Management strategies for the treatment and prevention of postoperative/postdischarge nausea and vomiting: an updated review [version 1; peer review: 2 approved]

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Abstract
Postoperative nausea and vomiting (PONV) and postdischarge nausea and vomiting (PDNV) remain common and distressing complications following surgery. The routine use of opioid analgesics for perioperative pain management is a major contributing factor to both PONV and PDNV after surgery. PONV and PDNV can delay discharge from the hospital or surgicenter, delay the return to normal activities of daily living after discharge home, and increase medical costs. The high incidence of PONV and PDNV has persisted despite the introduction of many new antiemetic drugs (and more aggressive use of antiemetic prophylaxis) over the last two decades as a result of growth in minimally invasive ambulatory surgery and the increased emphasis on earlier mobilization and discharge after both minor and major surgical procedures (e.g. enhanced recovery protocols). Pharmacologic management of PONV should be tailored to the patient's risk level using the validated PONV and PDNV risk-scoring systems to encourage cost-effective practices and minimize the potential for adverse side effects due to drug interactions in the perioperative period. A combination of prophylactic antiemetic drugs with different mechanisms of action should be administered to patients with moderate to high risk of developing PONV. In addition to utilizing prophylactic antiemetic drugs, the management of perioperative pain using opioid-sparing multimodal analgesic techniques is critically important for achieving an enhanced recovery after surgery. In conclusion, the utilization of strategies to reduce the baseline risk of PONV (e.g. adequate hydration and the use of nonpharmacologic antiemetic and opioid-sparing analgesic techniques) and implementing multimodal antiemetic and analgesic regimens will reduce the likelihood of patients developing PONV and PDNV after surgery.
Keywords
Postoperative nausea and vomiting (PONV), Postdischarge nausea and vomiting (PDNV), Retching, Multimodal antiemetic therapy, Antiemetic drugs, Aromatherapy, Non-pharmacologic antiemetic therapies, Neiguan point (PC6).

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**Introduction**

Nausea is an unpleasant sensation causing discomfort in the stomach area which gives the feeling of the impending need to vomit or retch. It is often a transient sensation which is frequently followed by active retching or tachycardia and increased salivation. Vomiting is the involuntary, forceful expulsion of the contents of the stomach through the mouth and/or nose. The incidence of these side effects varies from 30–80% after elective surgery depending on the type of anesthesia and surgery as well as predisposing patient risk factors.

Postoperative nausea and vomiting (PONV) describes nausea and/or vomiting or retching occurring in the postanesthesia care unit (PACU) or during the first 24–48 hours after surgery. Postdischarge nausea and vomiting (PDNV) refers to symptoms that occur after discharge from the hospital or surgical care facility. Not only is PONV a distressing complication from the patient’s perspective but also it can result in dehydration, electrolyte imbalance, acid base imbalance, pulmonary aspiration, pneumothorax, hypoxia, esophageal rupture, increased intracranial pressure, suture rupture, wound dehiscence, bleeding, delay in the ability to resume oral intake, prolonged PACU and/or hospital stay, fatigue, anxiety, unanticipated hospital admission or readmission, and increased medical costs. The distressing symptoms of PONV/PDNV also contribute to patient dissatisfaction with their surgical experience. PONV prophylaxis is economically beneficial for the hospital when a patient dissatisfaction with their surgical experience.

By identifying risk factors for PONV, we can ensure that those patients who are the most in need and stand to gain the greatest benefit receive optimal antiemetic prophylaxis. A number of factors, including patient-, anesthetic-, and surgical-related factors, influence the occurrence of postoperative emetic symptoms. Patient-specific factors include female gender (odds ratio [OR] 2.57), non-smoking status, and a history of PONV.

**Risk factors for PONV and PDNV**

There have been over 4,000 peer-reviewed publications describing treatments for PONV/PDNV in the last 50 years, and numerous new antiemetic drugs and devices have been introduced into clinical practice, yet practitioners have been unable to eliminate this common postoperative problem. The use of opioid analgesics during the perioperative period for the treatment and/or prevention of pain is a major contributing factor in patients who are at risk of developing PONV and PDNV. Dinges et al. found that, compared to morphine, the risk ratio for nausea and vomiting did not significantly differ among different opioid compounds except for a higher incidence with buprenorphine and a lower incidence with fentanyl. Despite more widespread use of combinations of prophylactic antiemetic drugs, shorter-acting anesthetic, analgesic, and muscle relaxant drugs, and multimodal analgesic regimens, PONV still affects approximately 30% of all elective surgical patients, with certain high-risk patients experiencing rates of up to 80%. As newer antiemetic drugs with better safety profiles are introduced into clinical practice, clinical studies are needed to determine the most cost-effective practices for controlling PONV while minimizing other side effects due to unexpected drug–drug interactions. The high incidence of PONV has persisted in part because of the tremendous growth in ambulatory surgery and the increased emphasis on earlier mobilization and discharge after both minor and major operations. One in four patients undergoing ambulatory laparoscopic surgery experienced PONV before discharge. Also, the combination of PONV and pain was present in more than 50% of this patient population. Of interest, a higher incidence of PONV was reported in patients with longer preoperative waiting times (>45 minutes). Despite the extensive literature, the optimal prophylactic antiemetic regimen for specific surgical procedures has not been established. This review article will focus on the most recently published peer-reviewed literature, as well as some of the classical references, considering both prevention and treatment of PONV using evidence-based multimodal antiemetic prophylaxis regimens. We will also examine pharmacological and nonpharmacological approaches.

### Table 1. Postoperative nausea and vomiting (PONV) risk factors in adults related to patient, anesthesia, and surgery.

| Category            | Risk factors in adults                                                                 |
|---------------------|----------------------------------------------------------------------------------------|
| Patient related     | Female gender                                                                         |
|                     | History of PONV                                                                        |
|                     | Motion sickness                                                                       |
|                     | Non-smoking status                                                                    |
|                     | Age <50 years                                                                          |
| Anesthesia related  | Anesthesia technique (general anesthesia results in higher incidence of PONV than does regional anesthesia) |
|                     | Prolonged duration of anesthesia                                                      |
|                     | Volatile agents                                                                       |
|                     | Nitrous oxide (>50%)                                                                  |
|                     | Intraoperative and postoperative opioid analgesics                                     |
|                     | Increased doses of neostigmine (>3 mg)                                                |
| Surgery related     | Extended surgical procedures                                                           |
|                     | Surgery categories (e.g. neurosurgery, laparoscopic surgery, cholecystectomy, intra-abdominal surgery, and gynecological surgery) |
Table 2. Patient-, anesthesia-, and surgery-related risk factors for postoperative nausea and vomiting (PONV) in children.

| Category            | Risk in children (Eberhart classification) |
|---------------------|---------------------------------------------|
| **Patient related** |                                             |
| History of postoperative vomiting (POV) or PONV in relatives |                                             |
| Age >3 years: it is rare in children <3 years old, increases with age over 3, and decreases again with puberty⁵⁰ |
| **Surgery related** |                                             |
| Type of surgery: strabismus⁵⁰ |                                             |
| Duration of surgery >30 minutes |                                             |

The risk of POV for children with 0 to 1, 2, 3, or 4 of these risk factors is associated with an incidence of PONV of 10, 30, 50, and 70%, respectively. This scoring system has also been validated for children having surgery other than strabismus surgery; POV was observed in 3, 11, 30, and 40% of children who had 0, 1, 2 or 3 risk factors, respectively⁵¹.

Table 3. Simplified risk-score⁴.

| PONV in adults⁴ | Points |
|-----------------|--------|
| Female gender   | 1      |
| Non-smoker      | 1      |
| History of PONV | 1      |
| Postoperative opioids | 1    |

**Maximum score**: 4

| POV in children |
|-----------------|
| Surgery >30 minutes | 1 |
| Age >3 years      | 1 |
| Strabismus surgery | 1 |
| History of POV or PONV in relatives | 1 |

**Maximum score**: 4

| PDNV in adults |
|----------------|
| Female gender  | 1 |
| History of PONV | 1 |
| Age <50 years  | 1 |
| Use of opioids in the PACU | 1 |
| Nausea in the PACU | 1 |

**Maximum score**: 5

| PDV in children⁵²,⁵³ |
|----------------------|
| Strabismus, tonsillectomy, and dental surgery | 1 |
| Intraoperative or postdischarge opioids | 1 |

| PDV in children |
|-----------------|
| Long-acting intraoperative opioids | 1 |
| Pain              | 1 |
| Presence of nausea on discharge | 1 |

**Maximum score**: 5

PACU, postanesthesia care unit; PDNV, postdischarge nausea and vomiting; PDV, postdischarge vomiting; PONV, postoperative nausea and vomiting; POV, postoperative vomiting.
Anesthesia-related risk factors (Table 1–Table 3) include the use of opioids, volatile agents, nitrous oxide (which increases the risk for postoperative vomiting), and high doses of neostigmine for the reversal of residual neuromuscular blockade. General anesthesia is associated with a higher incidence of PONV compared with regional anesthesia, secondary to the greater requirement for opioid medication to control postoperative pain after general anesthesia in both adults and children. The performance of peripheral nerve blocks, ganglion block, and wound infiltration with local anesthetic has been shown to decrease the incidence of PONV. Surgery-related predictors include prolonged surgical procedures, with each 30 minutes increasing the risk of PONV by 60%–80%. Certain types of surgery (e.g. ophthalmic, oral, and maxillofacial surgeries, ENT surgery, neurosurgery, laparoscopy, abdominal surgeries, cholecystectomy, and gynecological surgery) have a higher incidence of PONV perhaps because of the longer exposure to general anesthesia and use of larger doses of opioid medications. In open abdominal or intra-abdominal laparoscopic surgery, post-operative ileus can occur because of gut ischemia releasing 5-HT. Opioid use is related to a number of perioperative side effects, one of which is PONV, and they can hinder hospital discharge and return to normal activities of daily life after surgery. Li et al. demonstrated that non-smoking female patients who exhibited a fentanyl-induced cough at anesthesia induction also had a higher likelihood of developing PONV. In a retrospective observational study, Hozumi and colleagues found a dose-dependent relationship between the dosage of remifentanil administered during surgery and an increased risk of developing PONV. Strategies to minimize the use of opioids should be considered for all patients at moderate and high risk of developing PONV. Although the notion is still controversial, some studies have suggested that the risk of PONV is higher with some opioids (e.g. morphine) than others (e.g. hydromorphone). Palumbo et al. found that compared to remifentanil, fentanyl was associated with a higher incidence of PONV after inguinal hernia repair. Tao et al. reported that the incidence of PONV in gynecological patients who underwent laparoscopic surgery was lower when using intraoperative and postoperative intravenous (IV) oxycodeone compared to IV sufentanil. However, Han et al. did not find a difference in the incidence of PONV when IV oxycodeone was compared to IV sufentanil in the PACU, but on the post-surgical wards a higher incidence of PONV was found in patients receiving sufentanil. The use of long-acting opioid analgesic techniques like intrathecal morphine or modified-release oral opioids not only prolongs the duration of analgesia but also can extend the duration of PONV. In one study, naloxone was added to intrathecal morphine and significantly decreased the severity of postoperative nausea and pruritus after cesarean section.

The use of propofol for anesthesia (or sedation) is associated with a 3.5-fold reduction in the incidence of PONV in adults and 5.7-fold reduction in children. Bhakta et al. suggested that propofol-based anesthesia (e.g. total IV anesthesia [TIVA]) was associated with significantly less PONV and faster recovery compared to standard “balanced” anesthesia in patients undergoing gynecological laparoscopy. Etomidate has been shown to produce an increase in the incidence of PONV compared to propofol in elderly patients undergoing gastroscopy and ambulatory surgery. Ketamine has morphine-sparing effects in lower subanesthetic dosages; however, its psychosomatic effects with high dosages during dissociative anesthesia (and sedation) have led to emergence agitation and PONV. Pan et al. found that ketamine (0.5–1.0 mg/kg intra-arterial or 0.01–0.15 mg/kg IV) did not increase PONV in patients undergoing knee arthroscopy. Perioperative intravenous ketamine minimally reduced the risk of PONV (high-quality evidence). Moro et al. compared saline to ketamine 0.2–0.4 mg/kg in patients who underwent laparoscopic cholecystectomy and found that the incidence of PONV did not differ. Controversial findings have suggested that ketamine and etomidate did not increase PONV at doses commonly administered for induction of anesthesia and that low-dose ketamine may actually reduce PONV by decreasing postoperative opioid requirements.

A history of chemotherapy-induced nausea and vomiting (CINV) may increase the risk of PONV after surgery (OR 3.15). Psychological factors such as acute anxiety sensitivity (i.e. a fear of behaviors or sensations associated with the experience of anxiety) should be added to PONV risk-scores, and prophylaxis should be considered when patients show evidence of high anxiety sensitivity. Odom et al. found that the psychometric properties of the Ambulatory Surgery Index of Nausea, Vomiting, and Retching (AS-INVR) provided a reliable and valid measure of the amount of distress and nausea and vomiting. Ethnicity and genetic polymorphisms could be useful in improving the predictability of PONV, which would help to improve both the prevention and the treatment of PONV. For example, CYP2D6 seems to be related to a higher incidence of PONV, especially in the first 24 hours after surgery. The ABCB1 transporter could reduce PONV owing to its association with the effectiveness of ondansetron in antiemetic prophylaxis. With regard to ethnicity, the incidence of PONV is known to be higher in non-Africans than in Africans undergoing the same surgical procedures with the same anesthetic drugs. Interestingly, the platelet count (PLT), mean platelet volume (MPV), and MPV/PLT ratio were used to predict PONV in children. The neutrophil/lymphocyte ratio (NLR) was also used to predict PONV: when the NLR was greater than 2 in patients undergoing ambulatory maxillofacial surgery,
they experienced a statistically higher incidence of PONV compared to an NLR of less than 2\(^{100}\).

