Motion Sickness

Motion sickness (kinestosis) is a complex condition characterised by a combination of signs and symptoms that accompany movement or perceived movement in the environment. Many forms of motion sickness exist (Table I).

Most people experience motion sickness at some time. The incidence varies from less than one percent on large aircraft to more than 90% on a rough sea voyage. There is significant variation between individuals in both the susceptibility to motion sickness and the severity of symptoms experienced.

The direct cause for sea sickness, which is the motion patterns of a vessel, was mentioned by Hippocrates ("… sailing on the sea proves that motion disorders the body …"). Ibn Sina (Avicenna) discussed sea sickness in his Canon of Medicine, stating that "this condition is usually incurred in travel by ship and the symptoms are nausea, vomiting, and dizziness, which subside after the first or second day of travelling". The literature also mentions that Cicero, Julius Caesar and Admiral Lord Nelson suffered from sea sickness. Napoleon abandoned his idea of a camel corps due to motion sickness experienced by his soldiers.

The precise pathophysiology of motion sickness is uncertain. According to the sensory conflict theory proposed by Brandt and Reason, motion sickness occurs when the sensory inputs received from the vestibular receptors, eyes and proprioceptors conflict with each other or the brain’s positional memory. All situations resulting in motion sickness are similar in that multiple sensory cues concerning body position in space are available and can provide contradictory information.

Because the generation of motion sickness involves a comparison between current sensory inputs and signals expected on the basis of experience, repeated exposure to the provoking stimuli results in attenuation of symptoms and even their complete disappearance. Adaptation refers to exposure during a single continuous episode (for instance over days on a journey on a boat) whereas habituation refers to repeated exposure to the same or simulated experience interrupted by non-exposed periods (for instance after treatment of pupil pilots in a centrifuge). This adaptation/habituation is a learned central process, in which the decreased susceptibility to the provoking stimulus is maintained. When the exposure is of short duration, the adaptation/habituation acquired is highly specific to the stimulus but when the offending motion is extended beyond the point of adaptation, some degree of generalisation to other motion patterns occurs. For most individuals, adaptation occurs within three days of continuous stimulation but in about five percent of people adaptation does not occur.

Aetiology and Pathophysiology

Motion sickness is a normal physiological response to unusual perception of motion and can be induced by travel on boats, cars, trains, aeroplanes and spacecraft. Not all motion induces motion sickness. A common pattern of all the motions which induce motion sickness is a repetitive linear or angular acceleration of the head. The peak frequency for induction of motion sickness is 0.1–0.3 Hz for linear oscillation, vertical vibration and tilt motion, with susceptibility declining with both increasing and decreasing frequency.

Table I. Different forms of motion sickness

- Air sickness
- Sea sickness
- Car sickness
- Ski sickness
- Space sickness
- Mal de debarquement syndrome
A functional vestibular system is a prerequisite for motion sickness to occur, as individuals with bilateral vestibular dysfunction are not susceptible to motion sickness. Vision is not essential to motion sickness, since blind subjects are also susceptible. On the other hand visual stimulation alone can generate motion sickness. This is commonly experienced after prolonged exposure to video games and the “Imax” theatre. There are individual differences in both the susceptibility and adaptation to motion sickness.

Symptoms
The peak prevalence is between the ages of three years and twelve years, after which the prevalence gradually decreases. It is rare in children under the age of two years. The condition is more common in females than males, and occurs more frequently during pregnancy and menstruation. Motion sickness occurs in about 50-70% of people who experience migraines.

The initial symptom is usually discomfort around the upper abdomen, followed by nausea, increasing malaise, peri-oral and facial pallor, and cold sweating. In the late stages, nausea, feeling of body warmth, excessive salivating and vomiting occur. Lethargy, fatigue, and drowsiness can persist for hours after the motion stimulus ends. The degree of symptoms varies with the intensity of the stimulus and the patient’s individual susceptibility.

