Postoperative Nausea and Vomiting in Adults: Implications for Critical Care

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Postoperative nausea and vomiting is a dreaded, uncomfortable, and unpleasant patient experience that is also a factor contributing to adverse outcomes in postoperative recovery. The key to management of this concern is to identify high-risk patients and to develop a systematic method of assessment, intervention, and evaluation within the perianesthesia care continuum. This discussion outlines the wide range of pharmacological and alternative therapies that are available in clinical practice with a case study to illustrate incorporation of these interventions in critically ill patients. (Critical Care Nurse. 2011;31[6]:36-45)

Pathophysiology

Systematic reviews and meta-analysis have been used to determine predictors of postoperative vomiting (Table 1); however, an understanding of risk factors is lacking because knowledge of the pathophysiology of vomiting at the cellular and molecular level is incomplete. The biological responses of nausea and vomiting are not identical. The analysis of each one is vital to predicting a patient’s response. Each person has a different threshold for stimulation of nausea and vomiting. The known mechanisms for PONV are the pathways for neural stimulation that initiate a vomiting response. Nausea and vomiting are under control of the central nervous system via the vomiting center in the medulla oblongata and the chemoreceptor trigger zone.

One attribute of excellence in critical care is the degree of attentiveness to patients’ concerns. A concern frequently voiced by patients who are consenting for a surgical procedure is prevention of postoperative nausea and vomiting (PONV), which are distressing and dreaded. Nausea and vomiting after surgery reportedly occur in approximately 75 million patients annually, making these 2 conditions the most common postoperative complications. Furthermore, PONV can contribute to fluid and electrolyte imbalances, airway compromise, suture tension, esophageal tears, dehiscence, venous hypertension, bleeding, and increased intracranial pressure.

Lifesaving surgical intervention compresses the time frame available for preoperative assessment. Identification of high-risk patients, vigilance by health care providers, and multimodal interventions can decrease the incidence and severity of nausea and vomiting after surgery. Critical care areas can be structured by design or protocol to bypass postanesthesia areas. Although patients may bypass a geographic site, attentiveness to patients’ concerns mandates that professionals in critical care translate current evidence into standards of care.

PONV has been associated with administration of anesthetic agents since the 1800s. The definitions in the literature vary according to the research study and the investigators’ description. The most common operational definitions are the ones published by the American Society of PeriAnesthesia Nurses (ASPAN), which define PONV as nausea and vomiting that occurs within the first 24 hours after surgery.
The vomiting reflex initiates a 3-part set of physiological responses. These responses are characterized as preejection, ejection, and post-ejection. Preejection begins with acetylcholine activation of the vagus nerve. Vagal nerve stimulation produces increased salivation, tachycardia, diaphoresis, and a decrease in gastric tone. Nausea is commonly experienced in the pre-ejection phase. Ejection starts with abdominal and diaphragmatic contraction, continues with reflux of gastric contents into the esophagus, and finishes with propulsion of the gastric contents out the mouth. The glottis closes to prevent pulmonary aspiration. Postejection appears to be the diminished sensation of nausea in the central nervous system.

Nausea is a symptom associated with vomiting. Because it is a subjective sensation, nausea is considered conscious cortical activity. However, the anatomical tracts and chemical mediators that trigger nausea are more elusive than those that trigger vomiting. Odors, motion sickness, vestibular stimulation, and hormonal changes of pregnancy are all risk factors for nausea. In clinical practice and research, nausea and vomiting are often treated as a single phenomenon. However, they are separate and distinct entities that can occur either independently or together. Nausea should be evaluated independently of vomiting so that nausea can be more clearly delineated. Nausea in postoperative patients may have different risk factors than it does in other patients (eg, pregnant patients, patients with motion sickness). A reliable instrument for determining the risk factors for nausea has not been developed.
been validated. The most common method of measuring nausea is a simple 1 to 10 visual analogue scale.4,7,9

