Headache
©2007 the Authors
Journal compilation © 2007 American Headache Society

ISSN 0017-8748
doi: 10.1111/j.1526-4610.2007.00762.x
Published by Blackwell Publishing

Expert Opinion

CME

Motion Sickness and Migraine

Case History Submitted by: Randolph W. Evans, MD
Expert Opinion by Dawn Marcus, MD; Joseph M. Furman, MD, PhD

Key words: motion sickness, migraine, mal de debarquement

(*Headache* 2007;47:607-610)

Migraine is enough of a roller coaster illness without the addition of motion sickness as a comorbidity.

CASE 1

This 29-year-old-woman has had recurring headaches since the age of 13. She reports a back of the head throbbing with an intensity of 4/10 with light and noise sensitivity but not nausea, with attacks lasting a couple of hours and triggered by stress. Also since the age of 13, always when she is a passenger in a motor vehicle for a trip any longer than 5 minutes, she will get a generalized throbbing headache with an average intensity of 5/10 with nausea, light and noise sensitivity, and occasional vomiting but no aura. With longer trips, the headache will be as intense as 7/10 with nausea and vomiting. Despite having attacks 1 to 2 times weekly, she would continue to be a passenger to watch her children as her husband would drive. The headaches did not occur when she was the driver or a passenger on an airplane. She had never been on a boat. Her mother also had migraines that would occur without triggers, but could be triggered by being a passenger in a car or flying in turbulent weather.

Three months previously, for the first time, she developed typical episodic cluster headaches. Her first neurologist placed her on topiramate increasing the dose to 100 mg bid without benefit for the cluster attacks. I added verapamil with a reduction in the frequency of headaches and 100% oxygen prn with benefit.

As the topiramate was increased, she noted that she still had episodes of headaches with nausea as a passenger at 50 mg bid. Zolmitriptan 5 mg nasal spray worked well in relieving the headache and associated symptoms. However, in the next 6 weeks, on 100 mg bid, she only had one headache brought on after a 2 hour trip as a passenger.

CASE 2

A 25-year-old woman has migraine without aura since her early teens. Starting about the age of 8 months for about 1 year, almost every time she was in the car, she would vomit. She was then able to be a passenger except for occasional complaints of car sickness over the years. Both parents are migraineurs.

CASE 3

A 46-year-old woman has migraine without aura since her teens now occurring several times monthly. She had benign paroxysmal positional vertigo in 1999

For CME, visit http://www.headachejournal.org

From the University of Pittsburgh Medical Center, Pittsburgh, PA, USA (Dr. Marcus); Department of Otolarygology, University of Pittsburgh, PA, USA (Dr. Furman).

Address all correspondence to Dr. Dawn Marcus, University of Pittsburgh Medical Center, 5750 Centre Avenue, Pittsburgh, PA 15206, USA.

and 2001 successfully treated with positional exercises. She went on a 7-day cruise during which the ocean was rough for 3 days. On getting off the boat, she felt off balance, "giddy" and nauseous rather constantly for 5 days and then slowly less for another few days before recovering. Her symptoms were better supine. She had previously been on 18 cruises without similar symptoms. Her mother, brother, and daughter have migraine. Although her daughter had, she had never had car sickness.

Questions— What is the association between motion sickness and migraine? Can motion sickness be a precursor to the development of migraine? Are they comorbid? Is motor vehicle motion a common trigger for migraine or can motion sickness include headache as part of the symptomatology? What treatments are available? What is mal de debarquement and is it comorbid with migraine?

EXPERT OPINION

Motion sickness can be induced by motion alone or conflicts among difference balance systems, including vestibular, visual, and proprioceptive systems. Motion sickness symptoms may occur after exposure to actual motion, such as riding in transportation or amusement park rides, or perceived motion, such as viewing a large projection screen or virtual reality. Viewing an optokinetic rotating drum is an effective research technique for inducing motion sickness symptoms.[1] Motion sickness results in a variety of symptoms, including dizziness, nausea, cold sweat, pallor, lethargy, and headache. In one study of 31 college students, optokinetic rotation viewing for 12 minutes resulted in dizziness in 100%, warmth in 77%, sweating in 58%, nausea in 52%, and headache in 35%.[1] In both pediatric and young adult populations, females are more susceptible to motion sickness than males.[2,3]

The phenomenon of motion sickness has no apparent purpose. It has been hypothesized that motion sickness is a "poison response," ie, toxic ingestions led to abnormal brain processing of sensory information and then to motion sickness and vomiting.[4] Another theory is that motion sickness is "an eliciting or reinforcing stimulus for conditioned avoidance of potentially dangerous situations."[5] The central nervous system structures that are important for mediating motion sickness are not entirely known; however, pathways from the vestibular system to the autonomic nervous system are considered crucial.[6]

What Is the Relationship Between Motion Sickness and Migraine?—Motion sickness is uniquely linked to migraine, occurring in about half of migraineurs.[7] Only about 20% with tension-type headache also experience motion sickness susceptibility. Barabas et al reported motion sickness in 45% of pediatric migraineurs compared with 7% of pediatric patients with nonmigraine headaches, 7% with epilepsy, and 5% with learning disability or other neurological complaints without headache.[8]