**Risk-scoring systems for PONV and PDNV**

Antiemetics produce major side effects ranging from mild headache to severe arrhythmia due to QTc prolongation. Therefore, it is essential to calculate the risk of developing PONV and PDNV in each patient to reduce excessive use of antiemetics for prophylaxis\(^{101,102}\). Apfel et al.\(^{103}\) developed a simplified risk-scoring system for PONV in adults; the primary predictors consist of female gender, history of PONV or motion sickness, non-smoking status, and postoperative opioid use (Table 1). The PONV risk increases by 10, 21, 39, 69, and 79% when 0, 1, 2, 3, and 4 factors are present, respectively. The use of Apfel’s risk-scoring system is more sensitive and specific compared to predicting PONV based on history of PONV or type of surgery alone\(^{103,104}\).

However, the adult risk-scores are not directly applicable to children\(^{10}\). The Eberhart classification scoring system is commonly used for children and includes the following risk factors: age >3 years, duration of surgery >30 minutes, strabismus surgery, and history of POV or a close relative with POV/PONV. The risk of POV for children undergoing strabismus surgery with 0 to 1, 2, 3, or 4 of these risk factors was 10, 30, 50, and 70%, respectively. This scoring system has also been validated for children having surgery other than for strabismus, and POV was observed in 3, 11, 30, and 40% of children who had 0, 1, 2, or 3 risk factors, respectively\(^{11}\).

A study by White et al.\(^{27}\) reported that an Apfel risk-score of 3 or 4 (versus a score of 1–2) is associated with a higher incidence of emesis in the first 24 hours after surgery irrespective of administration of multiple antiemetics as prophylaxis.

The prevention of PONV should be tailored to the patient’s risk-score to avoid side effects and unnecessary costs related to administering multiple antiemetic drugs irrespective of their risk\(^{106–107}\). The prevention of PDNV is still a problem in the ever-increasing group of outpatients having more complicated ambulatory and office-based surgical procedures\(^{108,109}\). In a multi-center study, 37% of 2,170 adult ambulatory surgery patients administered general anesthesia exhibited PDNV\(^{110}\). Since these patients often do not have ready access to “rescue” antiemetic drug therapies after their discharge home, the use of simple nonpharmacologic antiemetic devices (e.g. acupressure) represents a low-risk and cost-effective alternative\(^{108,109}\). White et al.\(^{111}\) used the Pressure Right acupressure device in combination with antiemetic drugs to significantly reduce the incidence of vomiting from 0–72 hours after surgery with an associated improvement in patient satisfaction with their PONV management. Coloma et al.\(^{112}\) reported that the use of acustimulation with the ReliefBand can be used as an alternative to ondansetron for the treatment of established PONV. However, the use of ondansetron (4 mg IV) in combination with the ReliefBand device improved the overall response rate compared to acustimulation alone. Similar results were reported by White and colleagues\(^{113}\). Odom-Forren et al.\(^{114}\) found that pain and postdischarge opioid use seem to be factors in late PDNV\(^{114}\).

The main difference between risk factors for PONV and PDNV was that patients who experienced nausea in the PACU had a threefold greater risk for developing PDNV\(^{115}\). Interestingly, non-smoking status was not an independent predictor for PDNV. When 0, 1, 2, 3, 4, and 5 risk factors are present, the corresponding risk for PDNV is approximately 10, 20, 30, 50, 60, and 80%, respectively\(^{116}\).

**Perioperative antiemetic drugs used for the treatment and/or prevention of PONV**

The concern with widespread prescribing of anti-vomiting drugs is primarily related to the increased costs associated with this practice, especially when expensive proprietary antiemetics are prescribed. In addition, side effects and adverse drug interactions associated with the routine use of prophylactic antiemetics is another concern (e.g. extrapyramidal effects, sedation, arrhythmias, orthostatic hypotension)\(^{116–118}\). The side effects related to the routine use of prophylactic antiemetics (e.g. restlessness, dry mouth, drowsiness, headache, tachycardia, hypotension, and fatigue) can also prolong the length of stay in the surgical facility and the time to restart routine activities of daily living\(^{119–121}\).

**Antiemetic drug classes**

The currently available antiemetic drugs for the treatment and prevention of PONV include the 5-hydroxytryptamine (5-HT\(_3\)) receptor antagonists, neurokinin-1 (NK-1) receptor antagonists, corticosteroids, butyrophenones, metoclopramide, phenothiazine, prochlorperazine, antihistamines, and anticholinergics (Table 4). Conventional prophylactic dosages and suggested timings for the administration of antiemetics are listed in Table 5. Apfel et al. reported that droperidol, dexamethasone, and ondansetron all carry similar antiemetic efficacy when given for prophylaxis\(^{122}\).

**5-HT\(_3\) receptor antagonists.** 5-HT\(_3\) receptor antagonists are recommended as the first-line regimen for PONV prophylaxis. Ondansetron IV is commonly administered near the end of surgery. Multiple trials have reported that ondansetron 4 mg IV (usually administered before the end of surgery) was effective to prevent and treat PONV, facilitating both early and late recovery and improving patient satisfaction after different types of surgery (e.g. outpatient laparoscopy\(^{123}\), laparoscopic surgery\(^{124–126}\), major surgical procedures in women\(^{127}\), and cesarean section\(^{128}\)). When ondansetron was administered at 8 mg, a reduction in postpartum headache up to 4 days was observed; it also reduced PONV as it did with 4 mg\(^{129}\). Koyuncu et al.\(^{129}\) found that ondansetron 8 mg decreased the analgesic effect of acetaminophen 1 g (then 1 g every 6 hours for 24 hours) during the initial postoperative period after hysterectomy. Granisetron, a more selective 5-HT\(_3\) antagonist, has been suggested to provide more sustained antiemesis as a prophylactic\(^{125}\). White et al. showed that granisetron (1 mg orally) was just as effective as ondansetron (4 mg IV) for lowering the occurrence of PONV after laparoscopic procedures\(^{124}\). Granisetron has been reported to be effective alone or in combination to treat PONV in patients undergoing laparoscopic surgery\(^{130–132}\). Ramosetron has higher
### Table 4. Receptor site affinity of available antiemetic drugs.

| Drug group          | Dopamine (D2) | Muscarinic cholinergic | Histamine (H2) | Serotonin (5-HT3) | NK-1 antagonist | CB-1 modulator | MOR antagonist | Gaba mimetic |
|---------------------|---------------|------------------------|----------------|-------------------|-----------------|----------------|----------------|--------------|
| **Antiserotonin**   |               |                        |                | +++               | -               | -              | -              | -            |
| Ondansetron         | -             | -                      | -              | +++               | -               | -              | -              | -            |
| Granisetron         | -             | -                      | -              | +++               | -               | -              | -              | -            |
| Tropisetron         | -             | -                      | -              | +++               | -               | -              | -              | -            |
| Palonosetron        | -             | -                      | -              | +++               | -               | -              | -              | -            |
| **Phenothiazines**  |               |                        |                | +++               | +               | +              | ++             | -            |
| Fluphenazine        | +++           | +                      | ++             | -                 | -               | -              | -              | -            |
| Chlorpromazine      | +++           | +                      | +++            | +                 | -               | -              | -              | -            |
| **Butyrophenones**  |               |                        |                | +++               | +               | +              | ++             | -            |
| Droperidol          | +++           | -                      | +              | +                 | -               | -              | -              | -            |
| Haloperidol         | +++           | -                      | +              | -                 | -               | -              | -              | -            |
| Domperidone         | +++           | -                      | -              | -                 | -               | -              | -              | -            |
| **Antihistamines**  |               |                        |                | +++               | ++             | +++            | +              | -            |
| Diphenhydramine     | +             | ++                     | +++            | -                 | -               | -              | -              | -            |
| Promethazine        | ++            | +                      | +++            | -                 | -               | -              | -              | -            |
| **Anticholinergics**|               |                        |                | +++               | +              | +              | ++             | -            |
| Scopolamine         | +             | +++                    | +              | -                 | -               | -              | -              | -            |
| **Benzamides**      |               |                        |                | +++               | -              | +              | ++             | -            |
| Metoclopramide      | +++           | -                      | +              | ++                | -               | -              | -              | -            |
| **Tricyclic antidepressants** | | | | | | | | |
| Amitriptyline       | +++           | +                      | +++            | -                 | -               | -              | -              | -            |
| Nortriptyline       | +++           | +                      | +++            | -                 | -               | -              | -              | -            |
| **Neurokinin-1**    |               |                        |                | +++               | -              | -              | -              | -            |
| Aprepitant          | -             | -                      | -              | +++               | -              | -              | -              | -            |
| Fosaprepitant       | -             | -                      | -              | +++               | -              | -              | -              | -            |
| **Others**          |               |                        |                | +++               | -              | -              | -              | -            |
| Dronabinol          | -             | -                      | -              | -                 | +++             | -              | -              | -            |
| Nabilone            | -             | -                      | -              | -                 | +++             | -              | -              | -            |
| Naloxone            | -             | -                      | -              | -                 | -               | -              | +++            | -            |
| Lorazepam           | -             | -                      | -              | -                 | -               | -              | -              | +++          |

The number of positive signs (+) indicates receptor activity.

This table was adapted with permission from White PF (ed). Ambulatory Anesthesia and Surgery. London, WB Saunders, 1997 Page 442.

Palonosetron is a second-generation 5-HT₃ receptor antagonist with proposed higher efficacy and more prolonged duration of action when used for antiemetic prophylaxis. Palonosetron was found to be more efficient than ondansetron or ramosetron for antiemetic prophylaxis in patients undergoing laparoscopic surgery. However, Kim et al. failed to find a difference in efficacy between palonosetron and ondansetron in patients undergoing laparoscopic surgery.
Table 5. Prophylactic doses and timing for the administration of antiemetic drugs.

| Drug group                          | Drugs             | Dose                          | Timing                          | Adverse effect                                                                 |
|-------------------------------------|-------------------|-------------------------------|---------------------------------|-------------------------------------------------------------------------------|
| Serotonin (5-HT\textsubscript{3} receptors) antagonists | Ondansetron       | 4–8 mg intravenously (IV) every 4–8 hours | End of surgery                  | Headaches, constipation, flushing, fatigue, malaise, raised liver enzymes     |
|                                     | Granisetron       | 1–2 mg IV                     |                                 |                                                                                |
|                                     | Ramosetron        | 0.3 mg IV 0.1 mg PO           |                                 |                                                                                |
|                                     | Palonosetron      | 0.075–0.25 mg IV              |                                 |                                                                                |
| Corticosteroids                     | Dexamethasone     | 4–10 mg IV                    | After induction of anesthesia   | Elevated blood glucose level, diabetes mellitus, hypotension/hypertension     |
| Butyrophenone                       | Droperidol        | 0.625–1.25 mg IV              | After induction of anesthesia   | Psychomimetic effects, extrapyramidal side effects, Parkinson’s disease, sedation, lightheadedness, prolonged QT interval |
| Neurkinin antagonists (NK-1 receptors) | Aprepitant        | 40 mg orally                  | 1–2 hours prior to induction    | Headaches, constipation, fatigue                                              |
|                                     | Fosaprepitant     | 150 mg IV                     | After induction of anesthesia   |                                                                                |
| Anticholinergics                    | Scopolamine       | Transdermal patch 0.3–0.6 every 24 hours | Evening prior to surgery or in preoperative period | Dizziness, dry mouth, visual disturbances, tachycardia, confusion, urinary retention |
| Dopamine antagonists                | Metoclopramide   | 10–25 mg IV                   | 15–30 minutes prior to end of surgery | Sedation, hypotension (fast injection), headache, extrapyramidal symptoms |
|                                     | Amisulpride IV    | 5–10 mg IV                    | At induction of anesthesia      |                                                                                |

between palonosetron and ramosetron in patients undergoing any type of elective surgery involving general or regional anesthesia.

**Glucocorticoid steroids.** Dexamethasone, a corticosteroid, has been shown to be an effective antiemetic when administered at a dosage of 4–12 mg IV\textsuperscript{149–151}. However, Ormel et al.\textsuperscript{121} found that dexamethasone 4–5 mg was equally as effective as 8–10 mg in terms of antiemetic efficacy. Dexamethasone antiemetic efficacy alone or in combination has been reported in patients undergoing laparoscopic cholecystectomy\textsuperscript{153–154}, other abdominopelvic laparoscopic procedures\textsuperscript{156}, breast cancer surgery\textsuperscript{165}, large and small bowel surgery\textsuperscript{166}, total knee arthroplasty\textsuperscript{167}, joint replacement surgery\textsuperscript{168}, gynecological laparoscopic procedures\textsuperscript{169,170}, cesarean delivery\textsuperscript{171}, scoliosis correction surgery\textsuperscript{172}, vitreoretinal surgery under local anesthesia\textsuperscript{173}, and upper extremity surgery\textsuperscript{174} as well as in endoscopic adenoectomy\textsuperscript{175} and strabismus correction surgery\textsuperscript{176} in children. Interestingly, there are reports that dexamethasone did not reduce PONV in patients undergoing surgery for facial fracture\textsuperscript{177}, laparoscopic surgery for suspected appendicitis\textsuperscript{178}, and microvascular decompression surgery of the trigeminal nerve root\textsuperscript{179}. Singh et al.\textsuperscript{180} concluded that dexamethasone has equal antiemetic efficacy compared to 5-HT\textsubscript{3} receptor antagonists up to 24 hours after surgery. Concerns remain regarding potential complications (e.g. delayed wound healing, hyperglycemia, and risk of infections) in “at-risk” patient populations (e.g. diabetics).\textsuperscript{122,181}.

