryngol Ital 1998;18:363-7. (In Italian.)
43. Korres S, Riga MG, Xenellis J, Korres GS, Danielides V. Treatment of the horizontal semicircular canal canalithiasis: pros and cons of the repositioning maneuvers in a clinical study and critical review of the literature. Otol Neurotol 2011;32:1302-8.
44. Kim JS, Oh SY, Lee SH, et al. Randomized clinical trial for geotropic horizontal canal benign paroxysmal positional vertigo. Neurology 2012;79:700-7.
45. Nuti D, Mandalà M, Salerni L. Lateral canal paroxysmal positional vertigo revisited. Ann N Y Acad Sci 2009;1164:316-23.
46. Oh SY, Kim JS, Jeong SH, et al. Treatment of apogeotropic benign positional vertigo: comparison of therapeutic head-shaking and modified Semont maneuver. J Neurol 2009;256:1330-6.
47. Casani AP, Vannucci G, Fattori B, Berrettini S. The treatment of horizontal canal positional vertigo: our experience in 66 cases. Laryngoscope 2002;112:172-8.
48. Ciniglio Appiani G, Catania G, Gagliardi M, Cuiuli G. Repositioning maneuver for the treatment of the apogeotropic variant of horizontal canal benign paroxysmal positional vertigo. Otol Neurotol 2005;26:257-60.
49. Nuti D, Vannucchi P, Pagnini P. Benign paroxysmal positional vertigo of the horizontal canal: a form of canalolithiasis with variable clinical features. J Vestib Res 1996;6:173-84.
50. Kim JS, Oh SY, Lee SH, et al. Randomized clinical trial for apogeotropic horizontal canal benign paroxysmal positional vertigo. Neurology 2012;78:159-66.

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