A recent adult study compared self-reports of motion sickness susceptibility in 42 migraineurs and 39 headache-free controls.[9] Both groups were similarly susceptible to developing motion sickness with strong vestibular stimulation, such as riding on boats or amusement park rides. Migraineurs, however, were significantly more likely to endorse motion sickness susceptibility following milder vestibular stimulation. For example, 67% of migraineurs reported motion sickness when reading in the car, compared with 37% of controls. Optokinetic stimulation induced nausea more often in migraineurs versus controls for both viewing wide screen movies (28% vs 4%) and movement simulators (39% vs 0). In general, traveling in aircraft and trains was associated with substantially fewer reports of motion sickness compared with riding in buses, cars, and boats.

Can Motion Sickness be a Migraine Precursor?— In a small study, Jan evaluated 29 consecutive children with recurrent vomiting.[10] Motion sickness was reported by 15 children. Children with motion sickness were 4 times more likely to develop migraine than children without motion sickness. Among children with motion sickness, 11 of 15 developed migraine, compared with 5 of 14 children without motion sickness.

In a larger sample, Lanzi evaluated 247 consecutive pediatric migraine patients for the presence of associated periodic syndromes.[11] Motion sickness was endorsed by 48%, with symptoms first presenting at an average age of 2 years and resolving in 29% of patients at 8 years of age. In this same study population, migraine began at an average age of 8 years. Motion sickness in young children, therefore, may suggest a predisposition to developing migraine. This same pattern is probably apparent in Case 2, who similarly

endorsed severe motion sickness in very early childhood, with improvement as she aged, and persistent episodic migraine.

Can Motion Induce Migraine Symptoms?— Anecdotally, patients often report that motion sickness-provoking stimuli can trigger a migraine. Drummond showed that motion sickness symptoms induced by viewing optokinetic stripes also increased headache pain in migraineurs.[12] This same motion sickness provocation failed to result in headache in nonmigraineur control subjects.

Case 1 reports migraine after some types of motion exposure, such as riding as a passenger, but not with other types of motion exposure, such as driving or riding in an airplane. Riding in a vehicle as a passenger deprives an individual of anticipatory motion cues and is known to be associated with higher levels of motion intolerance.[13] Also, some types of motion, such as riding in an airplane, are less intense than motion in other vehicles, such as an automobile. Further, motion environments that are devoid of congruent visual motion cues, eg, being below deck on a ship, are especially motion sickness provoking, probably because of sensory conflict.

How Is Motion Sickness Treated?—Motion sickness may be prevented by minimizing exposure to provocative situations. Riding in a semi-recumbent position, minimizing head and body moving, fixing vision on the horizon, lowering temperatures, and improving ventilation may all reduce the risk of developing motion sickness.

Motion sickness symptoms are typically treated with anticholinergics and antihistamines. Promethazine, scopolamine, dimenhydrinate, and meclizine may all be beneficial. Serotonergic agents may also affect motion sickness symptoms. In a recent pilot study, Marcus and Furman demonstrated reduction in induced motion sickness in migraineurs with migraine-related dizziness pre-emptively treated with 10 mg rizatriptan before motion provocation.[14] Another pilot study similarly showed improved tolerability in healthy subjects for motion sickness provocation maneuvers after pretreatment with the antidiarrheal, μ-opiate receptor agonist, loperamide.[15]

What Is Mal de Debarquement and Is It Comorbid With Migraine?—Motion sickness is reported with traveling on small and large boats, respectively, in 42% and 33% with migraine and 32% and 29% headache-free controls.[9] Typically, these symptoms abate after continued boat travel for 2-3 days. In some cases, milder symptoms return after completing a boat ride, although these symptoms usually resolve within 1-2 days. *Mal de debarquement* literally means sickness of disembarkment. Some authors define any motion sickness symptoms after returning to land as mal de debarquement, while others reserve this term for persistent symptoms that last at least 1 month.[16]

A survey of 116 crew members of seagoing vessels identified transient imbalance immediately after disembarking in 72%.[17] Motion sickness symptoms occurred after landing very often in 15% and occasionally in 28%. Symptoms occurred immediately after landing in 46% and within 1 hour in 80%. Occurrence of symptoms was most likely after initial voyages. In 66% of crew members, symptoms occurred more frequently when they first began sea travel, with symptoms habituating with repeated journeys. Long voyages were more likely to provoke symptoms in 45%, and rough sea travel in 40%. In general, these symptoms resolved after a few hours, with resolution after $\leq$6 hours in 88%. This same research group published another analogous series with 234 healthy crew members, with similar results. In this second series, typical symptom duration was reported as minutes to 24 hours, with a mean of 156 minutes. Symptoms resolved in $<$ 6 hours in 93%.[18]

Persistent mal de debarquement is uncommon and was evaluated in 27 patients, with an average symptom duration of 3.5 years.[16] Symptoms were constant in 85% and most commonly included sensations of rocking, swaying, and imbalance. Nausea and headache were each reported by about one-third of these patients.

