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Persistent geotropic positional nystagmus in unilateral cerebellar lesions

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Abstract

Objective

To determine the prevalence of central lesions in persistent geotropic positional nystagmus, and characteristics and anatomical substrates of the nystagmus in cerebellar lesions.

Methods

We prospectively recruited 58 patients with persistent geotropic positional nystagmus at the Dizziness Clinic of Pusan National University Hospital. Seven patients with unilateral cerebellar lesions were subjected to analysis of clinical characteristics, oculographic data, and MRI lesions. For comparison, we studied 37 cases of peripheral persistent geotropic positional nystagmus.

Results

The prevalence of central lesions in persistent geotropic positional nystagmus was 12% (7/58). Persistent geotropic positional nystagmus in cerebellar lesions was mostly asymmetrical. Horizontal nystagmus changed in direction during the bow-and-lean test with null positions. All patients showed impaired horizontal smooth pursuit bilaterally, and 3 of them also had positional downbeat nystagmus. The peak intensity and asymmetry of persistent geotropic positional nystagmus did not differ between central and peripheral groups ($p > 0.05$), while there was a difference in the maxima. Lesion overlays revealed that damage to the cerebellar tonsil was responsible for the generation of persistent geotropic positional nystagmus.

Conclusion

Although persistent geotropic positional nystagmus in cerebellar lesions shares the characteristics of nystagmus measures with peripheral cases, accompanying central oculomotor signs can aid in differentiation. In tonsillar lesions, compensatory rotational feedback due to erroneous estimation of the direction of gravity may generate constant horizontal geotropic positional nystagmus.

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Glossary

SPV = slow-phase velocity; **SVV** = subjective visual vertical.

Frequent presentations of central positional nystagmus are apogeotropic nystagmus in the ear-down position and downbeat nystagmus during the straight head-hanging position in lesions involving the nodulus and uvula.[1–3] However, only a few reports are available for persistent geotropic positional nystagmus in CNS disorders including vestibular migraine, meningitis, HIV encephalitis, and focal lesions involving lateral medulla or cerebellar peduncle.[3,4] No study has reported persistent geotropic positional nystagmus after cerebellar lesions.

In this study, we aimed to investigate the prevalence of central lesions in persistent geotropic positional nystagmus, and characteristics and anatomical substrates of the nystagmus in cerebellar lesions.

Methods

Participants

We prospectively recruited patients with persistent geotropic positional nystagmus at the Dizziness Clinic of Pusan National University Hospital from March 2015 to April 2017. Inclusion criteria were (1) geotropic positional nystagmus during ear-down positions, and (2) persistent nystagmus lasting more than 1 minute.

Initially, 62 patients were recruited. After excluding 4 patients who declined to participate, 58 were selected for this study. Of these 58 patients, we imaged 32 (MRI in 31, CT in 1) with their first attack of positional nystagmus regardless of treatment response. Of these 32 patients, 7 had unilateral cerebellar lesions. The other 26 patients had recurrent positional vertigo without additional neurologic features and were therefore not imaged. Seven patients with unilateral cerebellar lesions were subjected to analysis of clinical characteristics, oculographic data, and MRI lesions. The patients included 6 men aged from 43 to 82 years (58.4 ± 11.9 years) (table). For comparison, of 51 patients with peripheral cases, we studied 37 (10 men, 66.7 ± 10.2 years).

Neuro-otologic evaluation

Spontaneous, gaze-evoked, head-shaking, and positional nystagmus, saccades, and smooth pursuit were measured using video Frenzel goggles (patient 6) or 3-dimensional video-oculography. The positional maneuvers included lying down assuming the ear-down positions, straight head-hanging, and the Dix-Hallpike positions. The peak intensity of geotropic positional nystagmus was determined by averaging the slow-phase velocity (SPV) of the maximal 3 beats. Asymmetry of peak intensity was calculated from the sum of the peak intensity during right and left ear-down positions using Jongkees formula. In 2 patients (patients 3 and 4), we performed the bow-and-lean test and determined the presence of null points. We measured the subjective visual vertical (SVV) in 5 patients.