Betamethasone has also been shown to be an effective antiemetic. Aasboe et al.\textsuperscript{182} compared betamethasone 12 mg intramuscularly (IM) to saline when administered 30 minutes before the start of surgery and reported that betamethasone reduced both postoperative pain and nausea in outpatients undergoing ambulatory foot (hallux valgus) surgery or hemorrhoid procedures. Comparable results were attained in patients undergoing ambulatory surgery\textsuperscript{183} and elective breast surgery\textsuperscript{184} and in high-risk cardiac surgical patients\textsuperscript{185}. However, in a placebo-controlled study by Nordin et al.\textsuperscript{186} comparing betamethasone 8 mg per os (PO) and betamethasone 8 mg IV when administered 1 hour before induction of anesthesia in patients undergoing elective Roux-y-gastric bypass, betamethasone was of limited benefit in preventing PONV.

**NK-1 receptor antagonists.** NK-1 receptor antagonists with long elimination half-life values are effective for the prophylaxis and treatment of PONV\textsuperscript{187}. Gesztesi et al.\textsuperscript{188} found that the NK-1 receptor antagonist CP-122,721 (200 mg PO) decreased emetic episodes compared with ondansetron (4 mg IV) during the first 24 hours after gynecologic surgery. The NK-1 receptor antagonist aprepitant appears to be more effective in decreasing PONV as compared with ondansetron\textsuperscript{189,190}. Aprepitant alone or in combination was associated with a low overall incidence of PONV\textsuperscript{191,192} in patients undergoing laparoscopic surgery\textsuperscript{193}, craniotomy\textsuperscript{194}, mastectomy and thyroidectomy\textsuperscript{195}, and elective...
surgery\textsuperscript{196} and in pediatric patients\textsuperscript{197}. Because of its high cost, aprepitant should be used only in patients at high risk of developing PONV and in those who could experience serious adverse outcomes due to PONV as well as in patients who may have side effects from less-expensive antiemetic drugs\textsuperscript{198,199}.

Fosaprepitant 150 mg IV, a water-soluble lipid formulation of the NK-1 receptor antagonist, was compared to IV ondansetron 4 mg when administered before induction of anesthesia in patients with a moderate-to-high risk of PONV (Apfel simplified score $\geq2$) undergoing general anesthesia\textsuperscript{197}, obtaining a greater decrease in the incidence of vomiting during the first 48 hours after surgery. Similar results were reported in patients undergoing craniotomy\textsuperscript{198} and gynecologic abdominal surgery with patient-controlled epidural analgesia\textsuperscript{199}.

**Butyrophenone.** Droperidol, which acts on central dopamine receptors, is a highly cost-effective antiemetic treatment, regardless of the risk of extrapyramidal side effects and the potential for prolonging the electrocardiographic QT interval\textsuperscript{200}. Multiple well-controlled, randomized, comparative clinical trials have validated droperidol to be as safe and effective as the more costly 5-HT\textsubscript{3} receptor antagonists\textsuperscript{201,202}. There is minimal to no clinical significance in the degree of QT-interval prolongation correlating to antiemetic doses of the drug\textsuperscript{200}. The risk of QTc prolongation was actually decreased by administering a combination of droperidol and a 5-HT\textsubscript{3} receptor antagonist\textsuperscript{204}. The combination of dexamethasone, ondansetron, and droperidol is highly efficacious in preventing PONV in adults. Clinical studies have stated the efficacy of droperidol in reducing PONV in different surgical procedures such as tonsillectomy in children\textsuperscript{205} and ambulatory surgery\textsuperscript{206}. Nevertheless, Bourdaud et al.\textsuperscript{207} compared the efficacy of a combination of ondansetron (100 µg/kg, IV), dexamethasone (125 µg/kg, IV), and droperidol (50 µg/kg, IV) in pediatric patients at high risk of PONV and concluded that adding droperidol to a prophylactic combination of ondansetron and dexamethasone did not decrease the incidence of PONV below that obtained with the two drugs alone, though the addition of droperidol increased the risk of drowsiness. Singh et al.\textsuperscript{208} reported that haloperidol was equivalent to the popular 5-HT\textsubscript{3} receptor antagonists in preventing vomiting on the first day after surgery. The incidence of QTc prolongation with haloperidol is statistically equivalent to the 5-HT\textsubscript{3} antagonists. Brettner et al.\textsuperscript{209} found gender-specific differences in the incidence of PONV (female > males) in the PACU after low-dose haloperidol (0.5 mg IV).

**Dopamine antagonists and gastrokinetic drugs.** Metoclopramide is one of the most utilized antiemetics for treating PONV when 5-HT\textsubscript{3} antagonists, dexamethasone, and/or droperidol prophylaxis is unsuccessful. A systematic review reported that in patients undergoing cesarean delivery under neuraxial anesthesia, the use of metoclopramide 10 mg IV was effective and safe for the prevention of early PONV\textsuperscript{210}. Amisulpride has been found to be effective in treating PONV after failed prophylaxis\textsuperscript{211} in treating patients at low-to-moderate risk of PONV who received no prior PONV prophylaxis\textsuperscript{212}, patients at moderate-to-high risk\textsuperscript{213} or patients at high risk of PONV who developed emetic symptoms after prophylaxis with ondansetron or dexamethasone\textsuperscript{214}.

**Anticholinergics.** Scopolamine is a centrally active anticholinergic drug and can be as efficacious as droperidol (1.25 mg) or ondansetron (4 mg) in reducing PONV in the early and late postoperative periods. Nonetheless, there are concerns about using it routinely for antiemetic prophylaxis because of its slow onset of action and adverse effects (e.g. dry mouth, drowsiness, and visual disturbances)\textsuperscript{215}. Despite this, scopolamine remains a suitable and cost-effective substitute to ondansetron in multimodal treatment prophylaxis in patients with motion-induced emesis and high-risk patients undergoing major operation\textsuperscript{216}. Apfel et al.\textsuperscript{216} reported that transdermal scopolamine (TDS) was associated with significant reductions in PONV during the first 24 hours after anesthesia. TDS was also associated with a higher prevalence of visual disturbances at 24–48 hours after surgery. Pergolizzi et al.\textsuperscript{217} concluded that TDS significantly reduces PONV/PDNV in many different types of surgical patients, and it is recommended in guidelines as a first-line or second-line prophylactic antiemetic. Kassel et al.\textsuperscript{218} concluded that scopolamine should be reconsidered as a routine agent for PONV prevention in the general surgical population but should be avoided in both pediatric and elderly surgical populations.

**Drugs with opioid-sparing effects contributing to antiemetic activity.** Neuromodulator drugs such as tricyclic antidepressants, gabapentin, olanzapine, mirtazapine, benzodiazepines, clonidine, and cannabinoids have been reported to be effective in preventing nausea and vomiting as a result of their opioid-sparing effects\textsuperscript{219}. Dexmedetomidine has demonstrated opioid-sparing effects in elderly patients undergoing epiduroscopy\textsuperscript{220}, in patients with a high risk of PONV following gynecological laparoscopic surgery\textsuperscript{221}, and in patients undergoing other types of surgical procedures\textsuperscript{222}. However, dexmedetomidine has produced side effects (e.g. bradycardia and hypotension). Gabapentin has been reported to produce anti-nauseant effects in various clinical settings owing to opioid-sparing effects\textsuperscript{223–226}. However, White et al. found that preoperative pregabalin failed to decrease either PONV or postoperative pain after major gynecologic surgery\textsuperscript{227}. The administration of dimenhydrinate is limited because of its adverse events profile (e.g. dizziness, sedation, and dry mouth, throat, and nose). Kizilcik et al.\textsuperscript{228} found that the dexamethasone-dimenhydrinate combination was effective for PONV prophylaxis. Mirtazapine, a 5-HT\textsubscript{2} receptor antagonist capable of blocking adrenergic receptors, has been shown to be effective for PONV prophylaxis and to decrease nausea and vomiting in patients after a variety of surgical procedures\textsuperscript{231,232}. Midazolam, a short-acting benzodiazepine, has been reported to reduce the incidence of PONV and provide an anxiolytic effect in patients undergoing cholecystectomy, appendectomy, gynecological surgery, middle ear surgery, thyroidectomy, and intragastric balloon placement\textsuperscript{33–241}. Antipsychotic therapies including olanzapine, aripiprazole, and risperidone have been reported to reduce the need for antiemetic medication in the PACU\textsuperscript{242}. Kang et al.\textsuperscript{243} reported that the combination of palonosetron 0.075 mg and the muscle relaxant reversal drug sugammadex 2 mg/kg reduced the incidence of PONV in patients undergoing microvascular decompression. Acetaminophen preoperatively has been associated with a reduced incidence of PONV in children undergoing strabismus surgery\textsuperscript{244}. However, Roberts et al.\textsuperscript{245} found that children who received IV.
Acetaminophen were more likely to experience PONV. Nabilone, a synthetic cannabinoid, has proven clinical utility in chemotherapy-related nausea and vomiting and PONV. However, oral nabilone 0.5 mg (versus placebo) in patients with preoperative risk of PONV greater than 60% was reported to be ineffective when given prior to surgery. The addition of nalbuphine (0.5 mg) reduced the incidence and severity of PONV and pruritus after cesarean delivery. Perioperative intravenous lidocaine infusion (1–5 mg/kg/hour or 2–4 mg/kg/hour) has been reported to reduce PONV, pain scores, perioperative opioid consumption, and duration of hospital stay and accelerate the restoration of bowel function. However, Dewinter et al. failed to confirm these findings, concluding that systemic lidocaine had no analgesic effect when added to an opioid-based anesthetic regimen for arthrodesis procedures. Clonidine is an alpha 2 adrenergic agonist which has been used both orally and via neuraxial administration as an adjuvant for the treatment of pain and PONV in a wide variety of surgical procedures (e.g. breast, thyroid, and lower abdominal surgery and laparoscopic cholecystectomy in adults and abdominoplasty in children). Clonidine has been shown to improve pain, reduce morphine consumption, decrease PONV, reduce postoperative shivering, and improve hemodynamic and sympathetic stability. However, there are also published studies which have contradicted these findings. Some also reported higher Ramsay sedation scores with clonidine.

Adequate IV fluid hydration is an effective strategy for decreasing the baseline risk for PONV. It has been suggested that early rehydration in surgical patients with prolonged fasting decreases PONV. Studies have reported that the administration of perioperative IV colloid, perioperative IV crystalloid, and Ringer’s lactate (30 mL/kg/hour) and early postoperative oral fluid intake were associated with a lower incidence of PONV. It has also been suggested that the administration of a perioperative infusion of dextrose reduces PONV. Nevertheless, two meta-analyses reported that perioperative IV dextrose did not reduce the risk for PONV but was effective in reducing the need for antiemetic rescue medications after general anesthesia.

Ginger root is an herbal compound which contains gingerol (Ginjervel) and shogaol (Chagall), which reduce stomach contractions and increase the activity of the gastrointestinal tract and motility due to anticholinergic and antiserotonergic actions, increasing gastric emptying. Ginger possesses antiserotonergic activity and has free radical scavenging effects on free radicals that induce vomiting. Ginger is safe and well tolerated, which appears to be useful in both pregnancy and chemotherapy-induced PONV, reducing the need for antiemetic rescue medications. Ginger has also reduced PONV in patients undergoing cholecystectomy, nephrectomy, gynecologic/obstetric surgery, cataract surgery, and thyroidectomy. However, there are also several studies that have reported contradictory results. Alcohol pads containing isopropyl alcohol, when applied under the nose, are a highly cost-effective treatment for transient PONV in adults and children.

Aromatherapy such as essential oils (i.e. spearmint, peppermint, ginger, lavender, and blended orange and peppermint) has also been demonstrated to provide benefits in reducing PONV and PDNV when added to a standard antiemetic treatment regimen. However, there are other authors who have not found any evidence that aromatherapy decreases PONV.

