

INTRODUCTION

- Nausea, the sensation of anticipating vomiting, may occur with or without concomitant dyspepsia, other gastrointestinal (GI) symptoms, or vomiting, which is the forceful expulsion of gastric contents (*Longstreth et al 2021*).
- Chemotherapy-induced nausea and vomiting (CINV) is often viewed as the most severe and distressing form of nausea and vomiting (n/v) that occurs in patients with cancer. Additional causes of n/v in this population include surgery, opioid therapy, and radiation (*Hesketh, 2021; Hesketh 2019*).
- Normal function of the upper GI tract involves interactions between the gut and the central nervous system (CNS), with the motor function of the GI tract being controlled at the level of the parasympathetic and sympathetic nervous systems, enteric brain neurons, and smooth muscle cells (*Longstreth et al 2021*).
- Three distinct types of CINV have been defined, including (*Hesketh 2021, Hesketh 2019*):
 - Acute emesis, which most commonly begins within 1 to 2 hours of chemotherapy and usually peaks in the first 4 to 6 hours
 - Delayed emesis, occurring beyond 24 hours after chemotherapy
 - Anticipatory emesis, occurring prior to treatment as a conditioned response in patients who have developed significant n/v during previous cycles of chemotherapy
- Approximately one-third of surgical patients have nausea, vomiting, or both after receiving general anesthesia, with increased risk associated with the female gender, nonsmoker status, previous history of postoperative n/v (PONV), and use of postoperative opioids (*Longstreth et al 2021*).
- Nausea and/or vomiting caused by radiation therapy (RT) is generally less severe than that caused by chemotherapy. The pathophysiology of radiation-induced n/v (RINV) remains unclear, but it is thought to be similar to that caused by chemotherapy (*Feyer et al 2020*).
- Nausea with or without vomiting is common in early pregnancy. Severe vomiting resulting in dehydration and weight loss is termed hyperemesis gravidarum and occurs less frequently. The treatment goals in patients with nausea and vomiting of pregnancy (NVP) are to reduce symptoms through changes in diet/environment and by medication, to correct consequences or complications of n/v such as dehydration, and to minimize the fetal effects of NVP treatment (*American College of Obstetrics and Gynecologists [ACOG] 2018 [reaffirmed in 2019], Smith et al 2021*).
- Nausea is common in motion sickness and symptoms may also include vomiting and headache. Motion sickness is thought to result from incongruent vestibular, visual, and somatosensory sensory cues (*Priesol 2020*).
- The mechanism of action for the 5-hydroxytryptamine (5-HT₃, or serotonin) agents results from the blockade of 5-HT₃ receptors in both the gastric area and the chemoreceptor trigger zone in the CNS. By blocking these receptors, these medications disrupt the signal to vomit and reduce the sensation of nausea (*Mannix et al 2006*).
- The substance P/neurokinin 1 (NK1) receptor antagonists cross the blood brain barrier and occupy the NK1 receptors in the brain, leading to reduced symptoms of n/v.
- Synthetic delta-9-tetrahydrocannabinol (THC) is the active ingredient in the THC derivative agents, also known as the cannabinoids. Cannabinoid receptors have been discovered in neural tissues, and these receptors may play a role in mediating the antiemetic effects of cannabinoids such as dronabinol and nabilone. These agents, like other cannabinoids, have the potential to be abused and produce psychological dependence. Both dronabinol and nabilone may produce alterations in mood (euphoria, detachment, depression, anxiety) and alterations in reality (distorted perceptions of objects and time and hallucinations).
- The mechanism of action of Diclegis and Bonjesta (doxylamine succinate/pyridoxine hydrochloride [HCl]) are unknown (*Diclegis and Bonjesta prescribing information 2018*).
- Dopamine receptor antagonists, such as prochlorperazine (a phenothiazine) and trimethobenzamide (a benzamide), primarily work by blocking D₂-dopamine receptors in the postrema area of the midbrain. They also have M₁-muscarinic and H₁-histamine antagonizing effects (*Longstreth 2020*). Scopolamine, an anticholinergic drug, is an M₁-muscarinic receptor antagonist. Antihistamines are used for motion sickness (*Longstreth 2020*).

