Review Article

Motorist Vestibular Disorientation Syndrome

Santosh Kumar Swain, Vasudha Singh

Department of Otorhinolaryngology and Head and Neck Surgery, Manipal Tata Medical College, Jamshedpur, Manipal Academy of Higher Education, Manipal, India

Abstract

The normal vestibular system may be adversely affected by environmental challenges. A disordered vestibular system lends susceptibility even to quotidian environmental experiences as the suffered becomes dependent on potentially misleading nonvestibular stimuli. Equilibrium is the ability of an individual to maintain posture as well as spatial orientation at rest and during movement. Vision, proprioception, and vestibular system are important components for making equilibrium of the body at rest and movement. Driving is a complex task for a motorist where a driver or passenger faces a dynamic environment of modern highways, bends, turns, and bridges. The vestibular system plays a vital role in the spatial navigation and orientation of motorists during driving. Patients of motorist vestibular disorientation syndrome (MVDS) manifest multiple morbid symptoms, which are often a challenge to modern vehicle drivers or passengers. MVDS can also occur secondary to other vestibular disorders such as vestibular migraine, persistent postural perceptual dizziness, and visual vertigo. MVDS is a lesser-known clinical entity among clinicians. Difficulty driving may be a real-world manifestation of impaired spatial cognition associated with vestibular loss. There is scarce knowledge about this disorder in the medical literature. Here, this review article intends to document the etiopathology, clinical manifestations, diagnosis, and treatment of MVDS. This review article discusses the epidemiology, putative mechanisms, clinical presentations, triggering factors, diagnosis, and treatment of MVDS.

Keywords: Somatosensory system, vestibular system, vision, visual vertigo

Introduction

Motorist vestibular disorientation syndrome (MVDS) is a disorder in which the patient experiences disorientation while driving and tries to make adjustments to compensate, which has serious implications.[1] Disorientation during driving is not a common symptom in patients with vestibular disorders.[2] This symptomatology is called as MVDS.[3] This disorientation is evidence of a particular set of abnormalities that render the patient susceptible. MVDS was originally described as mild asymmetries of vestibular function causing erroneous tilt and turning sensations or misinterpretations.[3] However, such vestibular disorientation is not typical of patients with even marked vestibular asymmetries; so, this explanation should probably be discounted as the major mechanism, although it may be a factor causing the emergence of the condition in individual patients.[4] During highway driving, the driver must learn to interpret his or her pattern of vestibular and somatic sensations according to the context or "frame of reference" of a four-wheeled vehicle constrained to a highway by the suspension system, which under normal driving conditions, prevents tilting from upright under the centripetal accelerations imposed by cornering.[5] This review article discusses the epidemiology, etiopathology, triggering factors, clinical presentations, diagnosis, and treatment of MVDS.

Methods of Literature Search

Multiple systematic methods were used to find current research publications on the MVDS and its etiopathology, clinical manifestations, and management. We started by searching the Scopus, PubMed, MEDLINE, and Google Scholar databases online. A search strategy using Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines was developed. This search strategy recognized the abstracts of published articles, while other research articles were discovered manually from the citations. Randomized controlled studies,

Address for correspondence: Dr. Santosh Kumar Swain, Department of Otorhinolaryngology and Head and Neck Surgery, Manipal Tata Medical College, Jamshedpur - 831 017, Jharkhand, India.
E-mail: santoshvoltaire@yahoo.co.in

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observational studies, comparative studies, case series, and case reports were evaluated for eligibility. There were a total number of articles of 38 (12 case reports; 14 cases series; and 12 original articles) [Figure 1]. This article focuses only on the details of the MVDS. This review article describes the epidemiology, etiopathology, clinical presentations, investigations, and treatment of MVDS. This analysis provides a better understanding of MVDS and its clinical profile along with its management. It will also catalyze further study of the etiopathogenesis of MVDS and the development of a newer surgical technique for the management of this clinical entity.

Epidemiology

The number of patients with MVDS is too small to draw a firm conclusion about its epidemiology.[3] Approximately 1% of patients of MVDS are referred to a well-established clinic specializing in vestibular and balance disorders and account for five individuals per annum.[6] The patients are usually adults of both sexes and rarely with a history of a significant psychiatric or organic disorder.