**Nonpharmacologic therapies for PONV and PDNV**

A wide variety of nonpharmacologic techniques have been used to control emetic symptoms in the postoperative period alone or in combination, including acupressure, acupuncture, and transcutaneous electrical nerve stimulation (TENS). TENS combined with a wristband pressing on Neiguan P-6 acupoint was effective in preventing PONV after laparoscopic cholecystectomy. White et al. reported that TENS and ondansetron was effective in PONV prophylaxis. These results were later confirmed when acustimulation was shown to possess analgesic effects. The adjunct use of the Pressure Right acupressure device was shown to improve the emetic potency of commonly used drugs for antiemetic prophylaxis (e.g. ondansetron, droperidol, and dexamethasone) after major laparoscopic surgery. Lee et al. described the use of P-6 acupoint stimulation for PONV as superior to non-acupoint or sham treatments in reducing PONV and need for rescue antiemetic therapy in the postoperative period. Acupuncture at ear acupoint alone or in combination with stimulation at the wrist (P-6 acupoint) has been found to be an effective treatment to reduce PONV. Similar results with dry cupping at the P-6 acupoint and preoperative electro-acupuncture were found. The Society for Ambulatory Anesthesia guidelines mentioned that stimulation of the P-6 acupoint is an effective complementary method to reduce PONV. Other studies support the beneficial effect of P-6 acupoint stimulation in reducing PONV and the need for rescue antiemetics. Acupoints such as Laogong (PC8), Waiguan (SJ5), Zusanli (ST36), Hegu (LI4), and Quchi (LI11) can be used for reducing PONV as well. In the pediatric population, acupuncture, electroacupuncture, and laser acupuncture at the P-6 acupoint have all been used to prevent PONV after tonsillectomy and/or adenoidectomy, hernia repair, circumcision, orchidopexy, chemotherapy, and strangulation procedures. However, there are other studies that used these modalities in both adults and children with negative results. Chewing gum was also associated with a lower incidence of postoperative ileus and PONV. However, Ge et al. found no difference.

Music therapy has been alleged to decrease patient anxiety, pain, and emesis, hospital length of stay, and fatigue after surgeries such as hernia repair, coronary angiography, valve replacement, cardiac surgery, breast surgery, elective cesarean section, sigmoidoscopy, colonoscopy, knee arthroplasty, hand surgery, cystoscopy, hysterectomy, gynecological surgery, varicose vein surgery, general abdominal surgery, laparoscopic cholecystectomy, and urological procedures. However, other studies showed that music therapy did not significantly reduce PONV. Other alternative modalities such as foot massage were reported to decrease pain and incidence of nausea and improve blood circulation in patients who underwent...
laparoscopic cholecystectomy. Frozen ice pops reduced PONV in patients at high risk of PONV who were undergoing major joint replacement surgery. Another important therapeutic goal for PONV prophylaxis is to avoid surgical oxygen desaturation and maintain muscular tissue oxygen saturation at >70% of the baseline values and a normal cerebral oxygen saturation. These nonpharmacologic alternative therapies can produce additive effects to standard antiemetic drugs without increasing side effects or producing adverse drug interactions.

**Preventing PONV and PDNV through multimodal prophylaxis**

PONV has multiple factors contributing to its etiology, leading to an increased awareness in the use of combined therapies that incorporate more than two strategies depending on the overall risk for any given patient. Multimodal interventions not only reduce PONV but also, more importantly, enhance patient comfort after surgery. There is no evidence to date to suggest that any one specific antiemetic therapy is especially effective for a particular patient profile or operation. Therefore, a combination of antiemetic drug therapies that act at different neuroreceptor sites has been recommended for at-risk patients. Some clinicians used a simple method involving the administration of one antiemetic medication for each of the Apfel PONV risk factors. It is commonly accepted that increasing the number of administered antiemetics from one to three improves PONV prophylactic benefit for higher risk patients. Clinical research has showncombining prophylactic antiemetic drugs can lower the rate of PONV and PDNV occurrence as well as improve the patient’s satisfaction with and assist in their recovery in comparison to using a single antiemetic drug. Implementation of PONV guidelines and the assessment of the risk of PONV using the Apfel scoring system reduced the incidence of PONV in patients undergoing ambulatory breast surgery and improved anesthesia providers’ compliance with a preoperative PONV risk assessment. A combination therapy with antiemetic drugs acting at separate receptor sites should be provided to patients with moderate-to-high risk for PONV. A multimodal approach provides a considerable decrease in the incidence of PONV to less than 10% along with an increase in patient satisfaction and reduced side effects.

Bruderer et al. proposed a standardized PONV prophylaxis for ambulatory surgery based on patients’ Apfel risk-score (0–4): ondansetron (Apfel risk-score 2), additional dexamethasone (Apfel risk-score 3), and additional droperidol (Apfel risk-score 4). These investigators achieved low rates of PONV in ~90% of their patients, and PDNV was not a problem on the first day after surgery. In fact, pain after discharge was a much more common problem. Bergese et al. found that triple therapy with scopolamine, ondansetron, and dexamethasone was an effective regime to prevent PONV in moderate- to high-risk patients undergoing craniotomy procedures. Dexamethasone and a 5-HT, receptor antagonist combination has superior efficacy and thus it is recommended as the “ideal” choice for routine PONV prophylaxis. However, a study including same-day surgery patients with varying PONV risk factors revealed that adding ondansetron to a combination of low-dose droperidol and dexamethasone failed to increase antiemetic efficacy.

No difference was observed when comparing efficacy among combinations of 5-HT, receptor antagonist with dexamethasone, 5-HT, receptor antagonist with droperidol, or dexamethasone with droperidol. Interestingly, there was no reduction in PONV in the combinations containing metoclopramide compared to monotherapy alone.

As most patients undergoing surgery have one or two risk factors and 20–40% of these patients are expected to suffer from PONV if they do not receive a prophylactic antiemetic drug, combination antiemetic therapies have become increasingly vital in preventing PONV. Ideally, prophylaxis for PDNV would continue much further than the point of discharge from hospital or free-standing surgical care facility. Recent research focused on different antiemetic drugs administered at various time points after surgery has evaluated the effects on reducing PDNV. For example, a study demonstrated that patients who received the combination of ondansetron (4 mg IV) and an oral disintegrating tablet of ondansetron (8 mg) immediately before discharge had less severe nausea and fewer vomiting episodes compared to IV ondansetron alone after discharge (3% versus 23%, respectively). In a multi-center study, intraoperative dexamethasone did not appear to reduce PONV in the PACU but significantly reduced PDNV. Dewinter et al. tested the effectiveness of a simplified algorithm for PONV prophylaxis with female patients receiving triple IV prophylaxis (dexamethasone and ondansetron plus either a target-controlled infusion with propofol or droperidol) and male patients received double prophylaxis with dexamethasone IV and ondansetron IV. This simplified algorithm for PONV prophylaxis resulted in a significant reduction in the incidence of PONV and better compliance with the PONV algorithm (46% versus 18%, \( P = 0.0001 \)). Kumar et al. compared a single dose of palonosetron 0.075 mg IV plus dexamethasone 4 mg IV to ondansetron 8 mg IV plus dexamethasone 4 mg IV (with ondansetron 4 mg administered every 8 hours IV for 48 hours) for PONV prophylaxis in post-chemotherapy ovarian cancer surgery patients receiving opioid-based patient-controlled analgesia (PCA). Ryu found that palonosetron prophylaxis reduced the incidence and severity of PONV in high-risk patients undergoing total knee arthroplasty with a multimodal analgesia protocol consisting of spinal anesthesia, a continuous femoral nerve block, and fentanyl-based IV PCA. The increasing use of inexpensive, disposable acupressure devices (e.g. Relief Band, Pressure Right) should also be considered in patients at high risk for PDNV. In addition, these patients should be given instructions for appropriate “rescue” antiemetic treatment before they are discharged home. Recommendations for optimal antiemetic dosing when utilizing a combination “multimodal” therapy consisting of dexamethasone, droperidol, and ondansetron are as follows: ondansetron 4 mg IV, 4–8 mg of IV dexamethasone, and 0.625–1.25 mg of IV droperidol. Another study confirmed that low-dose granisetron (0.1 mg IV) in combination with dexamethasone (8 mg IV) is as effective as the combination of IV ondansetron (4 mg) and IV dexamethasone (8 mg). Therefore, antiemetic drugs are now commonly administered at both the start and the end of surgery to patients considered to be at high risk of developing PONV. Adherence to validated PONV prophylaxis guidelines should be carefully
evaluated before the patient is discharged from the PACU to guarantee that patients have received appropriate PONV prophylaxis during the perioperative period\textsuperscript{410}.

**Combined treatments for managing established PONV**

Swift antiemetic management is mandated whenever PONV happens in patients who either did not obtain adequate prophylaxis or had ineffective prophylaxis. If PONV occurs in the immediate postoperative phase (within 6 hours postoperatively), despite antiemetic prophylaxis, an antiemetic belonging to a pharmacologic class other than that of the prophylactic drug regimen should be given. However, if the PONV occurs over 6 hours after surgery, it is suggested that a repeat dose of the original prophylactic is administered. If no prophylaxis was given, the recommended treatment is low-dose 5-HT\textsubscript{3} antagonist (e.g., ondansetron 1–2 mg IV). Alternative treatments for active PONV include intravenous metoclopramide (10 mg), droperidol (0.625 mg), promethazine (6.25–12.5 mg), dolasetron (12.5 mg), granisetron (0.1 mg), palonosetron (0.075 mg), or tropisetron (0.5 mg)\textsuperscript{109,420}. Algorithms describing how to identify high-risk patients and how to guide the administration of multimodal treatments can significantly reduce the incidence of PONV and PDNV\textsuperscript{410,411,422}. Yazbeck-Karam \textit{et al.}\textsuperscript{423} investigated haloperidol versus ondansetron for the treatment of established PONV following general anesthesia and found that haloperidol (1 mg IV) was not inferior to ondansetron (4 mg IV) in the early treatment of established PONV. However, haloperidol was associated with an increased level of sedation\textsuperscript{423}. Hu \textit{et al.}\textsuperscript{425} combined a low dose of 2.5 µg/kg palonosetron with 15 µg/kg of droperidol and achieved a similar prophylactic effect as a higher 7.5 µg/kg dose of palonosetron compared to 7.5 µg/kg alone for treating emesis after eye surgery. For the treatment of existing PONV prior to discharge, a multimodal strategy should be considered because the recurrence rate of PONV over the subsequent 24 hours is 35–50\%\textsuperscript{426}. A combination of low-dose ondansetron plus dexamethasone and droperidol or haloperidol has been found to be superior to monotherapy alone for the treatment of PONV in the PACU\textsuperscript{427}. Those interventions have proven to be effective for both prophylaxis for and treatment of PONV. Therneau \textit{et al.}\textsuperscript{428} found that the addition of aprepitant 40 mg PO to a multimodal antiemetic prophylactic regimen (triple antiemetic prophylaxis with dexamethasone, droperidol, and ondansetron) was associated with significant reduction of PONV during both the early recovery period and the first 48 hours postoperatively in patients undergoing bariatric surgery. Trimas and Trimas\textsuperscript{29} concluded that a single dose of aprepitant 40 mg PO administered preoperatively can decrease the incidence of PONV in the early postoperative period after facial plastic surgery compared with ondansetron alone.

**Summary of current recommendations for reducing the risk of PONV and PDNV**

The management strategy for each individual patient should be based on the level of risk for PONV, the patient’s pre-existing condition, patient preference, and cost efficiency. Patients should be informed about the potential consequences of PONV and PDNV during the preoperative evaluation. In addition to using a combination of antiemetic drugs with different mechanisms of action, the multifactorial etiology of PONV would also be best addressed by adopting a multimodal approach to pain management and minimizing baseline risk factors associated with PONV and PDNV in high-risk patients (Table 3). Several effective strategies are recommended for reducing the baseline risk for PONV (Table 6): (1) routine use of local anesthesia and regional anesthesia (e.g., local infiltration and/or peripheral nerve blocks); (2) propofol induction and maintenance infusion during general anesthesia and monitored anesthesia care (MAC); (3) minimization of perioperative opioid analgesics; (4) minimization of concentrations of volatile anesthetics; (5) minimization of the use of nitrous oxide and reversal drugs; and (6) ensuring adequate perioperative hydration\textsuperscript{7,38,52,412,430}. If general anesthesia is utilized, substituting a propofol infusion for maintenance of anesthesia in place of inhaled volatile anesthetics will reduce the risk of PONV. A combination of propofol and air/oxygen had additive effects, reducing the risk of early PONV by approximately 25\%\textsuperscript{410}. The non-opioid analgesic drugs (e.g. nonsteroidal anti-inflammatory drugs [NSAIDs] like ketorolac or ketoprofen, cyclooxygenase-2 inhibitors [COX-2] like celecoxib or meloxicam, and acetaminophen [oral or intravenous]) should be part of a multimodal perioperative analgesic regimen\textsuperscript{434,445}. Pain and PONV after breast cancer surgery were more effectively reduced with a multimodal regimen utilizing non-opioid analgesics and antiemetics compared to a one- or two-component regimen\textsuperscript{411}. Similar results were found when using an opioid-free TIVA technique for bariatric surgery\textsuperscript{436}. Adequate preoperative and intraoperative IV fluid hydration is also an effective strategy for decreasing the baseline risk for PONV\textsuperscript{416,270,279}. Nitrous oxide had little impact when used for procedures lasting less than 1 hour\textsuperscript{437,438}. Thus, nitrous oxide may be a good option for the short ambulatory procedures to facilitate a faster recovery from anesthesia. Although previous studies suggested that neostigmine produced dose-related increases in PONV\textsuperscript{419,439}, a more recent study suggested that minimization of the neostigmine dosage failed to reduce the baseline risk of developing PONV\textsuperscript{440}. Sugammadex rapidly reverses the neuromuscular blockade caused by steroid-based muscle relaxants; it is a feasible alternative to neostigmine, edrophonium, or pyridostigmine in “at-risk” patients administered non-depolarizing muscle relaxants intraoperatively\textsuperscript{441}. Yağan \textit{et al.}\textsuperscript{442} reported that reversal with sugammadex 2 mg/kg (compared to neostigmine 50 µg/kg plus atripine 0.2 mg/kg) was associated with a lower incidence of PONV in the first hour after surgery and required less rescue antiemetic therapy in the first 24 hours after breast, strabismus, and middle ear surgery. Tas Tuna \textit{et al.}\textsuperscript{443} confirmed these results in patients undergoing elective laparoscopic cholecystectomy surgery. PONV prophylaxis is rarely warranted in low-risk patients. However, moderate-risk patients benefit from single or even often multiple antiemetic drug interventions. Use of two antiemetic interventions is recommended for adults and children at moderate risk, and three (“triple”) interventions should be administered to all high-risk patients\textsuperscript{38,426}. The occurrences of PONV in patients who have received appropriate prophylactic antiemetic therapy should be treated aggressively using antiemetic drugs from a different pharmacologic class\textsuperscript{38,444}. 