- The 5-HT₃ receptor antagonists are Food and Drug Administration (FDA)-approved for the treatment of CINV, PONV, and/or RINV, although the medications and various dosage forms of each agent differ slightly with respect to these indications.
- The D₂ antagonist Barhemsys (amisulpride) is FDA-approved for treatment and prevention of PONV.
- The substance P/NK1 receptor antagonists are currently FDA-approved for the prevention of CINV. In addition, aprepitant is approved for the prevention of PONV.
- The combination product, Akynzeo, contains palonosetron, a 5-HT₃ receptor antagonist, and a substance P/NK1 receptor antagonist: netupitant in the oral formulation and fosnetupitant in the injectable formulation. This agent is approved for prevention of acute and delayed n/v associated with initial and repeat courses of cancer chemotherapy.
- Diclegis and Bonjesta are fixed-dose combination products of doxylamine succinate, an antihistamine, and pyridoxine HCl, a vitamin B6 analog. Diclegis and Bonjesta are indicated for the treatment of NVP in women who do not respond to conservative management. It should be noted that these agents have not been studied in hyperemesis gravidarum.
 - The combination of doxylamine and pyridoxine was previously available in the United States under the brand name Bendectin. However, this product was removed from the market in 1983 due to lawsuits alleging teratogenicity despite scientific evidence of the safety and efficacy of the medication. A meta-analysis (MA) of controlled studies on outcome of pregnancies exposed to Bendectin reported no increase in the incidence of birth defects (*Smith et al 2021*).
- Prescription meclizine is FDA-approved for vertigo; however, over-the-counter products are used for n/v and dizziness associated with motion sickness. Transdermal scopolamine is FDA-approved for n/v associated with motion sickness and for PONV. Prochlorperazine is FDA-approved for treatment of severe n/v, promethazine is approved for motion sickness and n/v associated with certain anesthesia and surgery, and trimethobenzamide is approved for PONV and nausea related to gastroenteritis.
- The scope of this review will focus on the agents outlined in Table 1 for their respective FDA-approved indications as related to CINV, PONV, or n/v associated with other conditions such as pregnancy and motion sickness, with a focus on CINV. Other agents including glucocorticoids may also be effective antiemetics; however, they have been excluded from this review. Although certain agents are FDA-approved for other indications, only those related to n/v are included in this review.
- Medispan Therapeutic Class: 5-HT₃ Receptor Antagonists; Dopamine Antagonist; Substance P/NK1 Receptor Antagonists; Antiemetics – Miscellaneous; Antiemetic Combinations – Two Ingredient.

Table 1. Medications Included Within Class Review

Drug	Generic Availability
Akynzeo (palonosetron/netupitant) capsule	–
Akynzeo (palonosetron/fosnetupitant) IV solution	–
Aloxi (palonosetron) IV solution	✓
Anzemet (dolasetron) tablets*	
Barhemsys (amisulpride) IV solution	–
Bonjesta (doxylamine succinate/pyridoxine HCl) 20 mg extended-release tablets	–
Cesamet (nabilone) capsule*	–
Cinvanti (aprepitant) IV emulsion	–
Compro (prochlorperazine) rectal suppository	✓
Diclegis (doxylamine succinate/pyridoxine HCl) 10 mg delayed-release tablets	✓
Emend (aprepitant) oral suspension	–
Emend (aprepitant) capsule, combination pack	✓
Emend (fosaprepitant) IV solution	✓
granisetron injection, tablets	✓ ‡
Marinol (dronabinol) capsule	✓
meclizine over-the-counter products	✓
ondansetron injection	✓ ‡
Phenergan (promethazine) injection	✓
prochlorperazine injection, tablet	✓
Promethegan (promethazine) rectal suppository	✓

Drug	Generic Availability
promethazine injection, tablet, syrup, oral solution	✓
Sancuso (granisetron) transdermal patch	—
Sustol (granisetron) extended-release subcutaneous injection	—
Syndros (dronabinol) oral solution	—
Tigan (trimethobenzamide) capsule	✓
Tigan (trimethobenzamide) injection	-
Transderm Scop (scopolamine) transdermal film	✓
Varubi (rolapitant) tablet†	—
Zofran (ondansetron) oral solution, tablet	✓ ‡
Zofran (ondansetron) ODT	✓ ‡
Zuplenz (ondansetron) oral soluble film	—

Abbrev: IV=intravenous, ODT=orally disintegrating tablet

*This product has been discontinued in most, but not all strengths.

‡Generic available in at least 1 dosage form and/or strength.

†The FDA website shows the IV rolapitant product as discontinued. The manufacturer of IV rolapitant suspended further distribution of the product in February 2018 due to reports of anaphylaxis, anaphylactic shock, and other serious hypersensitivity reactions associated with its use.

|| Marinol brand has been discontinued, but generic dronabinol is available.

(*Drugs@FDA 2021, Orange Book: Approved Drug Products with Therapeutic Equivalence Evaluations 2021*)

INDICATIONS
Table 2. Food and Drug Administration Approved Indications

Indication	5-HT ₃ Receptor Antagonists				D ₂ antagonist	Substance P/NK ₁ Receptor Antagonists			THC Derivatives		Combination Products	
	Dolasetron	Granisetron	Ondansetron	Palonosetron	Amisulpride	Aprepitant	Fosaprepitant	Rolapitant	Dronabinol	Nabilone	Palonosetron/ netupitant (oral) fosnetupitant (IV)	Doxylamine succinate/ pyridoxine HCl
	Anorexia in patients with AIDS											
Anorexia associated with weight loss in adults with AIDS									✓			
	CINV											
N/V associated with cancer chemotherapy in patients who have failed to respond adequately to conventional antiemetic treatments									✓	✓		
Highly emetogenic cancer chemotherapy (HEC) – prevention of acute n/v associated with initial and repeat courses in adults				✓								
Prevention of acute and delayed n/v associated with initial and repeat courses of HEC including high-dose cisplatin in patients ≥ 6 months of age						✓ * (oral suspension)	✓ *					
Prevention of acute n/v associated with initial and repeat courses of emetogenic chemotherapy, including HEC in pediatric patients aged 1 month to < 17 years				✓								
Prevention of acute and delayed n/v associated with initial and repeat courses of HEC, including high-dose cisplatin as a single dose regimen, in adults						✓ * (IV emulsion)						
Prevention of acute and delayed n/v associated with initial and repeat courses of cancer chemotherapy, including, but not limited to, HEC in combination with dexamethasone											✓ (capsule)	