Sopite syndrome is a poorly understood manifestation of motion sickness characterised by yawning, drowsiness, disinclination for physical or mental work, and a lack of willingness to participate in group activities. Other related symptoms include lethargy, apathy, decreased ability to concentrate, daydreaming, melancholy, sleep disturbances, performance errors, frequent daytime napping, irritability, and a desire to be left alone. The syndrome can exist in isolation from the more apparent symptoms of motion sickness and is sometimes its sole manifestation as it can occur in people with a very low susceptibility to motion-induced nausea and can persist in individuals fully adapted to nauseating stimuli.

Prophylaxis and Treatment
Non-Pharmacologic Measures
Patients should avoid reading, engaging in tasks requiring continual changes in visual fixation, avoid unnecessary head movements, align the head and body in the direction of the gravito-inertial force, try to be active, and use sunglasses during the day to reduce visual stimulation. These measures aim to reduce conflicting sensory input. The recommendation to fix vision on a stable reference point such as the horizon is very popular among sailors.

To ameliorate nausea before and during any journey it is recommended to avoid heavy, greasy meals and unpleasant odours (such as diesel and jet fuel fumes), and to ensure adequate ventilation. Controlled regular breathing has been shown to reduce symptoms of motion sickness. Cognitive behaviour training can be useful but is only practical in patients whose jobs involve frequent exposure to motion. Habituation can be induced in patients whose occupations require motion exposure such as pilots and sailors (Figure 1). Ginger has been advocated for prophylaxis against motion sickness but this has not been supported by controlled studies. Acupuncture has also been suggested as prophylaxis but there are no controlled studies on its efficacy.

Pharmacologic Measures
There are several drugs that can be used as prophylaxis against motion sickness, but they are not without side-effects. This is of vital importance in aircrew and in scuba divers where safety issues are paramount. Motion sickness induces gastric stasis which may reduce drug absorption. Oral medication should therefore preferably be taken prior to motion exposure.
Antihistamines
Histamine increases the firing rate in afferent nerves from the ampullae of the semicircular canals. This effect is antagonised by various H1 receptor inverse agonists used as anti-motion sickness agents. Histamine H1 receptors are present in the vestibular nuclei along with a high density of cholinergic receptors. Only first generation antihistamines are effective, as antihistamines that do not cross the blood brain barrier are not effective against motion sickness. These drugs also produce varying degrees of sedation, thus making it difficult to determine whether their efficacy results from a specific action on histaminergic receptors in the vestibular nuclei, nonspecific suppression of the excitability of many CNS neurons, or a combination of actions. The sedating potential of these drugs can result in impaired functional performance.

Not all antihistamines are effective in preventing motion sickness. Diphenhydramine is not effective but its salt dimenhydrinate is. Chlorpromazine does not have any anti-motion sickness efficacy while prochlorperazine is significantly less effective than the other antihistamines. The reason for the differences in effectiveness is uncertain.

Promethazine, dimenhydrinate, cyclizine and meclizine are the antihistamines most widely used for prophylaxis and active treatment of motion sickness. The first dose of the drug must be taken at least thirty minutes prior to motion exposure. Dimenhydrinate has antimuscarinic and antihistaminergic actions and is highly effective in treating motion sickness. It also helps to increase adaptation to motion sickness inducing stimuli. The drug is effective for six to eighteen hours. Significant drowsiness can occur but dry mouth and dizziness are less severe than with hyoscine. Dimenhydrinate has antimuscarinic and central sedative effects. It is effective for about eight hours. Dependence and tolerance can occur with long term use. Cyclizine is less effective than dimenhydrinate but causes less drowsiness. The dose must be repeated at 46 hourly intervals. Meclizine has a slower onset and longer (24 hours) duration of action than the other antihistamines but is less effective.

Flunarazine is an antihistamine that is also a calcium channel blocker that acts as a peripheral vestibular suppressant. It has been shown to be effective in preventing motion sickness. Cinnarizine is similar to flunarazine but is less potent. It is uncertain if the effectiveness of these drugs in preventing motion sickness is due to their effects as antihistamines, calcium channel blockers or a combination. These drugs do not have antimuscarinic properties.