Operative/Anesthetic Risk Factors

Numerous risk factors are associated with PONV. The 6 most common factors are surgical manipulations of organs, use of inhalation agents, use of opioids, hydration, body positioning, and release of cytokines.4,6-8 Surgical movement of organs by instrumentation, insufflations, and manual pressure disrupt the enterochromaffin cells that line the mucosa of the gastrointestinal tract. This disruption promotes the release of serotonin and stimulates the parasympathetic nervous system via the vagus nerve.9 Abdominal and gynecological surgeries are often associated with increased postoperative emesis.4,6 These types of surgery are often done laparoscopically, and insufflation is used to aid in surgical visualization and instrumentation. Brain and spinal surgeries have a high incidence of emetogenesis.4,13 Neufeld and Newburn-Cook5 completed a systematic review of the neurosurgery research literature and found that the reported incidence of nausea and vomiting in 13 studies was high enough to warrant prophylaxis in neurosurgery cases as a group. Flynn and Nemergut13 reported that postoperative vomiting increased in endonasal transphenoidal surgery when cerebral spinal fluid dynamics were affected by an intraoperative lumbar drain or fat grafts for spinal fluid leaks.

Nausea and vomiting are a commonly listed adverse effect of medications. The 4 medication classes frequently associated with PONV are inhalation agents, opioids, anticancer medications, and estrogen preparations.4,7,8,14,15 Inhalation agents are especially known as a trigger of PONV.7,8,15-17 Inhalation agents decrease the level of consciousness by decreasing the action potential amplitude and frequency of the central nervous system. This disruption of normal neural electrical output can stimulate the CTZ and vomiting center.4 Compared with regional anesthesia, general anesthesia is associated with an 11-fold increase in risk for PONV.17 Opioids such as morphine or hydromorphone activate the CTZ directly. Additionally, opioids bind to the µ and κ opioid receptors in the brain, spinal column, and peripheral nerves. Opioids activate the µ2 receptor sites in the parasympathetic nervous system, a situation

Figure 1 Anatomy of emesis and variables that start the process.

Image by Rebecca Edwards.
that delays gastric and intestinal motility. This activation leads to the adverse effects of nausea, vomiting, and constipation. Opioids also trigger the release of serotonin from the enterochromaffin cells in the gastrointestinal tract.

Relative hypovolemia and dehydration associated with preoperative fasting, mandatory bowel preparation, and blood loss also contribute to PONV. Induction of anesthesia in which systolic pressures decrease 35% is associated with a higher incidence of PONV than induction in which systolic pressures decrease less. Preliminary reports of more aggressive preoperative hydration suggest that this intervention can diminish PONV, but the mechanism by which the reduction occurs is unclear.

During long surgical procedures, patients are unable to reposition themselves because of anesthesia and neuromuscular blockade. The lack of movement can lead to pooling and sensations of dizziness that can stimulate vestibular disequilibrium. This disequilibrium may lead to further activation of the CTZ by the vestibular nerve, acting as an additional trigger of PONV.

Cytokines, immunoregulatory glycoproteins, are released after barotrauma and other types of cellular damage. Cytokines trigger the release of tachykinins such as substance P. Substance P, a neuropeptide, is important in sensory transmission in both pain and nausea. The concentration of receptors for this neuropeptide (neurokinin type 1) is high in the medulla vomiting center. Activation of the receptors appears to be a part of the common pathway to regulate vomiting.

Substance P also increases the discharge of salvia and histamine. Conversely, substance P decreases the release of bile and insulin.

Patient-Specific Risk Factors

Two additional variables that affect a patient’s risk for PONV are being female and being a nonsmoker. Compared with males, females have a lower threshold for vomiting that is noted after puberty. Females vomit 2 to 3 times more often than do males of the same age. Nausea and vomiting also occur more often with pregnancy and use of birth control pills. These changes are attributed to the different endocrine mechanisms associated with child bearing. Nonsmokers metabolize anesthetic agents more slowly than do their smoking counterparts. Smoking blocks liver enzymes involved in the metabolism and excretion of anesthetics.