Indication	5-HT ₃ Receptor Antagonists				D ₂ antagonist	Substance P/NK ₁ Receptor Antagonists			THC Derivatives		Combination Products	
	Dolasetron	Granisetron	Ondansetron	Palonosetron	Amisulpride	Aprepitant	Fosaprepitant	Rolapitant	Dronabinol	Nabilone	Palonosetron/ netupitant (oral) fosnetupitant (IV)	Doxylamine succinate/ pyridoxine HCl
Prevention of acute and delayed n/v associated with initial and repeat courses of HEC in combination with dexamethasone											✓* (IV)	
Prevention of acute and delayed n/v associated with initial and repeat courses of HEC, including high-dose cisplatin, in patients ≥ 12 years of age						✓* (capsule)						
Prevention of delayed n/v associated with initial and repeat courses of emetogenic cancer chemotherapy, including, but not limited to, HEC								✓*				
Prevention of n/v associated with HEC including cisplatin ≥ 50 mg/m ²			✓ (tablet, ODT, oral solution, oral soluble film)									
Prevention of n/v associated with initial and repeat courses of emetogenic cancer chemotherapy, including high-dose cisplatin		✓ (injection, tablets)										
Prevention of n/v associated with initial and repeat courses of emetogenic cancer chemotherapy, including high-dose cisplatin, in patients ≥ 6 months of age			✓ (injection)									
Moderately emetogenic cancer (MEC) chemotherapy – prevention of n/v associated with initial and repeat courses in adults				✓								
Prevention of n/v in patients receiving MEC and/or HEC for up to 5 consecutive days		✓ (TD)										
Prevention of n/v associated with initial and repeat courses of MEC			✓									

Indication	5-HT ₃ Receptor Antagonists				D ₂ antagonist	Substance P/NK ₁ Receptor Antagonists			THC Derivatives		Combination Products	
	Dolasetron	Granisetron	Ondansetron	Palonosetron	Amisulpride	Aprepitant	Fosaprepitant	Rolapitant	Dronabinol	Nabilone	Palonosetron/netupitant (oral) fosnetupitant (IV)	Doxylamine succinate/ pyridoxine HCl
			(tablet, ODT, oral solution, oral soluble film)									
Prevention of n/v associated with MEC, including initial and repeat courses in ages ≥ 2 years	✓											
Prevention of n/v associated with initial and repeat courses of MEC, in patients ≥ 6 months of age						✓ (oral suspension)						
Prevention of acute and delayed n/v associated with initial and repeat courses of MEC or anthracycline and cyclophosphamide combination chemotherapy regimens.		✓ * (ER injection)										
Prevention of delayed n/v associated with initial and repeat courses of MEC in patients ≥ 6 months of age							✓ *					
Prevention of n/v associated with initial and repeat courses of MEC in patients ≥ 12 years of age						✓ * (capsule)						
Prevention of n/v associated with initial and repeat courses of MEC as a 3 day regimen, in adults						✓ * (IV emulsion)						
Prevention of delayed n/v associated with initial and repeat courses of MEC as a single dose regimen, in adults						✓ * (IV emulsion)						
	NVP											
Treatment of NVP in women who do not respond to conservative management												✓
	PONV											
Prevention of PONV for up to 24 hours following surgery; efficacy beyond 24 hours has not been				✓								

Indication	5-HT ₃ Receptor Antagonists				D ₂ antagonist	Substance P/NK ₁ Receptor Antagonists			THC Derivatives		Combination Products		
	Dolasetron	Granisetron	Ondansetron	Palonosetron	Amisulpride	Aprepitant	Fosaprepitant	Rolapitant	Dronabinol	Nabilone	Palonosetron/netupitant (oral)	fosnetupitant (IV)	Doxylamine succinate/pyridoxine HCl
demonstrated; as with other antiemetics, routine prophylaxis is not recommended for patients in whom there is little expectation that n/v will occur post-operatively. In patients where n/v must be avoided postoperatively, Aloxi injection is recommended even where the incidence of PONV is low													
Prevention of PONV in adults			✓ (tablet, ODT, oral solution)			✓ (generic aprepitant only)							
Prevention and treatment of PONV; as with other antiemetics, routine prophylaxis is not recommended for patients in whom there is little expectation that n/v will occur post-operatively. In patients where n/v must be avoided postoperatively, this drug is recommended even where the incidence of PONV is low.		✓ (injection)			✓								
Prevention of PONV; as with other antiemetics, routine prophylaxis is not recommended for patients in whom there is little expectation that n/v will occur post-operatively. In patients where n/v must be avoided postoperatively, this drug is recommended even where the incidence of PONV is low.			✓ (injection [†] , oral soluble film)										
RINV													
Prevention of n/v associated with RT, including TBI and fractionated abdominal RT		✓ (tablets)											
Prevention of n/v associated with radiotherapy in patients receiving either TBI, single high-dose			✓ (tablet, ODT, oral solution,										

Indication	5-HT ₃ Receptor Antagonists				D ₂ antagonist	Substance P/NK ₁ Receptor Antagonists			THC Derivatives		Combination Products		
	Dolasetron	Granisetron	Ondansetron	Palonosetron	Amisulpride	Aprepitant	Fosaprepitant	Rolapitant	Dronabinol	Nabilone	Palonosetron/netupitant (oral)	fosnetupitant (IV)	Doxylamine succinate/pyridoxine HCl
fraction to the abdomen, or daily fractions to the abdomen			oral soluble film)										

Abbrev: 5-HT₃ = serotonin (5-hydroxytryptamine) 3 receptor, AIDS = acquired immunodeficiency syndrome, ER = extended release, HEC = highly emetogenic cancer chemotherapy, MEC = moderately emetogenic cancer chemotherapy, n/v = nausea/vomiting, NVP = nausea and vomiting of pregnancy, NK₁ = neurokinin 1, ODT = orally disintegrating tablet, PONV = postoperative nausea and vomiting, RINV = radiation-induced nausea and vomiting, RT = radiation therapy, TBI = total body irradiation, TD = transdermal patch, THC = delta-9-tetrahydrocannabinol

* When used in combination with other antiemetic agents.