Anticholinergics
Anticholinergic drugs that do not cross the blood-brain barrier are ineffective in preventing motion sickness. Hyoscine (scopolamine) is non-selective for the five types of muscarinic receptors found in the CNS. Its exact site and mechanism of action are uncertain, but it is believed to inhibit vestibular input to the vestibular nuclei and probably also acts directly on the vomiting centre in the reticular formation of the brainstem. A Cochrane review found that scopolamine was more effective than placebo in preventing motion sickness. However, hyoscine prevents adaptation to provocative stimuli.

Hyoscine tablets must be taken one hour prior to exposure to motion and eight hourly thereafter, making them suitable for short periods of motion exposure. They are effective in about 75% of patients. Dry mouth and drowsiness are common side effects but neuropsychologic side effects are less common than with the transdermal preparation.

Transdermal scopolamine was developed to provide effective motion sickness prophylaxis over an extended period of 72 hours, making it useful for long periods of motion. It is slightly less effective than oral scopolamine, being effective in about 65% of patients. The effect of transdermal scopolamine is obtained six to eight hours post-application. This delay can be overcome by simultaneous intake of oral hyoscine. The most common side effects are dry mouth (occurring in up to 50% of patients) and drowsiness (occurring in about 30% of patients), while blurred vision can occur with prolonged use. Other serious potential side effects include open angle glaucoma, confusion, disorientation, memory loss and restlessness. Use for more than one month can cause psychosis, contact dermatitis and withdrawal symptoms on cessation. Nasal and buccal formulations of hyoscine with a very rapid onset of action have been developed but are not as yet available in South Africa.
Anticonvulsants
Phenytoin acts diffusely on the central nervous system to stabilise neuronal membranes. It has been shown to be effective in the prophylaxis of motion sickness. The short term use of low doses of phenytoin used in the prophylaxis of motion sickness is unlikely to lead to side effects. Studies on the use of phenytoin for the prophylaxis of motion sickness have not demonstrated any significant deterioration in sensory, cognitive or performance capabilities.

Benzodiazepines
These drugs have a vestibular suppressant activity by acting on the GABA A receptors on the vestibular nuclei. They have been shown to be effective in low doses in the prophylaxis of motion sickness but their use may be limited by their sedative effect.

Sympathomimetics
These drugs act on the α-adrenergic receptors in the vestibular nuclei. Their systemic side effects and potential for abuse preclude their use in the prophylaxis of motion sickness.

Other anti-emetics
Metoclopramide, phosphoric acid, domperidone and ondansetron are some drugs that are used to treat nausea and vomiting but are not effective in the prophylaxis of motion sickness.

Betahistine
Betahistine is an analogue of Lhistidine, the immediate precursor of histamine. It is a weak agonist of post-synaptic H1 receptors and a moderate antagonist of presynaptic H3 receptors. It reduces the effects of excess histamine at the medial vestibular nucleus and improves the labyrinthine microcirculation. Although it has been found to be effective in preventing motion sickness in laboratory studies, it has been found to be of only marginal benefit in preventing seasickness. There are no reported studies in less provocative motion sickness situations. Sedation does not occur, even at high doses.

Mal de Debarquement Syndrome
Mal de debarquement syndrome is a disorder characterised by a persistent sensation of motion following a prolonged period of passive movement, which may be experienced after water travel, air travel, prolonged train rides or a prolonged car trip. Although a sensation of motion persistence after prolonged travel is physiologic, it is considered pathologic if it is present for more than one month. The condition is probably due to defective or delayed re-adaptation following cessation of motion. Individuals susceptible to mal de debarquement syndrome may have reduced reliance on vestibular and visual inputs and increased dependence on the somatosensory system for the maintenance of balance.

Patients experience a sensation of rocking, tilting or swaying or vague unsteadiness. Rotatory vertigo is rare. The symptoms begin immediately or shortly after cessation of external movement and are better with motion. The condition occurs predominantly in females, with most patients being between the ages of forty and fifty years. Patients may have a history of having previously experienced similar symptoms following passive motion. Clinical examination and special investigations are normal.

The condition is difficult to treat, with SSRIs being the most effective drugs. Benzodiazepines such as clonazepam may also be of value. Most patients experience spontaneous recovery but in some patients the symptoms can persist for years. Vestibular rehabilitation is not of benefit. Patients in remission should avoid long periods of passive motion.

References available on request.