Interventions and Guidelines

ASPAN has published evidence-based guidelines that provide 2 different algorithms as a practical plan of care for patients at risk for PONV. The first algorithm (Figure 2) is used when surgery is elective and time is too short to obtain a history that will allow for risk stratification for the patient. The level of risk determines the choice of prophylactic pharmacological interventions that may diminish the occurrence of PONV.

The second algorithm (Figure 3) can be used when preoperative assessment is truncated because of the need for immediate surgical intervention to save the patient’s life. This algorithm emphasizes early assessment and tracking of PONV and the importance of rescue antiemetic therapy. Many tasks must be completed when a patient who has had lifesaving surgery is transferred to the intensive care unit by the operating room nurse and anesthesia care provider. However, an important question during this transfer is what risk factors does the patient have for PONV and what antiemetic prophylaxis has been implemented. Every time the patient is assessed for pain, he or she should also be assessed for nausea and vomiting.

Antiemetic Therapies

Each acute care institution makes multidisciplinary decisions on which antiemetic therapies will be chosen for practice. These decisions are made based on cost, preference, past adverse effects with the product, the effects of PONV on patients’ outcomes, and current evidence. However, an aspect that should be included in the equation is the preference of the patient and the patient’s family. The effectiveness of any intervention for PONV varies because each patient has different absorption, distribution, metabolism, and excretion of anesthetic agents. These differences in pharmacokinetics are due to genetic factors, sex, weight, and concurrent diseases. Evidence supports use of pharmacological methods, aromatherapy, herbal materials, and acupuncture in PONV. If the surgery is elective, the health care provider can discuss the risks and benefits associated with each antiemetic agent or method. Finding the medication or therapy that is just right for a patient requires listening to the patient: what has worked in the past, what are his or
her preferences for alternative therapies, and what adverse effects of interventions has he or she experienced in the past?

Timing of the administration of antiemetic therapies is also important. Medications such as ondansetron, an antagonist of serotonin (5-HT₃) receptors, are most effective when the dose is given at the end of surgery.²³ Corticosteroids such as dexamethasone have greater efficacy when given at the induction of anesthesia.¹⁵,¹⁶ However, corticosteroids should be contraindicated in patients, such as those with diabetes, who may have problems with wound healing. If opioids are indicated and have been a problem in the past, then postoperative administration of methylnaltrexone may be helpful in blocking the unwanted adverse gastrointestinal effects.²⁴ Transdermal scopolamine should be applied 4 to 12 hours before surgery for optimal effect.²³

Aromatherapy with essential oils and acupuncture are most efficacious when used both before surgery and in the postoperative period.¹²,²⁵ Aromatherapy with inhaled isopropyl alcohol is used to diminish olfactory input in the CTZ in the postoperative area.²⁶ Cannabis-derived medications have not shown efficacy in PONV.²⁷

In 16 clinical trials used in the systematic review for the Cochrane Collaboration,²⁸ the effect of acupuncture on nausea was studied. The trials varied in methods used. Statistical analysis of data
from these trials indicated that P6 stimulation reduced the risk of nausea (relative risk, 0.72; 95% confidence interval, 0.59 to 0.89). The nausea response was found to be separate from the vomiting response. Acupuncture appears to diminish both nausea and vomiting. In the 40 research studies reviewed by the Cochrane Collaboration, each study varied in the type of acupressure and the timing of the intervention. The executive summary rated acupuncture as effective as pharmacological treatment with antiemetics in preventing PONV. Acupressure stimulation can be created by needle acupuncture, transcutaneous electrical stimulus, acupressure by manual pressure, and acupressure stimulation devices such as wristbands. The effect of invasive stimulation of acupuncture point P6 (Figure 4) on PONV outcomes did not differ from the effect of noninvasive stimulation.

In a recent trial of acupuncture in cardiovascular surgery patients, the incidence of nausea was significantly lower in the group who received 1 preoperative acupuncture treatment than in the control group. The acupuncture treatment occurred 0.5 to 3 hours before surgery, and the
acupuncture patients reported less postoperative nausea on day 1 and day 2 than the control patients did.

**Prophylaxis Therapies**

The interventions for PONV prophylaxis supported by published evidence are linked to using different instruments to measure a patient’s risk for PONV. No risk assessment instrument has been universally accepted and validated. The elements common to published instruments are the inclusion of the risk factors listed in Table 1.