† For patients who do not receive prophylactic ondansetron injection and experience n/v postoperatively, ondansetron injection may be given to prevent further episodes.

* Not studied for prevention of n/v associated with anthracycline plus cyclophosphamide chemotherapy.

Table 2 (cont.) Food and Drug Administration Approved Indications.

Indication	Antihistamine	Phenothiazines		Anticholinergic	Benzamide
	Mecizine	Promethazine	Prochlorperazine	Scopolamine	Trimethobenzamide
PONV					
Treatment of PONV					✓ † (capsules, injection)
Prevention and control of n/v associated with certain types of anesthesia and surgery		✓ * (injection, suppository,			

		solution, syrup, tablet)			
Antiemetic therapy in postoperative patients		✓ ‡ (suppository, solution, syrup, tablet)			
Prevention of PONV associated with recovery from anesthesia and/or opiate analgesia and surgery				✓	
Motion Sickness					
Prevents and treats n/v or dizziness associated with motion sickness	✓ *				
Prevention of n/v associated with motion sickness				✓	
Active treatment of motion sickness		✓ ‡ (injection)			
Active and prophylactic treatment of motion sickness		✓ ‡ (suppository, solution, syrup, tablet)			
Nausea associated with gastroenteritis					
Nausea associated with gastroenteritis					✓ † (capsules, injection)
Severe nausea and vomiting					
Control of severe n/v			✓ ** (tablets, injection, suppository)		

Abbrv: n/v = nausea and vomiting, FDA = Food and Drug Administration; ODT = orally disintegrating tablets, PONV = postoperative nausea and vomiting

*Antivert (meclizine) is FDA-approved for treatment of vertigo; however, over-the-counter meclizine prevents and treats nausea, vomiting or dizziness associated with motion sickness.

†Tigan not recommended to use in pediatric patients due to risk of extrapyramidal signs and symptoms, other CNS effects, and risk of exacerbating underlying disease in patients with Reye's syndrome or other hepatic impairment.

‡Promethazine is also FDA-approved for multiple indications including those related to allergic conditions, surgical analgesia, and sedation.

**Prochlorperazine is also FDA-approved for treatment of schizophrenia and anxiety.

(Prescribing information: Akynzeo 2020, Aloxi 2020, Antivert 2019, Anzemet tablets 2019, Barhemsys 2020, Bonjesta 2018, Cesamet 2020, Cinvanti 2019, Compro 2016, Diclegis tablets 2018, Emend capsules and oral suspension 2021, Emend for injection 2020, granisetron injection 2020, granisetron tablets 2019, Marinol 2017, meclizine chewable tablets 2020, meclizine soluble film 2021, meclizine tablets ODT 2020, ondansetron injection 2019, Promethagan suppository 2014, prochlorperazine injection 2020, prochlorperazine tablets 2018, promethazine injection 2016, promethazine oral solution 2019, promethazine syrup 2018, promethazine tablets 2019, Sancuso 2020, Sustol 2017, Syndros 2020, Tigan capsules 2017, Tigan injection 2016, Transderm Scop 2020, Varubi 2020, Zofran tablets ODT oral solution 2017, Zuplenz 2019)



- Information on indications, mechanism of action, pharmacokinetics, dosing, and safety has been obtained from the prescribing information for the individual products, except where noted otherwise.

CLINICAL EFFICACY SUMMARY

Anorexia in patients with AIDS

- A 2015 MA (N = 6,462; 79 trials) evaluated the efficacy and safety of cannabinoids in various conditions, including appetite stimulation in HIV/AIDS. Most trials were of low to moderate quality and compared cannabinoids to usual care, placebo, or no treatment across trials. Compared with placebo, cannabinoids were associated with a higher proportion of patients demonstrating a complete n/v response (47% vs 20%; odds ratio [OR], 3.82; 95% confidence interval [CI], 1.55 to 9.42; 3 trials), reduction in pain (37% vs 31%; OR, 1.41; 95% CI, 0.99 to 2.00; 8 trials), and a greater average reduction in numerical rating scale pain assessment (on a 0 to 10 point scale; weighted mean difference [WMD], -0.46; 95% CI, -0.80 to -0.11; 6 trials). A total of 4 trials evaluated dronabinol for appetite stimulation in 255 patients with HIV infection or AIDS, key outcomes are outlined below (*Abrams et al 2003, Timpone et al 1997, Whiting et al 2015*):
 - Data from 1 small study (n = 139, of which only 88 were evaluable) demonstrated that a large proportion of patients experienced weight gain of ≥ 2 kg within 6 weeks vs placebo (OR, 2.2; 95% CI, 0.68 to 7.27). An active comparison trial found that meggestrol acetate was associated with greater weight gain than dronabinol and that combining dronabinol with meggestrol acetate did not lead to additional weight gain.
- A 2013 MA of 7 trials, mostly of poor quality, found similar results as *Whiting et al*. Randomized controlled trials (RCTs) included any cannabis intervention and were of a short duration, ranging from 21 to 84 days. Patients had a mean weight gain in the dronabinol group of 0.1 kg, compared with a weight loss of 0.4 kg in the placebo group (*Lutge et al 2013*).