Etiopathology

An emerging body of evidence reveals that vestibular function is vital for spatial orientation and navigation.[7] A person with vestibular disorders is often disoriented more easily by extraneous visual stimuli or visual noise.[8] This shows that drivers are more often to have difficulty driving in decreased visual conditions such as driving at night or in the rain. There is a highly sophisticated mechanism in human being for maintaining balance while driving a vehicle or motion has developed and the mechanism is dependent on visual, vestibular, and proprioceptive sensory information.[9] The information is usually integrated with the central nervous system and is modulated by the activity originating in the reticular formation, the extrapyramidal system, the cerebellum, and the cerebellar cortex [Table 1]. Motorist's disorientation is probably multisensory. Driving a car involves unusual visual and motion stimuli which do not occur in normal activities. The driver is often exposed to a complex pattern of visual flow that the driver must interpret as the normal flow of traffic. In the motorist's disorientation, the interpretation of sensory input with respect to a vehicular frame of reference appears to have broken down and the driver is vulnerable to alternative interpretations of inherently ambiguous, visual, and somatosensory stimuli.[10] The steps in the pathogenesis of MVDS include orientation and motion in Space → Sensory signals for force and Motion → Complex and dynamic driving Environment → Inadequate or inappropriate Interpretation → Symptoms of MVDS.[3] The common factors involved in causing the motorist's vestibular dysfunction syndrome include the proximity and quality of the background surroundings and the speed and direction of the vehicle.[11] A theoretical explanation can be proposed to account for the illusions of turning, tilting, or the feeling of being pushed sideways. Most of the vestibular stimulation involved in driving is of low-frequency content and out of the normal physiological range of the labyrinth. Hence, vision, both peripheral and central, is of overriding importance not only for steering but also for assessing speed changes, and this dominance of vision obviates problems that come from a pathological vestibular system. The vestibular system is more important when the vision is reduced as when driving in an empty landscape. Hence, spatial disorientation in an empty visual field is likely to be a consequence of abnormal vestibular signals or erroneous central interpretation of vestibular information.[12] The vestibular apparatus is sensitive to both angular acceleration (semicircular canals) and lineal acceleration (otolithic organs).[13] If the otoliths are stimulated in isolation by the centripetal acceleration of turning, it gives an abnormal signal and may indicate either centrifugal force or tilt. The predominant interpretation is usually by centrifugal force. Tilt is an important sensation if the canals are stimulated when the head tilts. Hence, an abnormal otolith signal can be interpreted as a force acting sideways or a lateral acceleration, whereas an abnormal canal signal could provide the sensation of tilt or torque.[14] Comorbidities associated with MVDS

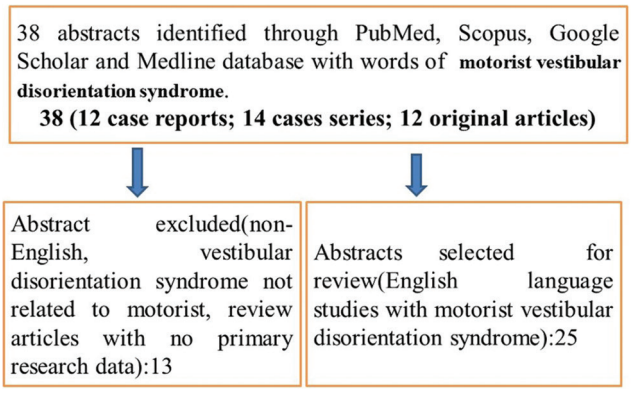

Figure 1: Methods for literature search

Table 1: Components of neural axis involved during driving

Neural system involved during driving	Neural components
Higher cognitive function	Visuospatial orientation
	Memory
	Visual cortex
	Pyramidal
	Extra-pyramidal
Cranial nerves	II
	III, IV, VI
	VIII
	IX
Motor system	Upper limb
	Trunk
	Lower limb
Sensory system	Proprioception
	Touch
	Vibration
Cerebellum	

include migraine, vestibular paroxysmia, old history of vestibular neuritis, and epilepsy are important comorbidities associated with MVDS.[15]