Table Clinical characteristics of 7 patients with persistent geotropic positional nystagmus due to unilateral cerebellar lesions

			PN							
No.	Sex/ age, y	SN	Ear-down positions	SHH positions	D-H test	HSN	Other ocular motor dysfunction	Associated neurologic signs	SVV, (°)[a]	Etiology
1	M/60	—	pGeo (R > L)	—	—	—	Impaired bilateral SP	—	3.21	(L) PICA infarction
2	M/56	—	pGeo (R > L)	—	—	—	Impaired bilateral SP	—	NC	(L) Glioblastoma multiforme
3	F/57	—	pGeo (R > L)	RB	pGeo	—	Impaired bilateral SP	—	0.99	(L) PICA infarction
4	M/43	LB	pGeo (R > L)	DB > RB	DB > pGeo	—	Impaired bilateral SP, MSO	R ataxia, saccadic hypermetria	1.76	(R) Cerebellar hemorrhage
5	M/82	RB	pGeo (R < L)	DB	DB > RB	RB	Impaired bilateral SP	—	2.01	(R) PICA infarction
6	M/52[b]	RB	pGeo (R > L)	DB	pGeo	RB	Impaired bilateral SP	—	NC	(R) PICA infarction
7	M/59	—	pGeo (R = L)	—	pGeo	—	Impaired bilateral SP	—	−0.44	(R) SCA infarction

Abbreviations: DB = downbeat nystagmus; D-H = Dix-Hallpike; HSN = head-shaking nystagmus; LB = left-beating nystagmus; MSO = macrosaccadic oscillation; NC = not checked; pGEO = persistent geotropic positional nystagmus; PICA = posterior inferior cerebellar artery; PN = positional nystagmus; RB = right-beating nystagmus; SCA = superior cerebellar artery; SHH = straight head-hanging; SN = spontaneous nystagmus; SP = smooth pursuit; SVV = subjective visual vertical.
[a] The given numbers are the mean value of SVV testing with binocular viewing (normal range −3.0 to 3.0; a negative value indicates a counterclockwise rotation).
[b] Ocular motor function was measured using video Frenzel goggles in patient 6 or 3-dimensional video-oculography (patients 1–5 and 7, SLMed, Seoul, Korea).

Lesion analysis

Of 7 patients with cerebellar lesions, 6 had MRI including diffusion-weighted, T1, contrast-enhanced T1, T2, and fluid-attenuated inversion recovery on a 3.0-tesla scanner. We performed lesion analysis in 5 patients after excluding patient 4 who did not have MRI and patient 7 with a superior cerebellar artery infarction. The lesions were delineated and overlapped using MRIcron (mccauslandcenter.sc.edu/mricro/mricron) on a spatially unbiased atlas template of the cerebellum and brainstem.[5]

Statistics

We compared the peak intensity and asymmetry of geotropic positional nystagmus between central and peripheral groups using the Mann-Whitney test. Statistical analyses were performed using SPSS version 18.0 (SPSS Inc., Chicago, IL), and $p < 0.05$ was considered significant.

Standard protocol approvals, registrations, and patient consents

All experiments followed the tenets of the Declaration of Helsinki and were approved by the institutional review board of Pusan National University Hospital. Written informed consents were obtained after the nature and possible consequences of this study had been explained to the participants.

Data availability

Anonymized data not published within this article will be made available by request from any qualified investigator.