CINV

- For the management of CINV, MAs and head-to-head trials have demonstrated that the cannabinoids, dronabinol and nabilone, are more effective compared to placebo and may be more effective than prochlorperazine and metoclopramide. There are no published clinical trials comparing dronabinol to nabilone for CINV. The effectiveness of Syndros (dronabinol) oral solution for its FDA-approved indications was based on studies of dronabinol capsules.
- In a study by *Lane et al*, the combination of dronabinol plus prochlorperazine significantly reduced the mean duration of vomiting per episode compared to either agent administered with placebo (*Lane et al 1991*).
- Dolasetron has been shown to be an effective therapy in the treatment of CINV in comparative studies with palonosetron, ondansetron, and placebo (*Eberhart et al 2004, Eisenberg et al 2003, Karamanlioglu et al 2003, Lofters et al 1997, Meyer et al 2005, Walker et al 2001*).
- Granisetron and ondansetron are generally recognized as equally efficacious in treating CINV and PONV. Various studies may show slight benefits of 1 over another, but this has not been a consistently proven outcome (*Billio et al 2010, Dabbous et al 2010, del Giglio et al 2000, Dempsey et al 2004, Gan et al 2005, Jaing et al 2004, Kalaycio et al 1998, Lacerda et al 2000, Orchard et al 1999, White et al 2006*).
- Sancuso (granisetron) patch was noninferior to orally administered granisetron for CINV in a randomized trial (*Boccia et al 2011*). However, a MA of 3 studies found oral granisetron significantly reduced the odds of CINV compared with transdermal granisetron (*Chua et al 2020*).
- Palonosetron was reported to be more effective than other medications in the class as well as placebo, particularly at preventing delayed emesis (*Aapro et al 2005, Billio et al 2010, Botrel et al 2011, Dong et al 2011, Eisenberg et al 2003, Gralla et al 2003, Kaushal et al 2010, Likun et al 2011, Massa et al 2009, Suzuki et al 2016, Chow et al 2018, Matsumoto et al 2020*).
- The safety and efficacy of Sustol (granisetron) were evaluated in a pivotal Phase 3, double-blind (DB), double-dummy, multicenter (MC), RCT in adults receiving HEC or MEC (*Raftopoulos et al 2015[a], Raftopoulos et al 2015[b]*). In the modified intention-to-treat population, both granisetron ER 5 mg and 10 mg were noninferior to palonosetron in preventing acute CINV after HEC and MEC. The FDA-approved dose of granisetron ER 10 mg was noninferior to palonosetron in preventing delayed CINV after MEC and was not superior in preventing delayed CINV after HEC (*Raftopoulos et al 2015[a], Raftopoulos et al 2015[b]*).
- All of the 5-HT₃ receptor antagonists have been shown to be equally effective in preventing acute CINV in separate MAs and are superior to placebo (*Billio et al 2010, del Giglio et al 2000, George et al 2009, Singhal et al 2012, Tang et al 2012*). A 2016 MA comparing ondansetron to other 5-HT₃ receptor antagonists used for CINV found that ondansetron exhibited similar efficacy to granisetron, but greater efficacy than dolasetron for acute vomiting; palonosetron exhibited greater efficacy than ondansetron for delayed nausea and acute and delayed vomiting (*Simino et al 2016*).