Of note, many experts caution that not all patients should receive prophylaxis for PONV, because in a patient with low risk, the benefits do not outweigh the potential adverse effects of the intervention.23 Additionally, the anesthesia provider will deliberate with the surgeon to determine if the surgery can be completed with a regional block of the site if the patient has a history of severe PONV. ASPAN guidelines7 recommend 1 prophylactic treatment for patients at moderate risk, 2 for patients at severe risk, and 3 for patients at very severe risk. Recommended medication classes are corticosteroids, serotonin (5-HT₃) receptor blockers, histamine₁ receptor blockers, and scopolamine patches.21,23 Other interventions that may be helpful are preoperative hydration, aggressive fluid replacement for blood loss, stimulation of acupuncture point P6, music therapy, and aromatherapy.18 Analysis of data36,37 on the efficacy of intraoperative supplemental oxygen in the prevention of PONV has been conflicting, and this intervention currently is not recommended.

Intraoperative treatments that can also be helpful are decreased blood pressure variability during induction, decreased use of neostigmine, avoidance of nitrous oxide, and minimization of intraoperative opioids.17,19,23 Ginger is an herbal alternative therapy used to prevent nausea; however, many anesthesia providers and surgeons think the use of ginger is contraindicated because of the increased risk of bleeding and hyperglycemia.32

**Rescue Therapies**

Breakthrough PONV or new development of PONV requires a detailed bedside assessment. The purpose of the assessment is to identify a possible medication or mechanical trigger, such as an obstruction in the nasogastric tube or administration of a dose of a postoperative antibiotic shortly before the occurrence of the PONV. If no trigger can be determined, then a rescue antiemetic therapy should be started. The American Society of Anesthesiologists consensus guidelines21 recommend 5-HT₃ receptor antagonists as the agents of first choice. If this medication class has been used for prophylaxis, then a medication from a different class should be used. A primary concern is controlling any possible environmental risk factors (eg, movement for radiographs, odors, dehydration, repositioning, dangling, first sips of liquids, and administration of opioids) to diminish the cycle of PONV.

For a comprehensive summary of antimetic therapies for prophylaxis and rescue, see Table 2.

**Monitoring**

Monitoring patients assists in making decisions that are based on both objective and subjective data. Severity of nausea should be quantified by asking the patient to rate the nausea from 1 to 10 on a visual analogue scale. Nausea or vomiting interventions should be reassessed at the peak time of the pharmacological or nonpharmacological intervention. The volume, color, and contents of vomitus can be additional data for determining hydration interventions and placement of decompression devices.