Trigger Factors for Motorist Vestibular Disorientation Syndrome

An emerging body of evidence suggests that vestibular function is vital for spatial orientation and navigation.[16] Driving a motor vehicle is one task that appears to reflect spatial cognitive ability.[17,18] The triggering factors associated with MVDS include the high speed of the vehicle (>80 km/h), bends/turns, multilanes, slopes, overtaking a big vehicle, and looking at other vehicles while at signals or in motion.[19]

Classification and Relationship to Other Disorientation Syndrome

The motorist's disorientation has been classified as phobic postural vertigo and, currently, persistent postural dizziness, which is a functional vestibular system disorder.[20] However, the phobia is not typical in the majority of cases, as neither is contextual postural vertigo. Some patients have a structural vestibular disorder that can account for misconceptions of orientation. Hence, such vague classifications are not useful, particularly since the stereotypical symptoms of disoriented motorists can be explained by known physiological mechanisms. The missing component in explaining the motorist's disorientation is the exact mechanism resulting in the driver abandoning the learned framework of sensory interpretation during driving and adopting an alternative interpretation of the sensory input. The proposed classification for MVDS includes primary and secondary MVDS. Primary MVDS has no undergoing vestibular disorders. Secondary MVDS has underlying vestibular disorders. The secondary MVDS may be: secondary to visual vertigo in vestibular migraine, secondary to visual vertigo in persistent postural perceptual dizziness, and secondary to other vestibular disorders.[21]

Clinical Presentations

Common clinical manifestations of MVDS include nausea/vomiting, giddiness/imbalance, yawning, malaise, headache, drowsiness, irritability, and fatigue.[3] Some patients with vestibular disorders report the triggering or worsening of dizziness and imbalance in certain visual environments. These patients often dislike moving visual surroundings, as encountered in traffic, crowds, under disco lights, and while watching car-chase scenes in films.[22,23] Such symptoms are also often seen when walking in busy visual surroundings like supermarket aisles. The development of these symptoms in some patients with vestibular disorders has long been recognized and known by different names, such as visual-vestibular mismatch or visual vertigo.[24] MVDS should not be confused with oscillopsia. In the case of oscillopsia, there is an oscillation of the visual world – the symptom is visual.[25] In visual vertigo, the triggering factor is visual, but the symptom is of a vestibular type such as dizziness, vertigo, disorientation, and unsteadiness. The symptoms of visual vertigo commonly develop after a vestibular insult. A patient who is previously asymptomatic and suffers an acute peripheral vestibular disorder like vestibular neuritis and after an initial period of recovery of a few weeks, he or she shows that dizzy symptoms do not completely disappear. Patients may also present anxiety or frustration because symptoms do not go away or because medical practitioners tend to disregard this syndrome.

Differential Diagnosis of Dizziness in Vehicle

The differential diagnosis of dizziness in motorists or passengers includes motion sickness, bilateral vestibulopathy, persistent postural phobic dizziness, drug-induced dizziness, postbenign paroxysmal positional vertigo dizziness, Meniere's disease, and MVDS.[26]

Motorist Vestibular Disorientation Syndrome and its Impact on Routine Life

The normal vestibular system may be affected seriously by environmental challenges which have characteristics that are unfamiliar or ambiguous in the pattern of sensory stimulation.[27] Routine life is severely affected by MVDS. These include stopped or reduced frequency of driving, avoidance of long journeys, avoidance of multilane highways, avoidance of driving on bridges, reduced overtaking, reduced speed far earlier before reaching the traffic signal, driving at low speed (<80 km/h), driving in slower lanes, taking frequent breaks in a long journey, usage of single-lane roads, and keeping water/juice ready during the journey.[3]