- A 2016 Cochrane review found that 5-HT₃ receptor antagonists are effective in children who receive emetogenic chemotherapy. Granisetron or palonosetron may be more effective than ondansetron, and the addition of dexamethasone improves vomiting symptoms (*Phillips et al 2016*).
- A randomized, DB, noninferiority study comparing single-dose palonosetron 20 mcg/kg to multi-dose ondansetron 150 mcg/kg x 3 doses for the prevention of CINV in pediatric patients, aged 0 to 17 years, receiving MEC or HEC found that palonosetron was noninferior to ondansetron in the acute phase (0 to 24 hours post chemotherapy) (*Kovacs et al 2016*). A randomized, DB study in pediatric patients, aged 0 to 18 years, receiving HEC found complete response rates were not significantly different during the acute phase between palonosetron 5 mcg/kg, 10 mcg/kg and ondansetron 150 mcg/kg x 3 doses (*Tan et al 2018*). Palonosetron 10 mcg/kg was superior to ondansetron and palonosetron 5 mcg/kg in the delayed phase. In a randomized, open-label study, palonosetron was found to be noninferior and cost-effective in comparison to ondansetron for the prevention of acute CINV in children (2 to 18 years of age) with cancer (*Jain et al 2018*).
- A randomized, DB study in patients receiving HEC found that when used as part of combination therapy with dexamethasone and aprepitant, palonosetron IV was not more efficacious than granisetron IV at overall prevention of CINV. Combination therapy with palonosetron was, however, more efficacious than granisetron in controlling CINV in the delayed phase (24 to 120 hours post chemotherapy) (*Suzuki et al 2016*).
- A phase 3, randomized, DB trial compared oral with IV palonosetron in cancer patients receiving MEC (*Cui et al 2020*). The primary endpoint, complete response rate in the acute phase, was not significantly different between treatment arms, and the authors concluded oral palonosetron was noninferior to IV palonosetron.
- One MC, DB, RCT evaluated dexamethasone compared to aprepitant in the prophylaxis of delayed CINV in patients with breast cancer who received chemotherapy containing anthracyclines and cyclophosphamide and the same antiemetic prophylaxis regimen. The primary endpoint was rate of complete response (ie, no vomiting or rescue treatment) from days 2 to 5 after chemotherapy. The results showed similar efficacy and toxicity between dexamethasone and aprepitant in the prevention of delayed emesis (*Roila et al 2014*).
- Aprepitant has been shown to be effective for the treatment of CINV as monotherapy and in combination with various 5-HT₃ antagonists and/or dexamethasone (*Herrington et al 2008, Rapoport et al 2010, Yeo et al 2009, Herrstedt et al 2005, Warr et al 2005, Gralla et al 2005, De Wit et al 2004, Poli-Bigelli et al 2003, Hesketh et al 2003, Martin et al 2003, Gore et al 2009, Jordan et al 2009, Grunberg et al 2009*).
- Oral aprepitant- and IV fosaprepitant-based regimens were compared in a phase 3, randomized, DB trial for the prevention of CINV in patients treated with cisplatin-based chemotherapy (*Zhang et al 2020*). The primary endpoint, complete response during the overall phase, was not significantly different between treatment arms, and the authors concluded the IV fosaprepitant-based regimen was noninferior to the oral aprepitant-based regimen.
- In combination regimens with granisetron and dexamethasone, rolapitant has been shown to be more effective than placebo for the prevention of CINV due to MEC and HEC in clinical trials (*Rapoport et al 2015, Schwartzberg et al 2015*). In combinations with 5-HT₃ antagonists and dexamethasone, addition of rolapitant has also been shown to be more effective at preventing CINV over multiple cycles of MEC or HEC, when compared to similar combinations without rolapitant (*Rapoport et al 2016*).
- The fixed-dose combination palonosetron and netupitant + dexamethasone has been shown to be significantly superior to each agent administered individually for CINV prevention following MEC (*Aapro et al 2014*); however, results from another study for CINV prevention revealed similar efficacy between the fixed-dose combination and each agent administered individually with dexamethasone (*Gralla et al 2014*). **In a small pilot study, palonosetron/netupitant was no better than placebo in treating chronic nausea in patients with cancer (*Hui et al 2021*).**
- In a small study, *Meiri et al* reported that dronabinol and ondansetron were similarly effective for the management of delayed CINV, but combination therapy with these 2 agents was not more effective than either agent alone (*Meiri et al 2007*).
- Trimethobenzamide has limited data supporting its use in CINV (*Hurley and Eshelman 1980*).
- In a large MA (13 dronabinol studies and 16 nabilone studies), treatment with cannabinoids was more effective for complete control of nausea in the first 24 hours of chemotherapy compared to alizapride, chlorpromazine, domperidone, haloperidol, metoclopramide, prochlorperazine, or thiethylperazine (relative risk [RR], 1.38; 95% confidence interval [CI], 1.18 to 1.62; number needed to treat [NNT] = 6) and for complete control of vomiting (RR, 1.28; 95% CI, 1.08 to 1.51; NNT = 8). Of note, cannabinoids were not more effective compared to other agents when the chemotherapy regimen was of very high- or very low-emetogenic risk (*Tramèr et al 2001*).

- In a second MA, authors concluded that with regard to antiemetic efficacy, dronabinol was no more effective compared to placebo (RR, 0.47; 95% CI, 0.19 to 1.16; $p = 0.1$) but was more effective compared to neuroleptics (RR, 0.67; 95% CI, 0.47 to 0.96; NNT = 3.4). Nabilone was not more effective than neuroleptics (RR, 0.88; 95% CI, 0.72 to 1.08; $p = 0.21$). With regard to patient preference and tolerability, cannabinoids were preferred over other study agents (RR, 0.33; 95% CI, 0.24 to 0.44; $p < 0.00001$; NNT = 1.8) (*Machado Rocha et al 2008*).
- In a MA of 23 RCTs (11 dronabinol studies and 12 nabilone studies), compared to placebo, treatment with cannabinoids resulted in a higher chance of reporting complete absence of *n/v* (RR, 2.9; 95% CI, 1.8 to 4.7; 3 studies); however, patients were more likely to withdraw due to an adverse event compared to placebo (2 trials; RR, 6.9; 95% CI, 1.96 to 24) and compared to prochlorperazine (RR, 3.9; 95% CI, 1.3 to 12; 5 studies). The proportion of patients who reported absence of *n/v* was not different between cannabinoids and prochlorperazine (*Smith et al 2015*).