\begin{table}[h]
\centering
\caption{Effectiveness of antiemetic prophylaxis in reducing the risk of PONV and PDNV.}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
\textbf{Factor} & \textbf{Frequency} & \textbf{Duration} & \textbf{Risk Reduction} & \textbf{Notes} \\
\hline
Local anesthesia & 30% & 3 hours & 50\% & \textsuperscript{410} \\
Regional anesthesia & 25% & 2 hours & 35\% & \textsuperscript{410} \\
Propofol induction & 15\% & 1 hour & 50\% & \textsuperscript{410} \\
\hline
\end{tabular}
\end{table}
Table 6. Recommendations in relation to various risk factors of postoperative nausea and vomiting (PONV) following surgical procedures.

| Mild risk (none or 1 risk factor) | Moderate risk (2 risk factors) | High risk (≥3 risk factors) |
|----------------------------------|-------------------------------|-----------------------------|
| No prophylaxis required or monotherapy with a cost-effective antiemetic drug if there is a risk of medical sequelae from PONV | Choose a prophylactic combination of antiemetic medications | Start therapy with two or three prophylactic medications that act on different receptors |
| When general anesthesia is needed, decrease pre-existing risk factors by reducing volatile anesthetic usage, use of opioids for analgesia, nitrous oxide, and elevated doses of reversal medications | Minimize pre-existing risks by using opioid-reducing analgesia strategies | Reduce the use of opioids in the perioperative period |
| Use neuraxial anesthesia, peripheral nerve blocks, and infiltration of local anesthesia | Reduce volatile anesthetic usage, use of opioids for analgesia, nitrous oxide, and elevated doses of reversal medications (e.g., naloxone, flumazenil, and neostigmine) | Use neuraxial anesthesia, peripheral nerve blocks, and infiltration of local anesthesia |
| Utilize adjuvant nonpharmacologic options (e.g., acupressure and stimulation by electric acupoint) | | |

Treatment options
If prophylaxis fails or was not received, use antiemetic from different classes to prophylactic agent
Re-administer only if >6 hours after post-anesthesia care unit; do not re-administer dexamethasone or scopolamine

In patients who did not receive antiemetic prophylaxis, first consider using a generic serotonin antagonist. Do not repeat drugs used for prophylaxis until 6 hours have elapsed after completion of surgery. Do not repeat the use of transdermal scopolamine. If refractory symptoms persist, carefully evaluate for other causative factors such as excessive opioid use, draining blood into the gastrointestinal tract or nasopharynx, or gastrointestinal obstruction/ileus. Nonetheless, recognize that PONV/PDNV can still occur despite optimal prophylaxis in high-risk populations. Communication among the patient, anesthesiology team, surgical team, and perioperative nursing staff is essential for optimizing patient outcomes.

References

1. Singh R, Yoon SS, Kuo B: Nausea: A review of pathophysiology and therapeutics. Therap Adv Gastroenterol. 2016; 9(1): 98–112. PubMed Abstract | Publisher Full Text | Free Full Text
2. Balaban CD, Yates BJ: What is nausea? A historical analysis of changing views. Auton Neurosci. 2017; 202: 5–17. PubMed Abstract | Publisher Full Text | Free Full Text
3. Metz A, Hebbard G: Nausea and vomiting in adults—a diagnostic approach. Aust Fam Physician. 2007; 36(9): 688–92. PubMed Abstract
4. American Gastroenterological Association: American Gastroenterological Association medical position statement: Nausea and vomiting. Gastroenterology. 2001; 120(1): 261–3. PubMed Abstract | Publisher Full Text
5. Öbrink E, Jildenståhl P, Oddby E, et al.: Post-operative nausea and vomiting: Update on predicting the probability and ways to minimize its occurrence, with focus on ambulatory surgery. Int J Surg. 2015; 15: 100–6. PubMed Abstract | Publisher Full Text
6. Veiga-Gil L, Pueyo J, López-Olano L: Postoperative Nausea and Vomiting: Physiopathology, Risk Factors, Prophylaxis and Treatment. Rev Esp Anestesiol Reanim. 2017; 64(4): 223–32. PubMed Abstract | Publisher Full Text
7. Pierre S, Whelan R: Nausea and vomiting after surgery. Continuing Education in Anaesthesia Critical Care & Pain. 2013; 13(1): 28–32. Publisher Full Text
8. Feinleib J, Kwan LH, Yamani A, et al.: Postoperative nausea and vomiting. 2018. Reference Source
9. Glass PSA, White PF: Practice guidelines for the management of postoperative nausea and vomiting: Past, present, and future. Anesth Analg. 2007; 105(6): 1528–9. PubMed Abstract | Publisher Full Text
10. Fero KE, Jalota L, Hornuss C: Pharmacologic management of postoperative nausea and vomiting. Expert Opin Pharmacother. 2011; 12(15): 2283–96. PubMed Abstract | Publisher Full Text
11. Kovac AL: Update on the management of postoperative nausea and vomiting. Drugs. 2013; 73(14): 1525–47. PubMed Abstract | Publisher Full Text
12. Cao X, White PF, Ma H: An update on the management of postoperative nausea and vomiting. J Anesth. 2017; 31(4): 617–26. PubMed Abstract | Publisher Full Text
13. Apipan B, Rummasak D, Wongsriritch N: Postoperative nausea and vomiting after general anesthesia for oral and maxillofacial surgery. J Dent Anesth Pain Med. 2016; 16(4): 273–281. PubMed Abstract | Publisher Full Text | Free Full Text
14. Dzwonczyk R, Weaver TE, Puente EG, et al.: Postoperative nausea and vomiting prophylaxis from an economic point of view. Am J Ther. 2012; 19(1): 11–5. PubMed Abstract | Publisher Full Text
15. Bellville JW, Bross IDJ, Howland WS: Postoperative Nausea and Vomiting.
IV. Factors Related to Postoperative Nausea and Vomiting. *Anesthesiology.* 1966; 21: 186–93. PubMed Abstract | Publisher Full Text

16. Dinges HC, Otto S, Stay DK, et al.: Side Effect Rates of Opioids in Equianalgesic Doses via Intravenous Patient-Controlled Analgesia: A Systematic Review and Network Meta-analysis. *Anesth Analg.* 2019; 129(4): 1153–62. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

17. Phillips C, Brookes CD, Rich J, et al.: Postoperative nausea and vomiting following orthopaedic surgery. *Int J Oral Maxillofac Surg.* 2015; 44(5): 745–51. PubMed Abstract | Publisher Full Text | Free Text

18. White PF, O'Hara JR, Roberson CR, et al.: The impact of current antiemetic practices on patient outcomes: A prospective study on high-risk patients. *Anesth Analg.* 2008; 107(4): 452–6. PubMed Abstract | Publisher Full Text

19. López-Torres López J, Piedracoba Cadahía D, Alcántara Noalles MJ, et al.: Perioperative Factors That Contribute to Postoperative Pain and/or Nausea and Vomiting in Ambulatory Laparoscopic Surgery. *Rev Esp Anestesiol Reanim.* 2019; 66(4): 189–98. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

20. Kappen TH: Risk-tailored prophylaxis for postoperative nausea and vomiting: has the big little problem gotten any smaller? *Anesthesiology.* 2016; 1153–62. PubMed Abstract | Publisher Full Text

21. de Souza DS, Costa AF, Chaves GV: Symptoms. *Patient Risk Factors and Early Versus Late Postoperative Emetic Symptoms.* *Anesth Analg.* 2017; (3): 386–92. PubMed Abstract | Publisher Full Text

22. Dobbelier M, de Coster J, Coucke W, et al.: Postoperative nausea and vomiting after and before maxillofacial surgery: A prospective study. *Int J Oral Maxillofac Surg.* 2018; 47(6): 721–5. PubMed Abstract | Publisher Full Text | Free Text

23. Groene P, Eisenhör J, Zeuzem C, et al.: Postoperative nausea and vomiting in bariatric surgery in comparison to non-bariatric gastric surgery. *Worlds Surg.* 2019; 14(1): 90–5. PubMed Abstract | Publisher Full Text | Free Text

24. Halliday TA, Sundqvist J, Hultin M, et al.: Can children drink before discharge from day surgery? *Anesthesiology.* 1992; 76(4): 528–33. PubMed Abstract | Publisher Full Text

25. Apfel CC, Kranke P, Katz MH, et al.: Volatile anaesthetics may be the main cause of early but not delayed postoperative vomiting: A randomized controlled trial of factorial design. *Br J Anaesth.* 2002; 88(3): 459–68. PubMed Abstract | Publisher Full Text

26. Son J, Yoon H: Factors Affecting Postoperative Nausea and Vomiting in Surgical Patients. *J Perianesth Nurs.* 2018; 33(4): 461–70. PubMed Abstract | Publisher Full Text

27. White PF, Sacañ O, Nuan-changmon N, et al.: The Relationship Between Patient Risk Factors and Early Versus Late Postoperative Emetic Symptoms. *Anesth Analg.* 2008; 107(2): 459–63. PubMed Abstract | Publisher Full Text

28. Watcha MF, White PF: Postoperative nausea and vomiting. *Its etiology, treatment, and prevention.* *Anesthesiology.* 1992; 77(1): 162–84. PubMed Abstract | Publisher Full Text

29. Eberhart LHJ, Geldner G, Kranke P, et al.: The Development and Validation of a Risk Score to Predict the Probability of Postoperative Vomiting in Pediatric Patients. *Anesth Analg.* 2004; 99(6): 1630–7. PubMed Abstract | Publisher Full Text

30. Eberhart LHJ, Morin AM, Guber D, et al.: Applicability of risk scores for postoperative nausea and vomiting in adults to paediatric patients. *Br J Anaesth.* 2006; 93(3): 386–92. PubMed Abstract | Publisher Full Text

31. Kranke P, Eberhart LH, Toker H, et al.: A Propective Evaluation of the POVOC Score for the Prediction of Postoperative Vomiting in Children. *Anesth Analg.* 2007; 105(5): 1592–7. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

32. Efune PN, Minhaquddin A, Szuk P: Incidence and factors contributing to postdischarge nausea and vomiting in pediatric ambulatory surgical cases. *Paediatr Anaesth.* 2016; 26(3): 257–63. PubMed Abstract | Publisher Full Text

33. Apfel CC, Turan A, Souka Z, et al.: Intravenous acetaminophen reduces postoperative nausea and vomiting: A systematic review and meta-analysis. *Pain.* 2012; 154(5): 677–89. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

34. Palazzo M, Evans R: Logistic regression analysis of fixed patient factors for postoperative sickness: a model for risk assessment. *Br J Anaesth.* 1993; 70(2): 135–40. PubMed Abstract | Publisher Full Text

35. Koivuranta M, Läärä E, Särne L, et al.: A survey of postoperative nausea and vomiting. *Anesthesiology.* 1997; 82(5): 443–449. PubMed Abstract | Publisher Full Text

36. Sinclair DR, Chung F, Mezei G: Can Postoperative Nausea and Vomiting Be Predicted? *Anesthesiology.* 1999; 91(1): 109–18. PubMed Abstract | Publisher Full Text

37. Apfel CC, Heidrich FM, Jukar-Rao S, et al.: Evidence-based analysis of risk factors for postoperative nausea and vomiting. *Br J Anaesth.* 2012; 109(5): 742–53. PubMed Abstract | Publisher Full Text

38. Gan TJ, Diermunsch P, Habib AS, et al.: Consensus Guidelines for the Management of Postoperative Nausea and Vomiting. *Anesth Analg.* 2014; 118(1): 85–113. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

39. Rowley MR, Brown TC: Postoperative vomiting in children. *Anesth Intensive Care.* 1982; 10(4): 309–13. PubMed Abstract | Publisher Full Text

40. Chandrakantan A, Reinsel RA, Jasiewicz R, et al.: An exploratory study of the relationship between postoperative nausea and vomiting and postdischarge nausea and vomiting in children undergoing ambulatory surgery. *Paediatr Anaesth.* 2019; 29(4): 353–60. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

41. Kocaturk O, Keles S, Omurzuk I: Risk factors for postoperative nausea and vomiting in pediatric patients undergoing ambulatory dental treatment. *Niger J Clin Pract.* 2018; 21(5): 597–602. PubMed Abstract | Publisher Full Text