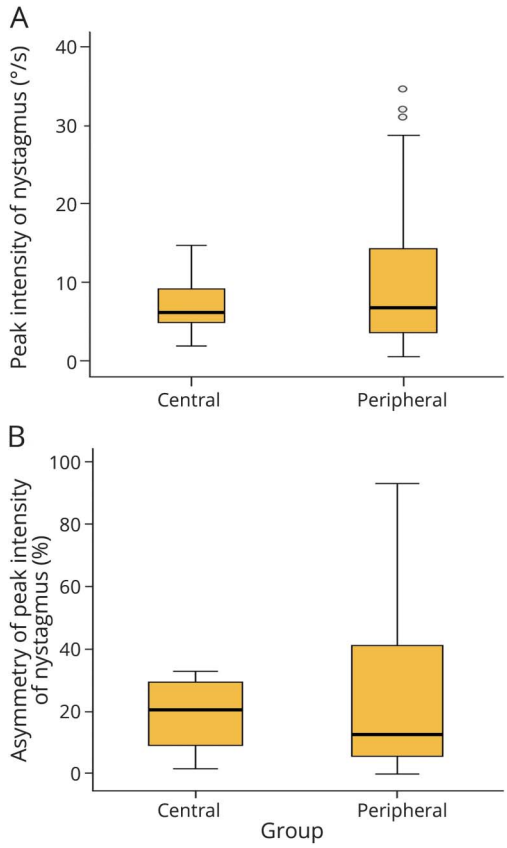
Results

Clinical characteristics of central positional geotropic nystagmus

The prevalence of central lesions was 12% (7/58) in persistent geotropic positional nystagmus. Three patients had horizontal nystagmus in the sitting position ("pseudo-spontaneous nystagmus"), which was ipsilesional in 2 and contralesional in 1 (table). The peak intensity of geotropic positional nystagmus was asymmetrical in 6 patients and was more prominent during ipsilesional (n = 2) or contralesional ear-down position (n = 4), and symmetrical in one. The maximal SPV of central geotropic positional nystagmus ranged from 2° to 15°/s. The peak intensity (7.0° ± 3.5°/s vs 9.7° ± 8.1°/s, $p > 0.05$) and asymmetry (19.2% ± 13.1% vs 22.8% ± 23.8%, $p > 0.05$) of geotropic positional nystagmus did not differ between central and peripheral groups, while there was a difference in the maxima (figure 1). In 11 (30%) of 37 patients with peripheral cases, the maximal SPV exceeded 15°/s and asymmetry exceeded 33%.

Three patients had positional downbeat nystagmus during straight head-hanging or Dix-Hallpike tests, or both. Patients 3 and 4 with asymmetrical geotropic positional nystagmus had null positions between the supine and left ear-down position. They showed left-beating nystagmus in bowing position, and right-beating nystagmus in leaning position. All patients had impaired horizontal smooth pursuit bilaterally, and one had ataxia and macrosaccadic oscillations. One of the 5 patients tested exhibited contralesional tilt of SVV.

Figure 1 Comparison of persistent geotropic positional nystagmus between central and peripheral groups



The peak intensity (A) and asymmetry (B) do not differ between the 2 groups ($p > 0.05$), but there is a difference in the maxima.

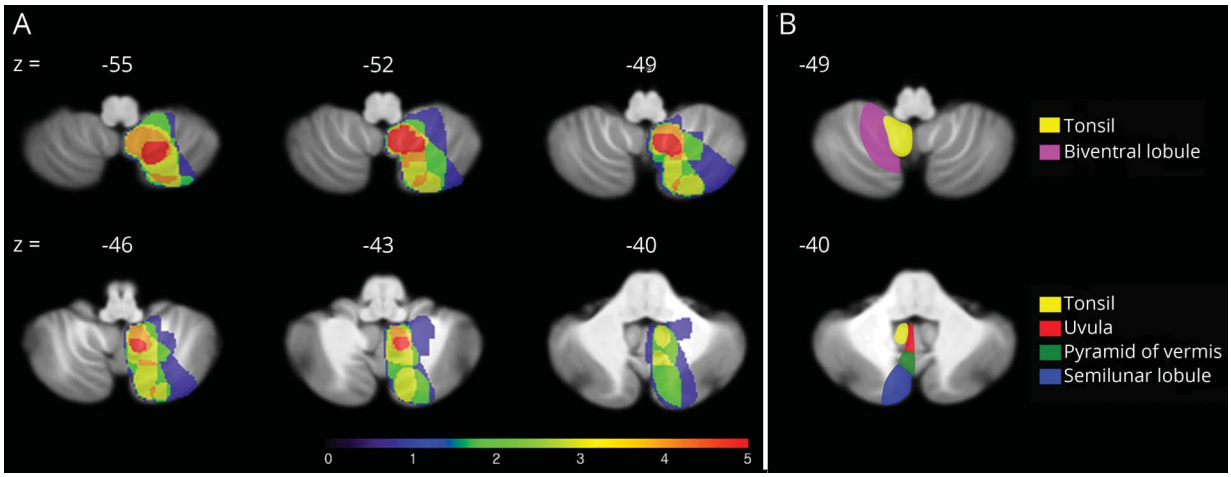
Lesion analysis

Brain MRI disclosed unilateral posterior inferior cerebellar artery infarctions in 4 patients and superior cerebellar artery infarction in one, a unilateral cerebellar hemorrhage in one, and a tumor involving unilateral cerebellum in one. Lesion overlays in 5 patients with posterior inferior cerebellar artery infarctions or tumor demonstrated that the tonsil was the common area of injury (figure 2).