NVP

- In a MA on interventions for hyperemesis gravidarum, drowsiness, dizziness, and dystonia were experienced by more women treated with promethazine compared to metoclopramide in a single study. In another study, duration of hospital admission was not different between promethazine and ondansetron, but sedation was more common with promethazine (*Boelig et al 2016*).
- FDA-approvals of Diclegis and Bonjesta (doxylamine succinate/pyridoxine HCl) were based on 1 DB, randomized, multi-center, placebo-controlled study that evaluated the safety and efficacy of doxylamine succinate/pyridoxine HCl in pregnant adult women in the gestational age range of 7 to 14 weeks with *n/v*. Patients (N = 298) were randomized to 14 days of placebo or 2 tablets daily at bedtime and up to a maximum dose of 4 tablets of doxylamine succinate/pyridoxine HCl. Doxylamine succinate/pyridoxine hydrochloride treatment resulted in a statistically significant improvement in both the symptom and quality of life domains of the Pregnancy Unique-Quantification of Emesis (PUQE) score. There was a 4.8 point mean decrease from baseline in the symptom domain PUQE score at day 15 in the doxylamine succinate/pyridoxine HCl group compared to 3.9 point decrease in the placebo group ($p = 0.006$). For quality of life, there was also a 2.8 point mean increase from baseline in the score at day 15 in the Diclegis group compared to a 1.8 point decrease in the placebo group ($p = 0.005$) (*Koren et al 2010*).
 - A follow-up analysis of this trial was conducted in 2015 to evaluate the maternal safety of doxylamine/pyridoxine as compared to placebo. Based on the results of this analysis, doxylamine/pyridoxine was not associated with an overall increased in rate of adverse effects as compared to placebo (*Koren et al 2015*).

PONV

- A Cochrane network meta-analysis of drugs for PONV concluded with high certainty that aprepitant (RR, 0.26; 95% CI, 0.18 to 0.38), granisetron (RR, 0.45; 95% CI, 0.38 to 0.54), and ondansetron (RR, 0.55; 95% CI, 0.51 to 0.60) effectively reduce vomiting, and with moderate certainty that fosaprepitant (RR, 0.06; 95% CI, 0.51 to 0.60) and droperidol (RR, 0.61, 95% CI, 0.54 to 0.69) also effectively reduce vomiting. Monotherapy with NK1 receptor antagonists was found to be as effective as other drugs used in combination, but in general, combination therapy was more effective than monotherapy in preventing vomiting. There was a lack of certainty in safety analyses with the individual drugs that were found to be effective, although the authors concluded that droperidol probably reduces headache compared to placebo (RR, 0.76; 95% CI, 0.67 to 0.86) (*Weibel et al 2020*).
- In a MA, palonosetron was shown to be more effective for prevention of early and late postoperative nausea and late postoperative vomiting compared to ondansetron (*Xiong et al 2015*).
- A 2016 MA found that when compared to other 5-HT₃ antagonists and NK1 antagonists, aprepitant reduces incidence of PONV, and need for rescue medications (*Singh et al 2016*).
- In prevention of PONV, amisulpride was studied in 2 randomized, DB, placebo-controlled trials (*Barhemsys prescribing information 2020, Gan et al 2017, Kranke et al 2018*). In one study, patients received amisulpride monotherapy; in another, patients received amisulpride in combination with IV ondansetron, dexamethasone, or betamethasone. The primary endpoint, complete response within the first 24 postoperative hours, was significantly improved with amisulpride in both trials.
- In treatment of PONV, amisulpride was studied in 2 unpublished randomized, DB, placebo-controlled trials (*Barhemsys prescribing information 2020, Candiotti et al 2020, Habib et al 2020*). In one study, patients received no PONV prophylaxis; in another, patients received and failed PONV prophylaxis with an antiemetic of another class. The primary

endpoint, complete response within the first 24 postoperative hours, was significantly improved with amisulpride in both trials.

RINV

- There are very few trials evaluating the prevention of RINV, and trials generally include patients with moderate to high risk RINV. The 5-HT₃ receptor antagonists are the only agents in class which have demonstrated efficacy, and of these, only ondansetron and granisetron are FDA-approved.
- One DB, active-comparator trial compared oral ondansetron 8 mg to oral granisetron 2 mg in 34 bone marrow transplant patients receiving TBI, which is associated with high emetogenic risks. The study was only powered to demonstrate a difference between each active treatment groups and historical controls. In the intention-to-treat population, significantly more patients given granisetron (33.3%) or ondansetron (26.7%) had zero emetic episodes over 4 days, the primary efficacy end point, than those within the historical control group (0%) ($p < 0.01$) (*Spitzer et al 2000*).
- In a MA of 9 trials, fewer patients had residual emesis with 5-HT₃ receptor antagonists compared with placebo (40% vs 57%; RR, 0.7; 95% CI, 0.57 to 0.86), and fewer required rescue medication (6.5% vs 36%; RR, 0.18; 95% CI, 0.05 to 0.60). Despite treatment, most patients did develop RT-induced nausea (70% vs 83%; RR 0.84; 95% CI, 0.73 to 0.96) (*Salvo et al 2012*).

Motion Sickness

- In a MA of 14 studies, scopolamine prevented symptoms of motion sickness more effectively than placebo (RR 0.48; 95% CI, 0.32 to 0.73), but conclusions could not be made regarding its efficacy compared to antihistamines and calcium channel blockers (*Spinks and Wasiaik 2011*).