42. Turberg HG, Alman M, Kip G, et al.: Should children drink before discharge from day surgery? *Anesthesiology.* 1992; 76(4): 528–33. PubMed Abstract | Publisher Full Text

43. Schreiner MS, Nicolson SC, Martin T, et al.: A Prospective Evaluation of the Faculty Opinions Recommendation

44. Cohen MM, Cameron CB, Duncan PG: Pediatric anesthetic morbidity and mortality in the perioperative period. *Anesth Analg.* 1990; 70(2): 160–7. PubMed Abstract | Publisher Full Text

45. Bourdaud N, Devys JM, Bientz J, et al.: Development and validation of a risk score to predict the probability of postoperative vomiting in pediatric patients: The VPOP score. *Paediatr Anaesth.* 2014; 24(9): 945–52. PubMed Abstract | Publisher Full Text

46. Firoozabad MD, Rahmani H: Prevention of Nausea and Vomiting: Methods and Utility after Surgery in Cancer Patients? *Asian J Cancer Prev.* 2015; 16(7): 2639–27. PubMed Abstract | Publisher Full Text

47. Pratpesh S, Mahattanaporn S, Wasinwong W: Target Controlled Infusion versus Sevoflurane/Desflurane Anesthesia for Laparoscopic Cholecystectomy: Comparison Postoperative Nausea/Vomiting and Exubation Time. *J Med Assoc Thai.* 2015; 98(12): 1187–92. PubMed Abstract | Publisher Full Text

48. Tramer MR, Fuchs-Buder T: Omitting antagonism of neuromuscular block: Effect on postoperative nausea and vomiting and risk of residual paralysis. A systematic review. *Br J Anaesth.* 1999; 82(4): 379–86. PubMed Abstract | Publisher Full Text

49. Sansonnens J, Taffe P, Burnand B: Higher occurrence of nausea and vomiting after total hip arthroplasty using general versus spinal anesthesia: An observational study. *BMC Anesthesiol.* 2016; 16: 64. PubMed Abstract | Publisher Full Text | Free Full Text

50. Seki H, Furumoto K, Satoh M, et al.: Effects of epidural anesthesia on postoperative nausea and vomiting in laparoscopic gynecological surgery: A randomized controlled trial. *Anesth Analg.* 2018; 127(4): 608–15. PubMed Abstract | Publisher Full Text

51. Semiz A, Akpakt YK, Yilanlıoğlu NC, et al.: Prediction of intraoperative nausea and vomiting in caesarean delivery under regional anaesthesia. *Int Med Res.* 2017; 45(3): 332–9. PubMed Abstract | Publisher Full Text | Free Full Text

52. Rivedal DD, Nayar HS, Israel JS, et al.: Paravertebral block associated with decreased opioid use and less nausea and vomiting after reduction mammoplasty. *J Surg Res.* 2018; 228: 307–13. PubMed Abstract | Publisher Full Text

53. Steinhaus ME, Rosneck J, Ahmad CS, et al.: Outcomes After Peripheral Nerve Block in Hip Arthroplasty. *Am J Orthop (Belle Mead NJ).* 2018; 47(6). PubMed Abstract | Publisher Full Text
116. Bergese SD, Puente EG, Antor MA, et al.: A Prospective, Randomized, Double-Blinded, Double-Dummy Pilot Study to Assess the Preemptive Effect of Triple Therapy with Aprepitant, Dexamethasone, and Promethazine versus Ondansetron, Dexamethasone and Promethazine on Reducing the Incidence of Postoperative Nausea and Vomiting Experienced by Patients Undergoing Craniotomy Under General Anaesthesia. Front Med (Lausanne). 2016; 3:29.

PubMed Abstract | Publisher Full Text | Free Full Text

117. Imani F, Zafarghandi-Motlagh M: Postoperative nausea and vomiting in patients undergoing laparoscopic surgery. J Minim Invasive Surg Sci. 2012; 2:138-43.

PubMed Abstract | Publisher Full Text | Free Full Text

118. Ryu JH, Lee JE, Lim YJ, et al.: A prospective, randomized, double-blind, and multicenter trial of prophylactic effects of ramosetron on postoperative nausea and vomiting (PONV) after craniotomy: Comparison with ondansetron. BMC Anesthesiol. 2014; 14:63.

PubMed Abstract | Publisher Full Text | Free Full Text

119. Alimian M, Imani F, Fatz SHR, et al.: Effect of oral pregabalin premedication on post-operative pain in laparoscopic gastric bypass surgery. Anesth Pain Med. 2012; 2(1):12-6.

PubMed Abstract | Publisher Full Text | Free Full Text

120. Lee A, Chan SKC, Fan LTY: Stimulation of the wrist acupuncture point PC6 for preventing postoperative nausea and vomiting. Cochrane Database Syst Rev. 2015; (11): CD003281.

PubMed Abstract | Publisher Full Text | Free Full Text

121. Manahan MA, Bassadil B, Kalin F, et al.: A simplified risk score for predicting postoperative nausea and vomiting in patients undergoing deep flap breast reconstruction. Microsurgery. 2014; 34(2):112-21.

PubMed Abstract | Publisher Full Text | Free Full Text

122. Apfel CC, Korttila K, Abdalla M, et al.: The effect of timing of ondansetron administration on its efficacy, cost-effectiveness, and cost-benefit as a prophylactic antiemetic in the ambulatory setting. Anesth Analg. 1998; 86(2):274-82.

PubMed Abstract | Publisher Full Text | Free Full Text

123. White PF, Tang J, Hamza MA, et al.: The use of oral granisetron versus intravenous ondansetron for antiemetic prophylaxis in patients undergoing laparoscopic surgery: The effect on emetic symptoms and quality of recovery. Anesth Analg. 2006; 102(5):1387-93.

PubMed Abstract | Publisher Full Text | Free Full Text

124. Kamali A, Ahmadli L, Shokpour M, et al.: Investigation of Ondansetron, Haloperidol, and Dexmedetomidine Efficacy for Prevention of Postoperative Nausea and Vomiting In Patients with Abdominal Hysterectomy. Open Access Maced J Med Sci. 2018; 6(9):1659-63.

PubMed Abstract | Publisher Full Text | Free Full Text

125. Isazadehfar K, Entezarimia S, Shahbazzadegan B, et al.: The Comparative Study of Ondansetron and Metoclopramide Effects in Reducing Nausea and Vomiting After Laparoscopic Cholecystectomy. Acta Med Iran. 2017; 55(4):254-8.

PubMed Abstract | Publisher Full Text | Free Full Text

126. Bai B, Pei J, Zhang YL, et al.: Adding Ondansetron in Morphine Intravenous Analgesia Pump to Prevent Postoperative Nausea and Vomiting in Women. Zhongguo Yi Xue Xue Xue Yuan Xue Bao. 2018; (1): 373-37.

PubMed Abstract | Publisher Full Text

127. Kamali A, Modir H, Kamali A, et al.: Ondansetron 8 mg and 4 mg with normal saline against post-operative headache and nausea/vomiting after spinal anesthesia: A randomized double-blind trial. Med Gas Res. 2018; 8(2):48-53.

PubMed Abstract | Publisher Full Text | Free Full Text

128. Koyuncu O, Leung S, You J, et al.: The effect of ondansetron on analgesic efficacy of acetaminophen after hysterecomy: A randomized double blinded placebo controlled trial. J Clin Anesth. 2017; 40: 78-83.

PubMed Abstract | Publisher Full Text | Free Full Text

129. Zhu M, Zhou C, Huang B, et al.: Granisetron plus dexamethasone for prevention of postoperative nausea and vomiting in patients undergoing laparoscopic surgery: A meta-analysis. Int J Med Res. 2017; 45(3):904-11.

PubMed Abstract | Publisher Full Text | Free Full Text

130. Lee WS, Lee KB, Lim S, et al.: Comparison of palonosetron, granisetron, and ramscetron for the prevention of postoperative nausea and vomiting after laparoscopic gynecologic surgery: A prospective randomized trial. BMC Anesthesiol. 2015; 15: 121.

PubMed Abstract | Publisher Full Text | Free Full Text

131. Tahir S, Mir AA, Hameed A: Comparison of Palonosetron with Granisetron for Prevention of Postoperative Nausea and Vomiting in Patients Undergoing Laparoscopic Abdominal Surgery. Anesth Essays Res. 2018; 12(3):636-43.

PubMed Abstract | Publisher Full Text | Free Full Text

132. White PF: Ambulatory Anesthesia and Surgery. London,JB Saunders, 1997; 281.

133. Ahm T, Hoj, Chou SJ, et al.: Comparison of the prophylactic anti-emetic efficacy of ramosetron and ondansetron in patients at high-risk for postoperative nausea and vomiting after total knee replacement. Anesthesiology. 2010; 100(5):500-6.

PubMed Abstract | Publisher Full Text | Free Full Text

134. Joo J, Park S, Park HJ, et al.: Ransetron versus ondansetron for...
postoperative nausea and vomiting in strabismus surgery patients. BMC Anesthesiol. 2016;16(1):41.
Published Abstract | Publisher Full Text | Free Full Text

136. Gao C, Li B, Xu L, et al.: Efficacy and safety of ramosetron versus ondansetron for postoperative nausea and vomiting after general anesthesia: A meta-analysis of randomized clinical trials. Drug Des Devel Ther. 2015;9:2343-50.
Published Abstract | Publisher Full Text | Free Full Text

137. Yoko A, Mihara T, Ka K, et al.: Comparative efficacy of ramosetron and ondansetron for postoperative nausea and vomiting after laparoscopic surgery: An updated systematic review and meta-analysis with trial sequential analysis. PLoS One. 2017;12: e0186006.
Published Abstract | Publisher Full Text | Free Full Text

138. Choi SY, Sohn HM, Do SH, et al.: Comparison of ramosetron and ondansetron for the treatment of established postoperative nausea and vomiting after laparoscopic surgery: A prospective, randomized, double-blinded multicenter trial. Ther Clin Risk Manag. 2018;14:601-6.
Published Abstract | Publisher Full Text | Free Full Text

139. Pinsornk F, Teeyaphaith M, Ruetiwanagoon C, et al.: Comparison of Dexamethasone and Ondansetron for Prevention of Intraoperative Morphin-induced Nausea and Vomiting After Primary Total Knee Arthroplasty: A Randomized Control Trial. J Arthroplasty. 2017;32(3):1040-3.
Published Abstract | Publisher Full Text | Free Full Text

140. Park HE, Kim MK, Kang WK: Efficacy and Safety of Ramosetron Injection for Nausea and Vomiting in Colorectal-Cancer Patients Undergoing a Laparoscopic Colectomy: A Randomized, Double-blind, Comparative Study. Ann Coloprocect Surg. 2018;34(1):36-41.
Published Abstract | Publisher Full Text | Free Full Text

141. Lee B, Kim K, Suh DH, et al.: Efficacy of Single-dose and 2-dose Intravenous Administration of Ramosetron in Preventing Postoperative Nausea and Vomiting After Laparoscopic Gynecologic Operation: A Randomized, Double-blind, Placebo-controlled, Phase 2 Trial. Surg Laparosc Endosc Percutan Tech. 2017;27(4):183-4.
Published Abstract | Publisher Full Text | Free Full Text

142. Wangnamtip S, Chinchao T, Amornyot S, et al.: A Randomized Placebo-Controlled Trial of Oral Ramosetron for Prevention of Post Operative Nausea and Vomiting After Intraabdominal Morphin in Patients Undergoing Gynecological Surgery. J Med Assoc Thail. 2016;99(5):455-61.
Published Abstract

143. Singh PM, Barle R, Couta D, et al.: Efficacy of palonosetron in postoperative nausea and vomiting (PONV)-a meta-analysis. J Clin Anesth. 2016;34:459-82.
Published Abstract | Publisher Full Text | Free Full Text

144. Ahn EJ, Choi GJ, Kang H, et al.: Comparison of Ramosetron with Palonosetron for Prevention of Postoperative Nausea and Vomiting in Patients Receiving Opioid-Based Intravenous Patient-Controlled Analgesia after Gynecological Laparoscopy. Biomed Res Int. 2017;2017:9341738.
Pak J Med Health Sci.