Treatment

A highly structured background or the presence of other traffic has a protective effect on the individual's ability to corner or drive fast. The rehabilitation of motorist disorientation is based on the rehabilitation of flying disorientation and motion sickness.[28] Specific measures should be introduced in the rehabilitation program for MVDS. The aim is to promote desensitization and increase tolerance to visual stimuli and to visual-vestibular conflict. Patients are, therefore, exposed under the guidance of the vestibular physiotherapist, to optokinetic stimuli which can be delivered through projection screens, head-mounted virtual reality systems, video monitors, ballroom planetariums, or optokinetic rotating systems.[29] Progressive desensitization is done following an explicit schedule of driving commencing with short-duration exposures on local roads at quiet times and progressing to highway driving. The motorist verbalizes the planning and execution of the journey with a continual appraisal of the road conditions to strengthen cognitive context. The motorist should stop the vehicle for a rest if driving becomes significantly stressful

Table 2: Treatment options for motorist vestibular disorientation syndrome

Clinical manifestations	Treatment options
Car tilting illusion Previous vestibular disease No panic attacks	Vestibular rehabilitation
No illusion No vestibular disease Panic attacks	SSRIs/anxiolytics/ cognitive behavioral therapy

SSRIs: Selective serotonin reuptake inhibitors

and perform anxiolytic exercises such as postural control, controlled breathing, and stretching his legs. Desensitization by immersion driving in one long session challenge is not usually recommended, as it may cause extreme levels of anxiety and panic that prevent rehabilitation.[29] Car simulation games may be advised. Cognitive behavioral therapy is suggested for patients with anxiety and depression [Table 2]. A person with a phobia of driving loses control when exposed to common driving events, shows exaggerated and inappropriate reactions, and endangers the safety of himself/herself and others. The main steps for car simulation are to improve driver behavior such as braking, lane changing, and car following.[30] In the case of braking maneuver, the individual has to brake because they face obstacles blocking the street, pedestrians crossing the street, or drifting of an adjacent vehicle. Road safety is an important criterion for reducing MVDS. A high proportion of road traffic incidents is attributed to lapses of attention without adequate consideration of spatial orientation. It should be stressed that a main factor in tuning attention and regulating vigilance is the state of spatial orientation such as driving fast on a highway may be unremarkable, whereas viewing nearby fast traffic from the roadside is alarming.[31]

Conclusion

There is a growing understanding of the vestibular action in spatial navigation and orientation. The person with impaired vestibular function shows disturbance in static and dynamic tests of spatial cognition. MVDS is an important clinical entity that requires diagnostic consideration and treatment. Widespread awareness of this clinical entity is helpful to reduce the timing for diagnosis of this condition. The majority of patients with MVDS respond to the treatment of comorbid conditions, especially migraine.

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Conflicts of interest

There are no conflicts of interest.