**Case Study**

Ms Y, a 23-year-old woman, fell asleep while driving home from the night shift at the hotel where she was night manager. Her compact car collided with a large passenger van at an estimated speed of 50 mph (80.5 km/h). Ms Y arrived in the level I emergency department within 10 minutes of removal from her deformed car. Her hemodynamic status was unstable, and she was unconscious upon arrival at the hospital. Ms Y was restrained in her vehicle, but the van intruded into the driver’s compartment. Ms Y sustained a skull fracture of the left basilar area, left xyphoid bone, lacrimal bone, and supraorbital bone, with a penetrating injury of the left eye. She had a pseudo-aneurysm of the...
<table>
<thead>
<tr>
<th>Medication</th>
<th>Neurotransmitter blocked, relevance to postoperative nausea and vomiting</th>
<th>Mechanism of action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phenothiazines</strong></td>
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<tr>
<td>Promethazine</td>
<td>Decrease uptake of dopamine in the CNS cause sedation</td>
<td>Increased incidence of adverse effects in elderly patients (e.g., delirium), increased intraocular pressure. Intra-arterial administration may cause severe tissue necrosis. Administer diluted in 10 mL of normal saline: 25 mg intravenously in 10-15 min.</td>
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<tr>
<td>Prochlorperazine</td>
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<td><strong>Antihistamines</strong></td>
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<tr>
<td>Dimenhydrinate</td>
<td>H1 receptor sites in the CNS are blocked, causes adverse effects of systemic anticholinergic action.</td>
<td>When used for motion sickness, administer 1-2 hours before event. Dilute dimenhydrinate to 5 mg/mL and inject in several minutes.</td>
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<tr>
<td>Hydroxyzine</td>
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<tr>
<td>Meclizine</td>
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<tr>
<td><strong>Prokinetic agents</strong></td>
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<tr>
<td>Metoclopramide</td>
<td>Increase gastrointestinal motility and rate of gastric emptying by promoting the release of acetylcholine in the gastrointestinal tract.</td>
<td>Give doses slowly in 2-3 minutes. Given to patients with gastroesophageal reflux disease. Contraindicated in patients with history of seizures or Parkinson disease.</td>
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<tr>
<td><strong>5-HT3 serotonin receptor antagonists</strong></td>
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<tr>
<td>Dolasetron</td>
<td>Prevent activation of the CTZ by emetogenic drugs or stimuli.</td>
<td>Contraindicated in patients with history of migraines. Recommended administration before induction of anesthesia or before reversal.</td>
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<td>Granisetron</td>
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<td>Ondansetron</td>
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<tr>
<td>Palonestron</td>
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<tr>
<td><strong>Substance P/neurokinin type 1 receptor antagonist</strong></td>
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<tr>
<td>Aprepitant</td>
<td>Blocks the neurokinin type 1 receptors in the medulla vomiting center.</td>
<td>Used as an adjunct with corticosteroid and 5-HT antagonist. Administer in 15 minutes. Incompatibility with calcium in lactated Ringer solution. Use with pimozide (medication for Tourette syndrome) can trigger life-threatening adverse cardiovascular reactions.</td>
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<tr>
<td>Fosaprepitant</td>
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<tr>
<td><strong>Dronabinol</strong></td>
<td>Activates cannabinoid receptors and blocks activation of vomiting center.</td>
<td>Use cautiously with patients with history of substance abuse. Stimulates appetite. Increased risk of adverse effects when administered with sedative, hypnotics, and psychoactive drugs.</td>
</tr>
<tr>
<td><strong>Scopolamine</strong></td>
<td>Blocks receptor sites in the CNS, causing adverse effects of systemic anticholinergic action.</td>
<td>Contraindicated in patients with angle-closure glaucoma, hyperthyroidism. Patch applied before surgery. When given intravenously, should be diluted with sterile water and given in 2-3 min.</td>
</tr>
<tr>
<td><strong>Corticosteroids</strong></td>
<td>Block prostaglandins activity in the cerebral cortex.</td>
<td>Contraindicated in patients with active untreated infections. Delays wound healing. Increases insulin resistance.</td>
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<tr>
<td>Dexamethasone</td>
<td>Reduces anticipatory nausea and vomiting but decreases input to the cerebral cortex.</td>
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<tr>
<td>Methylprednisolone</td>
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<tr>
<td><strong>Methylnaltrexone</strong></td>
<td>Blocks peripheral opioids receptor sites.</td>
<td>Contraindicated in patients with known or suspected mechanical gastrointestinal obstruction.</td>
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<tr>
<td><strong>Ginger</strong></td>
<td>Antiserotonin-3 effects on the CNS and gastrointestinal system.</td>
<td>Increased risk of bleeding particularly with anticoagulant therapy. Potentiates antiplatelet, thrombolytic, and anti-diabetic agents.</td>
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</tbody>
</table>

*Continued*
thoracic aorta at the level of the isthmus descending downward and stopping at the level of the diaphragm. Additional compound fractures of the left femur and pelvis were noted on computed tomography. Her blood pressure was sustained by administration of 20 units of blood products and crystalloids transfused via a rapid infuser. With minimal time for history, she was taken directly to the operating room.