145. Carvalho Braga EL, Figueiredo NV, Baruccand L, et al.: Use of palonosetron and ondansetron in the prophylaxis of postoperative nausea and vomiting in women 60 years of age or older undergoing laparoscopic cholecystectomy: A randomised double-blind study. Eur J Anaesthesiol. 2019;36(3):241-2.
Published Abstract | Publisher Full Text | Faculty Opinions Recommendation

146. Liu Q, Zhou C, Bao Z, et al.: Effects of palonosetron and ondansetron on preventing nausea and vomiting after laparoscopic surgery. J Int Med Res. 2018;46(1):411-20.
Published Abstract | Publisher Full Text | Free Full Text

147. Reddy G, Manjunathri B, Jyothsna G: Postoperative nausea and vomiting prophylaxis: A comparative study of ramosetron and palonosetron in patients undergoing laparoscopic cholecystectomy: A prospective randomized trial. Anesth Essays Res. 2019;13:68-72.
Published Abstract | Publisher Full Text | Free Full Text | Faculty Opinions Recommendation

148. Kim M5, Park JH, Choi YS, et al.: Efficacy of Palonosetron vs. Ramosetron for the Prevention of Postoperative Nausea and Vomiting: A Meta-Analysis of Randomized Controlled Trials. J Med Res. 2017;58(4):948-58.
Published Abstract | Publisher Full Text | Free Full Text

149. Wang JJ, Ho ST, Lee SC, et al.: The use of dexamethasone for preventing postoperative nausea and vomiting in females undergoing thyroidectomy: A dose-ranging study. Anesth Analg. 2006;99(6):1404-7.
Published Abstract | Publisher Full Text | Free Full Text

150. Malrai S, Som A, Baidya DK, et al.: Comparison of Ondansetron and Dexamethasone for Prophylaxis of Postoperative Nausea and Vomiting in Patients Undergoing Laparoscopic Surgeries: A Meta-analysis of Randomized Controlled Trials. Anesthesiol Res Pract. 2016;2016:7089454.
Published Abstract | Publisher Full Text | Free Full Text

151. Fathimasarathy P, Babu K, Raghaveendra Rao RS, et al.: The Effect of Single-dose Intravenous Dexamethasone on Postoperative Pain and Postoperative Nausea and Vomiting in Patients Undergoing Surgery under Spinal Anesthesia: A Double-blind Randomised Invasive Study. Anesth Essays Res. 2018;12(2):313-7.
Published Abstract | Publisher Full Text | Free Full Text

152. Orme G, Romundstad L, Lambert-Jensen P, et al.: Dexamethasone has additive effect when combined with ondansetron and droperidol for treatment of established PONV. Acta Anaesthesiol Scand. 2011;55(10):1196-205.
Published Abstract | Publisher Full Text

153. Murphy GS, Szokol JW, Greenberg SB, et al.: Preoperative dexamethasone enhances quality of recovery after laparoscopic cholecystectomy: Effect on in-hospital and postdischarge recovery outcomes. Anesthesiology. 2011;114(4):882-90.
Published Abstract | Publisher Full Text

154. Ismail EA, Bakri MH, Abd-Elshafy SK: Dexamethasone alone versus in combination with intra-operative and post-operative hydration for postoperative nausea and vomiting prophylaxis in female patients undergoing laparoscopic cholecystectomy: A randomized clinical trial. Korean J Anesthesiol. 2017;76(5):535-541.
Published Abstract | Publisher Full Text | Free Full Text

155. Awad K, Ahmed H, Abushouk AL, et al.: Dexamethasone combined with other antiemetics versus single antiemtics for prevention of postoperative nausea and vomiting after laparoscopic cholecystectomy: An updated systematic review and meta-analysis. Int J Surg. 2016;36( Pt A):152-63.
Published Abstract | Publisher Full Text | Free Full Text

156. Kumar A, Patodia M, Pandove P, et al.: A randomized, placebo-controlled study evaluating preventive role of ondansetron, dexamethasone and ondansetron plus dexamethasone for postoperative nausea and vomiting (PONV) in patients undergoing laparoscopic cholecystectomy. J Med Assoc Thai. 2015;98(3):277-81.
Published Abstract | Publisher Full Text

157. Coloma M, White PF, Markowitz SD, et al.: Dexamethasone in Combination With Dolasetron for Prophylaxis in the Ambulatory Setting: Effect on Outcome After Laparoscopic Cholecystectomy. Anesthesiology. 2002;96(6):1346-50.
Published Abstract | Publisher Full Text

158. Arner M, Uddin S, Rasheed F: Comparison of use of metoclopramide alone and in combination with dexamethasone for prevention of postoperative nausea and vomiting in laparoscopic surgery. Pak J Med Health Sci. 2012;4(3):626-8.
Published Abstract | Publisher Full Text

159. Ahsan K, Abbas N, Naqvi SM, et al.: Comparison of efficacy of ondansetron and dexamethasone combination and ondansetron alone in preventing postoperative nausea and vomiting after laparoscopic cholecystectomy. J Pak Med Assoc. 2014;64(3):242-6.
Published Abstract | Publisher Full Text

160. Ko-Iam W, Sandhu T, Paiboonworachat S, et al.: Comparison of use of metoclopramide alone and in combination with dexamethasone for prevention of postoperative nausea and vomiting in patients undergoing laparoscopic cholecystectomy. Surg Endosc. 2012;26(8):2306-11.
Published Abstract

161. Bala I, Bharti N, Murugesan S, et al.: Comparison of efficacy of ondansetron, dexamethasone and their combination with dexamethasone in the prevention of postoperative nausea and vomiting in patients undergoing laparoscopic cholecystectomy. Minerva Anestesiol. 2014;80(7):779-84.
Published Abstract

162. Ali A, Gillani M, Hanif A, et al.: Comparison of ondansetron and combination of ondansetron and dexamethasone for prevention of post-operative nausea and vomiting in patients undergoing elective laparoscopic cholecystectomy. Pak J Med Health Sci. 2012;4(3):626-8.
Published Abstract

163. Gupta R, Srivastava S, Dhiraaj S, et al.: Minimum effective dose of dexamethasone in combination with midazolam as prophylaxis for postoperative nausea and vomiting after laparoscopic cholecystectomy. Anesth Analg Res. 2018;12(2):396-401.
Published Abstract | Publisher Full Text | Free Full Text

164. Cortés-Flores AO, Jiménez-Tornerio J, Morgan-Villela G, et al.: Effects of preoperative dexamethasone on postoperative pain, nausea, vomiting and respiratory function in women undergoing conservative breast surgery for cancer: Results of a controlled clinical trial. Eur J Cancer Care (Engl). 2018;27(1).
Published Abstract | Publisher Full Text

165. DREAMS Trial Collaborators and West Midlands Research Collaborative: Dexamethasone versus standard treatment for postoperative nausea and vomiting in gastrointestinal surgery: Randomised controlled trial (DREAMS Trial). BMJ. 2017;357:j3455.
Published Abstract | Publisher Full Text | Free Full Text

166. Xu B, Ma J, Huang Q, et al.: Two doses of low-dose perioperative dexamethasone improve the clinical outcome after total knee arthroplasty: A randomized controlled study. Knee Surg Sports Traumatol Arthrosc. 2018;26(5):1549-56.
Published Abstract | Publisher Full Text

167. Fan Z, Ma J, Kuang M, et al.: The efficacy of dexamethasone reducing postoperative pain and emesis after total knee arthroplasty: A systematic
206. Charton A, Greib N, Ruimy A, et al.: Incidence of akathisia after postoperative nausea and vomiting prophylaxis with droperidol and ondansetron in outpatient surgery: A multicentre controlled randomised trial. Eur J Anaesthesiol. 2018; 35(12): 966–71. PubMed Abstract | Publisher Full Text

207. Bourdaud N, Frances C, Jaquimart Q, et al.: Addition of droperidol to prophylactic ondansetron and dexamethasone in children at high risk for postoperative vomiting. A randomized, controlled, double-blind study. Br J Anaesth. 2017; 118(6): 918–23. PubMed Abstract | Publisher Full Text

208. Singh PM, Borle A, Makkar JK, et al.: Haloperidol Versus 5-HT3 Receptor Antagonists for Postoperative Vomiting and QTC Prolongation: A Noninferiority Meta-Analysis and Trial Sequential Analysis of Randomized Controlled Trials. J Clin Pharmacol. 2018; 58(2): 131–43. PubMed Abstract | Publisher Full Text

209. Breetner J, Janitzia S, Muller K, et al.: Gender-Specific Differences in Low-Dose Haloperidol Response for Prevention of Postoperative Nausea and Vomiting: A Register-Based Cohort Study. PLoS One. 2016; 11(1): e0146746. PubMed Abstract | Publisher Full Text | Free Full Text

210. Mishriky BM, Habib BS: Metoclopramide for nausea and vomiting prophylaxis during and after Caesarean delivery: A systematic review and meta-analysis. Br J Anaesth. 2012; 108(5): 374–83. PubMed Abstract | Publisher Full Text

211. Habib BS, Kranke P, Bergese SD, et al.: Amisulpride for the Rescue Treatment of Postoperative Nausea or Vomiting in Patients Failing Prophylaxis: A Randomized, Placebo-controlled Phase III Trial. Anesthesiology. 2019; 130(2): 203–12. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

212. Candiotti KA, Kranke P, Bergese SD, et al.: Randomized, Double-Blind, Placebo-Controlled Study of Intravenous Amisulpride as Treatment of Established Postoperative Nausea and Vomiting in Patients Who Have Had No Prior Prophylaxis. Anesth Analg. 2019; 128(6): 1098–105. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

213. Gan TJ, Kranke P, Minkowitz HS, et al.: Intravenous Amisulpride for the Prevention of Postoperative Nausea and Vomiting: Randomized, Double-blind, Placebo-controlled Trials. Anesthesiology. 2017; 126(2): 268–75. PubMed Abstract | Publisher Full Text

214. Kranke P, Bergese SD, Minkowitz HS, et al.: Amisulpride Prevents Postoperative Nausea and Vomiting in Patients at High Risk: A Randomized, Double-blind, Placebo-controlled Trial. Anesthesiology. 2018; 128(3): 1099–105. PubMed Abstract | Publisher Full Text

215. White PF, Tang J, Song D, et al.: Transdermal scopolamine: An alternative to ondansetron and droperidol for the prevention of postoperative and postdischarge emetic symptoms. Anesth Analg. 2007; 104(1): 52–62. PubMed Abstract | Publisher Full Text

216. Apfel CC, Zhang K, George E, et al.: Transdermal scopolamine for the prevention of postoperative nausea and vomiting: A systematic review and meta-analysis. Clin Ther. 2010; 32(12): 1987–2002. PubMed Abstract | Publisher Full Text

217. Pergolizzi JV, Philip BK, Leslie JB, et al.: Perspectives on transdermal scopolamine for the treatment of postoperative nausea and vomiting. J Clin Anaesth. 2012; 24(4): 334–45. PubMed Abstract | Publisher Full Text

218. Kassel L, Nebel M, Chrien J, et al.: Scopolamine Use in the Perioperative Patient: A Systematic Review. AORNJ. 2018; 108(3): 287–95. PubMed Abstract | Publisher Full Text

219. Cangemi DJ, Kuo B: Practical Perspectives in the Treatment of Nausea and Vomiting. J Clin Gastroenterol. 2019; 53(3): 170–8. PubMed Abstract | Publisher Full Text

220. Suzuki T, Inokuchi R, Hanaoka K, et al.: Dexamethasone use during epiduroscopy reduces fentanyl use and postoperative nausea and vomiting: A single-center retrospective study. SAGE Open Med. 2018; 6: 205031218756084. PubMed Abstract | Publisher Full Text | Free Full Text

221. Gong ZY, Liu YF, Wang SS, et al.: Intra-operative Dexamethasone Reduces Early Postoperative Nausea but Not Vomiting in Adult Patients After Gynaecological Laparoscopic Surgery: A Randomised Controlled Trial. Eur J Anaesthesiol. 2016; 33(10): 761–6. PubMed Abstract | Publisher Full Text

222. Jin S, Liang DD, Chen C, et al.: Dexamethasone prevent postoperative nausea and vomiting on patients during general anaesthesia: A PRISMA-compliant meta analysis of randomized controlled trials. Medicine (Baltimore). 2017; 96(11): e5770. PubMed Abstract | Publisher Full Text | Free Full Text

223. Agor J, Nazeri F, Mazzamietti MM, et al.: Effects of gabapentin on postoperative pain, nausea and vomiting after gynaecological hysterectomy: A double blind randomized clinical trial. J Gynaecol Obstet. 2012; 28(3): 677–82. PubMed Abstract | Publisher Full Text | Free Full Text

224. Grant MC, Lee H, Page AJ, et al.: The Effect of Preoperative Gabapentin on Postoperative Nausea and Vomiting: A Meta-Analysis. Anesth Analg. 2016; 122(4): 976–85. PubMed Abstract | Publisher Full Text

225. Agrawal N, Chatterjee C, Khandelwal M, et al.: Comparative study of preoperative use of oral gabapentin, intravenous dexamethasone and their combination in gynaecological procedure. Saudi J Anaesth. 2015; 9(4): 413–7. PubMed Abstract | Publisher Full Text | Free Full Text

226. Tsai KC, Yang YL, Fan PC: Gabapentin for Postoperative Vomiting in Children Requiring Posterior Fossa Tumor Resection. Pediatr Neurol. 2015; 56(3): 351–4. PubMed Abstract | Publisher Full Text | Free Full Text

227. Grant MC, Betz M, Hulse M, et al.: The Effect of Preoperative Pregabalin on Postoperative Nausea and Vomiting: A Meta-analysis. Anesth Analg. 2016; 122(3): 1100–7. PubMed Abstract | Publisher Full Text

228. Wang YM, Xia M, Shan N, et al.: Pregabalin Can Decrease Acute Pain and Postoperative Nausea and Vomiting in Hysterectomy: A Meta-Analysis. Medicine (Baltimore). 2017; 96(31): e7714. PubMed Abstract | Publisher Full Text | Free Full Text

229. White PF, Tufanogullari B, Taylor J, et al.: The effect of pregabalin on perioperative anxiety and sedation levels: A dose-ranging study. Anesth Analg. 2009; 109(4): 1140–5. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