Case 3 reports fairly characteristic post-travel motion sickness symptoms of moderate duration, with symptoms resolving after about 2 weeks. Available literature on mal de debarquement does not identify a relationship between this vestibular disorder and migraine, although one may exist.

Why Is Motion Sickness Identification Important?—As noted above, motion sickness may be precursor to or a comorbid condition with

migraine. In addition, motion sickness can significantly limit leisure and business travel. For example, studies have shown that motion sickness develops in nearly half of ambulance workers during routine transports.[19] In addition, simulators and virtual environments are used increasingly in the business world. In one recent study, over 80% of adults exposed to an immersive virtual environment experienced motion sickness.[20]

Motion sickness may also affect routine medical care. For example, 43% of healthy adults transported in an ambulance over mountainous roads developed motion sickness.[21] Consistent with the previously reported retrospective data showing less motion sickness with air travel compared with land and water transport,[9] only 7% of patients transported via helicopter reported motion sickness.[22] In addition, motion sickness has recently been identified as a strong predictor for developing postoperative nausea and vomiting, with an odds ratio of 2.4.[23]

Finally, motion sickness is an easily reproduced vestibular symptom. Studying motion sickness may provide an opportunity to gather information important for understanding other balance disorders, as well as other periodic syndromes, like migraine.

Conflict of Interest: None

REFERENCES

1. Hu S, Luo YJ. Susceptibility to motion sickness induced by optokinetic rotation and self-rotation by walking around a vertical pole. *Percep Mot Skills.* 2001;93:289-296.
2. Dobie T, McBride D, Dobie T, May J. The effects of age and sex on susceptibility to motion sickness. *Aviat Space Environ Med.* 2001;72:13-20.
3. Flanagan MB, May JG, Dobie TG. Sex differences in tolerance to visually-induced motion sickness. *Aviat Space Environ Med.* 2005;76:642-646.
4. Money KE, Cheung BS. Another function of the inner ear: Facilitation of the emetic response to poisons. *Aviat Space Environ Med.* 1983;54:208-211.
5. Balaban CD. Vestibular autonomic regulation (including motion sickness and the mechanism of vomiting). *Curr Opin Neurol.* 1999;12:29-33.
6. Yates BJ, Miller AD, Lucot JB. Physiological basis and pharmacology of motion sickness: An update. *Brain Res Bul.* 1998;47:395-406.
7. Kayan A, Hood JD. Neuro-otological manifestations of migraine. *Brain.* 1984;107:1123-1142.
8. Barabas G, Matthews WS, Ferrari M. Childhood migraine and motion sickness. *Pediatrics.* 1983;72:188-190.
9. Drummond PD. Triggers of motion sickness in migraine sufferers. *Headache.* 2005; 45:653-656.
10. Jan MM. History of motion sickness is predictive of childhood migraine. *J Paediatr Child Health.* 1998;34:483-484.
11. Lanzi G, Balottin U, Fazzi E, Rosano FB. The periodic syndrome in pediatric migraine sufferers. *Cephalalagia.* 1983;(suppl 1):91-93.
12. Drummond PD. Effect of tryptophan depletion on symptoms of motion sickenss in migraineurs. *Neurology.* 2005;65:620-622.
13. Rolnick A, Lubow RE. Why is the driver rarely motion sick? The role of controllability in motion sickness. *Ergonomics.* 1991;34:867-879.
14. Marcus DA, Furman JM. Prevention of motion sickness with rizatriptan: A double-blind, placebo-controlled pilot study. *Med Sci Monit.* 2006;12:PI1-7.
15. Otto B, Riepl RL, Otto C, et al. μ-Opiate receptor agonists – A new pharmacological approach to prevent motion sickness? *Br J Clin Pharmacol.* 2005;61:27-30.
16. Hain TC, Hanna PA, Rheinberger MA. Mal de debarquement. *Arch Otolarhyngol Head Neck Surg.* 1999;125:615-620.
17. Gordon CR, Spitzer O, Doweck I, Melamed Y, Shupak A. Clinical features of mal de debarquement: Adaptation and habituation to sea conditions. *J Vestib Res.* 1995;5:363-369.
18. Gordon CR, Spitzer O, Shupak A, Doweck I. Survey of mal de debarquement. *BMJ.* 1992;304:544.
19. Wright MS, Bose CL, Stiles AD. The incidence and effects of motion sickness among medical attendants during transport. *J Emerg Med.* 1995;13:15-20.
20. Stanney KM, Hale KS, Nahmens I, Kennedy RS. What to expect from immersive virtual environment exposure: Influences of gender, body mass index, and past experience. *Hum Factors.* 2003;45:504-520.
21. Weichenthal L, Soliz T. The incidence and treatment of prehospital motion sickness. *Prehosp Emerg Care.* 2003;7:474-476.
22. Levins TT. Air sickness in flight: Frequency and factors. *Air Med J.* 2003;22:26-27.
23. Choi DH, Ko JS, Ahn HJ, Kim JA. A Korean predictive model for postoperative nausea and vomiting. *J Korean Med Sci.* 2005;20:881-815.