References

1. Wei EX, Agrawal Y. Association between vestibular vertigo and motor vehicle accidents: Data from the 2016 national health interview survey. Ear Hear 2018;39:1232-5.
2. Bronstein AM, Golding JF, Gresty MA. Visual vertigo, motion sickness, and disorientation in vehicles. Semin Neurol 2020;40:116-29.
3. Page NG, Gresty MA. Motorist's vestibular disorientation syndrome. J Neurol Neurosurg Psychiatry 1985;48:729-35.
4. Cohen HS. Disability and rehabilitation in the dizzy patient. Curr Opin Neurol 2006;19:49-54.
5. Swain SK, Acharya S. Alternobaric vertigo-An uncommon medical hazard. J Clin Sci Res 2020;9:229-34.
6. Bronstein AM, Golding JF, Gresty MA. Vertigo and dizziness from environmental motion: Visual vertigo, motion sickness, and drivers' disorientation. Semin Neurol 2013;33:219-30.
7. Bigelow RT, Semenov YR, Trevino C, Ferrucci L, Resnick SM, Simonsick EM, *et al.* Association between visuospatial ability and vestibular function in the baltimore longitudinal study of aging. J Am Geriatr Soc 2015;63:1837-44.
8. Swain SK, Baliarsingh D, Sahu MC. Vertigo among elderly people: Our experiences at a tertiary care teaching hospital of eastern India. Ann Indian Acad Otorhinolaryngol Head Neck Surg 2018;2:5-8.
9. Cohen HS, Wells J, Kimball KT, Owsley C. Driving disability and dizziness. J Safety Res 2003;34:361-9.
10. Golding JF, Gresty MA. Motion sickness and disorientation in vehicles. In: Bronstein AM, editor. Oxford Textbook of Vertigo and Imbalance. Oxford, England: Oxford University Press; 2013. p. 293-305.
11. Uwents MH, Jorissen C, Van Ombergen A, Dobbels B, van de Berg R, Janssens de Varebeke S, *et al.* Driving ability in patients with dizziness: A systematic review. Eur Arch Otorhinolaryngol 2022;279:1813-29.
12. Swain SK, Sahoo L, Sarangi R. Vertigo during childhood: A disabling clinical entity. Int J Health Allied Sci 2021;10:5-10.
13. Swain SK. Vertigo following cochlear implantation: A review. Int J Res Med Sci 2022;10:572-7.
14. Guerraz M, Yardley L, Bertholon P, Pollak L, Rudge P, Gresty MA, *et al.* Visual vertigo: Symptom assessment, spatial orientation and postural control. Brain 2001;124:1646-56.
15. Swain SK, Munjal S, Pradhan S. Vestibular migraine. Apollo Med 2021;18:179.
16. Popp P, Wulff M, Finke K, Rühl M, Brandt T, Dieterich M. Cognitive deficits in patients with a chronic vestibular failure. J Neurol 2017;264:554-63.
17. Ott BR, Davis JD, Papandonatos GD, Hewitt S, Festa EK, Heindel WC, *et al.* Assessment of driving-related skills prediction of unsafe driving in older adults in the office setting. J Am Geriatr Soc 2013;61:1164-9.
18. Vitte E, Sémont A, Berthoz A. Repeated optokinetic stimulation in conditions of active standing facilitates recovery from vestibular deficits. Exp Brain Res 1994;102:141-8.
19. Pyykkö I, Manchaiah V, Zou J, Levo H, Kentala E. Driving habits and risk of traffic accidents among people with Ménière's disease in finland. J Int Adv Otol 2019;15:289-95.
20. Staab JP, Eckhardt-Henn A, Horii A, Jacob R, Strupp M, Brandt T, *et al.* Diagnostic criteria for persistent postural-perceptual dizziness (PPPD): Consensus document of the committee for the Classification of Vestibular Disorders of the Bárány Society. J Vestib Res 2017;27:191-208.
21. Popkirov S, Staab JP, Stone J. Persistent postural-perceptual dizziness (PPPD): A common, characteristic and treatable cause of chronic dizziness. Pract Neurol 2018;18:5-13.
22. Swain SK. Vascular loop of anterior inferior cerebellar artery causing disabling tinnitus, vertigo, and hearing loss-A review. Matrix Sci Med 2022;6:29-33.
23. O'Connell Ferster AP, Priesol AJ, Isildak H. The clinical manifestations of vestibular migraine: A review. Auris Nasus Larynx 2017;44:249-52.
24. Longridge NS, Mallinson AI, Denton A. Visual vestibular mismatch in patients treated with intratympanic gentamicin for Meniere's disease. J Otolaryngol 2002;31:5-8.
25. Brantberg K, Löfqvist L. Preserved vestibular evoked myogenic potentials (VEMP) in some patients with walking-induced oscillopsia due to bilateral vestibulopathy. J Vestib Res 2007;17:33-8.
26. Keshavarz B, Golding JF. Motion sickness: Current concepts and management. Curr Opin Neurol 2022;35:107-12.
27. Swain SK. Acute brain stem vertigo without neurological deficits. BLDE Univ J Health Sci 2021;6:206-8.
28. Benson AJ. Spatial disorientation-common illusions. In: Ernsting J, Nicholson AN, Rainford DJ, editors. Aviation Medicine. 3rd ed. Oxford,

England: Butterworth Heinemann; 1999. p. 437-54.
29. Swain SK. Pharmacotherapy for vertigo: A current perspective. Int J Otorhinolaryngol Head Neck Surg 2020;6:1400-6.
30. Stavros P, Charisma FC. Transferability of car-following models between driving simulator and field traffic. Transp Res Rec 2017;2623:60-72.
31. Golding JF, Gresty MA. Motion sickness and disorientation in vehicles. In: Bronstein AM, editor. Oxford Textbook of Vertigo and Imbalance. 2nd ed., Ch. 27. Oxford:Oxford University Press; 2020.