A history was obtained from Ms Y’s mother by a member of the operative team 20 minutes into the case. According to her mother, Ms Y had no known medication allergies, was a nonsmoker, had a history of motion sickness, had no concurrent diseases, had previously had surgery for repair of the anterior cruciate ligament of the right knee, and was taking birth control pills and a selective serotonin reuptake inhibitor for menstrual mood changes. It was not known if she had eaten before driving away from work. Ms Y’s risk factors for PONV were head trauma, hypovolemia, being female, being a nonsmoker, a history of motion sickness, and use of birth control pills. With 6 risk factors, she was considered at very high risk for PONV. Triple therapy consisted of a 5-HT3 antagonist (dolasetron), a corticosteroid (dexamethasone), and a phenothiazine (prochlorperazine). Ms Y’s surgery required 6 hours, with staged repair of the injuries; she was intubated, and general anesthesia was required. Open reduction internal fixation was used to treat the fracture of the left femur, and control of bleeding was achieved when the femoral artery was repaired. The aortic pseudoaneurysm was repaired via a right femoral approach with an endovascular graft. The left eye was removed, and the eyelid was sutured shut. Because Ms Y had sustained a basilar skull fracture, no nasogastric tube was placed.

Ms Y was brought directly from the operating room to the surgical intensive care unit. Her care required coordination of many health care providers. The team leaders were the surgical resident and the anesthesiology resident who were on call that day in the unit. The 4 main concerns for the first 4 days were keeping the cerebral perfusion pressure optimized, preventing aspiration, preserving the left lower extremity, and preventing multiple organ system dysfunction. All of these concerns could be compromised if PONV was not controlled. At 12 hours after surgery, Ms Y opened her eyes and tried to turn to the right.

### Table 2

<table>
<thead>
<tr>
<th>Medication</th>
<th>Neurotransmitter blocked, relevance to postoperative nausea and vomiting</th>
<th>Mechanism of action</th>
<th>Comments relevant to medication administration</th>
</tr>
</thead>
</table>
| Quease (aromatherapy) Essential oils of peppermint, ginger, lavender, and spearmint in a patented blend | Antiserotonin-3 effects of inhalation of oils through cranial nerve I | Simple olfaction Aroma of the blend sends a chemical message to the olfactory bulb where the impulses are processed and passed along to the limbic system in the brain | Contraindicated in patients with allergy to peppermint, ginger, or lavender Skin rashes and irritation may occur

| Inhaled isopropyl alcohol Aromatherapy | Antiserotonin-3 effects of inhalation of oils through cranial nerve I | Simple olfaction Aroma sends a chemical message to the olfactory bulb where the impulses are processed and passed along to the limbic system in the brain | Contraindicated in patients with allergy to alcohol-based products Skin rashes and irritation may occur

| Acupuncture stimulation of the wrist point P6: invasive and noninvasive | Unknown | Cochrane Collaboration summarizes that P6 acupressure seems to reduce the risk of both nausea and vomiting | Patients’ reports of headache, bruising of wrist, uncomfortable wrist bands, tiredness and sleepiness during electroacupuncture stimulation|

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vomited up 400 mL of green bile. Her heart rate decreased to 50/min because of the vagal stimulation. The rescue interventions were application of a scopolamine patch and repeat doses of dolasetron every 8 hours for the next 48 hours. Aspiration was prevented, and additional episodes of PONV did not occur. Before any mobilization and changes of position, aromatherapy was used to diminish possible risk factors that might cause nausea and vomiting.

Ms Y’s injuries required additional plastic surgery and fitting for a prosthetic eye. She spent a total of 7 weeks in the critical care unit. Before her discharge, staff members in the unit signed a large card to celebrate her overcoming multiple injuries that almost cost her her life. Ms Y’s comment to her providers was thanks for relieving the worst headache and nausea and vomiting of her life.

Conclusion

PONV is an important concern of patients, and effective management can improve patients’ outcomes and comfort. Finding the right intervention requires a discussion with the patient and the patient’s family about unique risk factors and preferences and communication between the providers of care across the perianesthesia continuum. When health care choices are based on the concerns of patients and patients’ families, synergy promotes optimal outcomes.

Financial Disclosures

None reported.

References

12. Apfel CC, Roewer N, Korttila K. How to diminish possible risk factors that might cause nausea and vomiting of her life.

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