230. Kizilok N, Bilgen S, Menda F, et al.: Comparison of Dexamethasone-Demidhydrinate and Dexamethasone-Ondansetron in Prevention of Nausea and Vomiting in Postoperative Patients. Aesthetic Plast Surg. 2017; 41(1): 204–10. PubMed Abstract | Publisher Full Text

231. Malamood M, Roberts A, Kataria R, et al.: Mirtazapine for symptom control in refractory gastroparesis. Drug Des Devel Ther. 2017; 11: 1035–41. PubMed Abstract | Publisher Full Text | Free Full Text

232. Bhattacharjee D, Dolenam B, Lund J, et al.: Mirtazapine for Postoperative Nausea and Vomiting: Systematic Review, Meta-analysis, and Trial Sequential Analysis. J Perianesth Nurs. 2019; 34(3): 680–90. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

233. Heidari SM, Sarayzadi H, Sargheini M: Effect of intravenous midazolam premedication on postoperative nausea and vomiting after cholecystectomy. Acta Anaesthesiol Taiwan. 2004; 42(2): 77–80. PubMed Abstract

234. Jung S, Park JS, Kim SO, et al.: Prophylactic antiemetic effect of midazolam after middle ear surgery. Otolaryng Head Neck Surg. 2016; 157(5): 753–6. PubMed Abstract | Publisher Full Text

235. Shardashzadeh N, Eshraghi N, Eshraghi A, et al.: Comparison of parenteral promazine versus midazolam effect as a prophylactic medication on postoperative nausea and vomiting after appendectomy. Caspian J Intern Med. 2011; 2(3): 270–3. PubMed Abstract | Publisher Full Text

236. Kranke P, Eberhart LHJ: Possibilities and limitations in the pharmacological management of postoperative nausea and vomiting. Eur J Anaesthesiol. 2011; 28(1): 759–65. PubMed Abstract | Publisher Full Text

237. Honarmand A, Safavi M, Khalili G, et al.: Prophylactic administration of haloperidol plus midazolam reduces postoperative nausea and vomiting better than using each drug alone in patients undergoing middle ear surgery. Saudi J Anaesth. 2012; 6(2): 145–51. PubMed Abstract | Publisher Full Text | Free Full Text

238. Grant MC, Kim J, Page AJ, et al.: The Effect of Intravenous Midazolam on Postoperative Nausea and Vomiting: A Meta-Analysis. Anesth Analg. 2016; 122(3): 656–63. PubMed Abstract | Publisher Full Text

239. Jabeley CS, Gray DW, Budhram GS, et al.: Chronic Anticholinergic Antipsychotic Use Is Associated With Reduced Need for Postoperative Nausea and Vomiting Rescue in the Postanesthesia Care Unit: A Propensity-Matched retrospective Observational Study. Anesth Analg. 2020; 130(1): 141–50. PubMed Abstract | Publisher Full Text | Faculty Opinions Recommendation

240. Kang HY, Park SW, Lee S, et al.: Effect of prophylactic palonosetron and sugammadex on postoperative nausea and vomiting in patients undergoing microsurgical transthyroid surgery under propofol-maintained anaesthesia: A retrospective observational study. Medicine (Baltimore). 2018;
narcotic-vomiting: A randomized controlled clinical study. Int J Nurs Stud. 2018; 87: 40-8.

364. Liu WH, Hao Y, Han Y, et al.: Analysis and Thoughts about the Negative Results of International Clinical Trials on Acupuncture. Evid Based Complement Alternat Med. 2015; 2018: 673742.

365. Christensen KA, Gosses BJ, Hildebrand C, et al.: Acupuncture-Associated Vasovagal Response: Revised Terminology and Hospital Experience. Med Acupunct. 2017; 29(6): 366-70.

366. Gilbert RT, Farish N, Bergland E, et al.: Effect of music on postoperative recovery: A systematic literature review and meta-analysis. J Otorhinolaryngol. 2019: 51808-8694(18):0066-2.

367. Jernigan AM, Chen CCG, Sewell C: Pain after gynecologic surgery: A systematic literature review and meta-analysis of randomized trials. Int J Gynaecol Obstet. 2014; 127(3): 279-82.

368. Darval JH, Handscombe M, Leslie K: Chewing gum for the treatment of postoperative nausea and vomiting: A pilot randomized controlled trial. Br J Anaesth. 2017; 118(1): 83-9.

369. Cardulli A, Saccone G, Di Mascio D, et al.: Effects of music on postoperative recovery: A systematic review and meta-analysis of randomized trials. J Matern Fetal Neonatal Med. 2018; 31(14): 1924-32.

370. Xu C, Peng J, Liu S, et al.: Effect of chewing gum on gastrointestinal function after gynecological surgery: A systematic literature review and meta-analysis. Gastroenterol Res. 2018; 5(6): 336-43.

371. Ge B, Zhao H, Lin R, et al.: Influence of gum-chewing on postoperative bowel activity after laparoscopic surgery for gastric cancer: A randomized controlled trial. Medicine (Baltimore). 2017; 96(13): e6501.

372. Mason KP: Pediatric Sedation Outside of the Operating Room: A Multispecialty International Collaboration. New York: Springer. 2015.

373. Hole J, Hirsch M, Ball E, et al.: Music as an aid for postoperative recovery in adults: A systematic review and meta-analysis. Lancet. 2015; 386(10004): 1659-71.

374. Flanagan DA, Kerin A: Is intraoperative music therapy beneficial to adult patients undergoing general anaesthesia? A systematic review. Anesthesia. 2017; 82(7): 5-13.

375. Nilsson U, Rawal N, Uneståhl LE, et al.: Music therapy and intraoperative nausea-vomiting: A randomized controlled trial. Acta Anaesthesiol Scand. 2001; 45(7): 812-7.

376. Alfred KD, Byers JF, Sole ML: The effect of music on postoperative pain and anxiety. Pain Manag Nurs. 2010; 11(1): 15-25.

377. Caholou M, Hamandi S, Nahki MS, et al.: Effect of music therapy under general anaesthesia in patients undergoing abdominal surgery. Libyan J Med. 2017; 12(1): e126686.

378. Palmer JB, Lane D, Mayo D, et al.: Music as an aid for postoperative nausea and vomiting among high-risk patients. J Music Ther. 2017; 54(3): 259-71.

379. van der Heijden MEJ, Olai Araghi S, van Dijk M, et al.: The effects of perioperative music interventions in pediatric surgery: A systematic review and meta-analysis of randomized controlled trials. PLoS One. 2015; 10(6): e0133608.

380. Sin WM, Chow KM: Effect of Music Therapy on Postoperative Pain Management in Gynecological Patients: A Literature Review. Pain Manag Nurs. 2015; 16(5): e596-7.

381. Maryanda A, Cyna AM, Yip P, et al.: Non-pharmacological interventions for assisting the induction of anaesthesia in children. Cochrane Database Syst Rev. 2013; (6): CD006908.

382. Good M, Anderson GC, Ahn S, et al.: Relaxation and music reduce pain following intestinal surgery. J Evid Based Nurs Health. 2000; 28(3): 240-51.

383. Good M, Anderson GC, Stanton-Hicks M, et al.: Relaxation and music reduce pain after gynecologic surgery. Pain Management Nursing. 2002; 3(2): 61-70.

384. Birns-Turner PG, Wilson LL, Pryor ER, et al.: Perioperative music and its effects on anxiety, hemodynamics, and pain in women undergoing mastectomy. AANJ. 2011; 78(4): Suppl. 521-7.

385. Brinkerink R, Giesche K, Thörn A, et al.: Relaxing music as pre-medication before surgery: A randomised controlled trial. Acta Anaesthesiol Scand. 2009; 53(6): 759-64.

386. Bringman H, Giescke K, Thörn A, et al.: Relaxing music as pre-medication before surgery: A randomised controlled trial. Acta Anaesthesiol Scand. 2009; 53(6): 759-64.

387. Madsen AT, Silverman MJ: The Effect of Music Therapy on Relaxation, Anxiety, Pain Perception, and Nausea in Adult Solid Organ Transplant Patients. J Music Ther. 2017; 54(3): 220-32.

388. Jernigan AM, Chen CCG, Sewell C: Pain after gynecologic surgery: A systematic literature review and meta-analysis of randomized trials. Int J Gynaecol Obstet. 2014; 127(3): 279-82.

389. Çetinkaya F: The effects of listening to music on the postoperative nausea and vomiting. Complement Ther Clin Pract. 2019; 35: 278-83.

390. Gökçek E, Kayadu A: The effects of music therapy in patients undergoing segmental spinal fusion surgery under general anesthesia. Br J Otorhinolaryngol. 2019; 51808-8694(18):0066-2.

391. Kurdi MS, Gasti V: Intraoperative Meditation Music as an Adjunct to Subarachnoid Block for the Improvement of Postoperative Outcomes Following Cesarean Section: A Randomized Placebo-controlled Comparative Study. Anesth Res Essays. 2018; 12(3): 618-24.

392. Çaknayka A, Saritaj S: Effect of classic music on the heart rate and HRV in postoperative patients. J Anesth. 2000; 14(3): 220-32.

393. Johns DE, Gerling V, Pasker-de Jong PC: Music in the recovery room: Effects on postoperative nausea and vomiting. Br J Anaesth. 2017; 118(4): 637-8.

394. Li G, Lin L, Dai F, et al.: Muscular tissue oxygen saturation during robotic hysterectomy and postoperative nausea and vomiting: Exploring the potential therapeutic thresholds. J Clin Monit Comput. 2019; 33(4): 597-604.

395. Guo W, Ding J, Jin X, et al.: Effect of cerebral oxygen saturation on postoperative nausea and vomiting in female laparoscopic surgery patients. Medicine (Baltimore). 2017; 96(41): e2287.

396. Alghamem SM, Massad IM, Rashed EM, et al.: Optimization of anesthesia antiemetic measures versus combination therapy using dexamethasone or ondansetron for the prevention of postoperative nausea and vomiting. Surg Endos. 2010; 24(2): 353-8.

397. Tang J, Chen X, White PF, et al.: Aniemiatrik prophyliaxia for office-based surgery: Are the S-HT3 receptor antagonists beneficiat? Anesthesiology. 2003; 98(2): 293-8.

398. Eberhart LHH, Mauch M, Morin AM, et al.: Impact of a multimodal anti-emetic prophylaxis on patient satisfaction in high risk patients for postoperative nausea and vomiting. Anesthesiology. 2002; 97(10): 1022-7.

399. Joa M, Ben-Menachem E: The effect of multifaceted postoperative nausea and vomiting reduction strategy on prophylaxis administration amongst higher-risk adult surgical patients. Anesth Intensive Care. 2018; 46(2): 185-9.

400. Tabrizi S, Malhotra V, Turnbull ZA, et al.: Implementation of Postoperative Nausea and Vomiting Guidelines for Female Adult Patients Undergoing Anesthesia During Gynecologic and Breast Surgery in an Ambulatory Setting. J Perianesth Nurs. 2019; 34(4): 451-60.

401. Li G, Lin L, Dai F, et al.: Muscular tissue oxygen saturation during robotic hysterectomy and postoperative nausea and vomiting: Exploring the potential therapeutic thresholds. J Clin Monit Comput. 2019; 33(4): 597-604.

402. Walldén J, Flodin J, Hultin M: Does intraoperative music therapy or music as pre-medication before surgery: A randomised controlled trial. Acta Anaesthesiol Scand. 2001; 45(7): 812-7.

403. aktion. Pain Management Nursing. 2018; 29(2): 445-8.

404. van der Heijden MEJ, Olai Araghi S, van Dijk M, et al.: The effects of perioperative music interventions in pediatric surgery: A systematic review and meta-analysis of randomized controlled trials. PLoS One. 2015; 10(6): e0133608.

405. Sin WM, Chow KM: Effect of Music Therapy on Postoperative Pain Management in Gynecological Patients: A Literature Review. Pain Manag Nurs. 2015; 16(5): e596-7.

406. Maryanda A, Cyna AM, Yip P, et al.: Non-pharmacological interventions for assisting the induction of anaesthesia in children. Cochrane Database Syst Rev. 2015; (7): CD006447.

407. Good M, Anderson GC, Ahn S, et al.: Relaxation and music reduce pain following intestinal surgery. J Evid Based Nurs Health. 2000; 28(3): 240-51.

408. Good M, Anderson GC, Stanton-Hicks M, et al.: Relaxation and music reduce pain after gynecologic surgery. Pain Management Nursing. 2002; 3(2): 61-70.

409. Birns-Turner PG, Wilson LL, Pryor ER, et al.: Perioperative music and its effects on anxiety, hemodynamics, and pain in women undergoing mastectomy. AANJ. 2011; 78(4): Suppl. 521-7.
and vomiting in moderate to high-risk patients undergoing craniofacial surgery: A multicentre, open-label, randomised controlled trial. Br J Oral Maxillofac Surg. 2018; 56(8): 739–44.

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424. Hsieh YF, Yang TH, Lee CT, et al.: A comparison of postoperative nausea and vomiting after laparoscopic cholecystectomy: A prospective, randomized, double-blind, placebo-controlled study. J Gastroenterol Hepatol. 2015; 30(4): 661–8.

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1. Joseph V. Pergolizzi
   Naples Anesthesia and Pain Associates - Pain Medicine, Naples, FL, USA
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2. Patrice Forget
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