Discussion

The present study demonstrated that the prevalence of central lesions in persistent geotropic positional nystagmus was 12%. Most patients with central lesions had pure geotropic positional nystagmus without additional neurologic features and shared the characteristics of nystagmus measures with

Figure 2 Lesion analyses in 5 patients with unilateral cerebellar lesions



(A) The tonsil is the most frequently involved structure (red). The numbers of overlapping lesions are illustrated by different colors from violet (n = 1) to red (n = 5). (B) Illustration of the areas corresponding to the tonsil, pyramid, and uvula, and in 2 representative templates of the SUIT toolbox.

peripheral cases.[6] Central geotropic positional nystagmus was mostly asymmetrical and had similar intensity to peripheral.[6] The direction of horizontal nystagmus changed during the bow-and-lean test with null positions, but those did not correspond to the side of asymmetrical positional nystagmus and lesion. All patients showed impaired horizontal smooth pursuit bilaterally, and 3 had positional downbeat nystagmus. Greater intensity and asymmetry of persistent geotropic positional nystagmus may indicate peripheral cause.

We found that patients with persistent geotropic positional nystagmus due to unilateral cerebellar lesions mostly involved the tonsil. Our findings are different regarding the neuroanatomical structures responsible for central apogeotropic positional nystagmus, especially affecting the nodulus and uvula. Thus, the tonsil can be a candidate for generation of persistent geotropic positional nystagmus in terms of impaired transduction of gravity-related signals from the otolith. There has been evidence that the tonsil may have a role in controlling the otolith system.[7] A patient with an isolated tonsillar infarction showed spontaneous nystagmus and SVV tilt.[7] The principal projections from the utricle are to the laterodorsal medial vestibular nucleus and ventrolateral superior vestibular nucleus with projections to the nodulus, flocculus, paraflocculus (tonsil), fastigial nuclei, and uvula.[8]

Although the mechanisms of central positional nystagmus remain uncertain, a recent study suggested a mechanism for central apogeotropic positional nystagmus based on the location of lesions and a mathematical model that uses the velocity-storage mechanism.[9] The model simulation produced gravity-related, apogeotropic nystagmus in ear-down positions assuming the lesion involves the vestibulocerebellar pathway that relays the estimated gravity to rotational feedback. The disruption of this pathway results in loss of information about the estimated gravity and causes a bias toward the nose along the naso-occipital axis of the head. As a result, when the head is turned to the side while supine, there will be sustained apogeotropic positional nystagmus because of inappropriate feedback signal indicating that the head is rotating. On the contrary, constant geotropic nystagmus in tonsillar lesion may be explained by compensatory rotational feedback due to a negative bias, away from the nose along the naso-occipital axis. Normal verticality perception in most patients reflects that the direct otolith-ocular pathways need not be damaged to generate persistent geotropic positional nystagmus.

Our study has limitations. Selection bias should be considered in interpreting the results. We did not perform neuroimaging in patients with recurrent positional vertigo, and thus, a few patients may have escaped the diagnosis of central lesions. However, we believe that the possibility of central lesions is very rare in recurrent positional vertigo.

Author contributions

Dr. S.Y. Choi conducted the experiments, analyzed and interpreted the data, and wrote the manuscript. Dr. J.-Y. Jang, Dr. E.H. Oh, Dr. J.Y. Park, Dr. S.-H. Lee, and Dr. J.-H. Choi conducted the experiments, and analyzed and interpreted the data. Dr. K.-D. Choi conducted the design and conceptualization of the study, interpreted the data, and revised the manuscript.

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Disclosure

The authors report no disclosures relevant to the manuscript. Go to Neurology.org/N for full disclosures.

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