CLINICAL GUIDELINES

- The 5-HT₃ receptor antagonists are considered part of the standard of care in the management of CINV due to chemotherapeutic agents with moderate-to-high emetic risk, RINV, and PONV. Treatment of CINV, RINV or PONV generally involves the use of multiple agents that affect different receptor types (*American Gastroenterological Association [AGA] 2001, Herrstedt et al 2017, Hesketh et al 2021, Gan et al 2020, Gupta et al 2016, NCCN 2021, Roila et al 2010*).
- The 2016 expert opinion statement from the American Society for Enhanced Recovery (ASER) for the prophylaxis and management of PONV provides the following recommendations (*Gupta et al 2016*):
 - All patients should receive PONV prophylaxis during the perioperative period.
 - The number of risk factors should determine the number of medications used for treatment and prophylaxis for PONV.
- The 2021 American Society of Clinical Oncology (ASCO) antiemetic guidelines recommend the following for CINV (*Hesketh et al 2021*):
 - For the prevention of n/v induced by HEC, a 4 drug combination of an NK1 receptor antagonist, a 5-HT₃ receptor antagonist, dexamethasone, and olanzapine is recommended as first-line therapy.
 - For MEC, other than carboplatin area under the curve (AUC) ≥ 4 mg/mL/min, a 2-drug combination of a 5-HT₃ receptor antagonist and dexamethasone is recommended.
 - For MEC that includes carboplatin AUC ≥ 4 mg/mL/min, a 3-drug combination of a NK1 receptor antagonist, a 5-HT₃ receptor antagonist, and dexamethasone is recommended.
 - For children receiving HEC, a 3-drug combination of a 5-HT₃ receptor antagonist, dexamethasone, and aprepitant or fosaprepitant is recommended. A 2-drug regimen of a 5-HT₃ receptor antagonist and dexamethasone can be used if aprepitant or fosaprepitant cannot be given; palonosetron and aprepitant or fosaprepitant can be used if dexamethasone cannot be given.
 - For children receiving MEC, a 2-drug combination of a 5-HT₃ receptor antagonist and dexamethasone. If dexamethasone cannot be used, a 2-drug combination of a 5-HT₃ receptor antagonist and aprepitant or fosaprepitant is recommended.
 - Cannabinoids (eg, nabilone, dronabinol) are not listed as appropriate first-line antiemetics for any group of patients receiving chemotherapy of high to low emetic risk. These agents can be used in conjunction with standard regimens for patients who continue to have symptoms despite optimal prophylaxis (including use of olanzapine).
 - Dopamine receptor antagonists (eg, prochlorperazine, metoclopramide) are included as agents that may be added on to regimens for patients who experience n/v despite optimal prophylaxis.

- The 2021 National Comprehensive Cancer Network (NCCN) antiemesis guideline recommends the following regimens for prevention of CINV depending on emetic risk (order does not imply preference) (NCCN 2021):
 - For high emetic risk IV chemotherapy on day 1: 1) NK-1 receptor antagonist, 5-HT3 receptor antagonist, plus dexamethasone; 2) olanzapine, palonosetron, plus dexamethasone; 3) olanzapine, NK-1 receptor antagonist, 5-HT3 receptor antagonist, and dexamethasone. Additional agents depending on the regimen are used on days 2, 3, and 4.
 - For moderate emetic risk IV chemotherapy on day 1: 1) 5-HT3 receptor antagonist plus dexamethasone; 2) olanzapine, palonosetron, plus dexamethasone; 3) NK-1 receptor antagonist, 5-HT3 receptor antagonist, plus dexamethasone. Additional agents depending on the regimen are used on days 2 and 3.
 - For low emetic risk IV chemotherapy: dexamethasone, metoclopramide, prochlorperazine, or a 5-HT3 receptor antagonist started before chemotherapy and continued daily.
 - For high to moderate emetic risk oral chemotherapy: 5-HT3 receptor antagonist started before chemotherapy and continued daily.
 - For low to minimal emetic risk oral chemotherapy: metoclopramide, prochlorperazine, or a 5-HT3 receptor antagonist started before chemotherapy and continued daily.
 - For breakthrough treatment for CINV (add an agent for a different drug class to the current regimen): olanzapine, lorazepam, dronabinol or nabilone, haloperidol, metoclopramide, scopolamine, prochlorperazine or promethazine, 5-HT3 receptor antagonist, or dexamethasone.
- The NCCN guideline recommends granisetron ± dexamethasone or ondansetron ± dexamethasone for pretreatment for RINV in patients receiving radiation therapy (upper abdomen/localized site) or total body irradiation (NCCN 2021).
- The 2018 ACOG Practice Bulletin for NVP recommends the following algorithm (ACOG 2018 [reaffirmed 2019]):
 - First-line nonpharmacologic options: Change the prenatal vitamin to 1 that contains only folic acid, ginger capsules, and P6 acupressure with wrist bands.
 - If symptoms persist, escalate to first-line pharmacologic interventions: pyridoxine (vitamin B6) monotherapy or pyridoxine in combination with doxylamine in various doses.
 - If symptoms persist, oral dimenhydrinate, oral diphenhydramine, rectal prochlorperazine, or oral/rectal promethazine may be added.
 - If there is no dehydration and symptoms persist, oral/intramuscular (IM) metoclopramide, oral ondansetron, oral/rectal/IM promethazine, or IM trimethobenzamide may be added.
 - If there is dehydration, patients should receive IV fluid replacement. If symptoms persist, IV dimenhydrinate, IV metoclopramide, IV ondansetron, or IV promethazine may be added.
 - If symptoms continue to persist, IM/IV chlorpromazine or oral/IV methylprednisolone may be added.

SAFETY SUMMARY

- The 5-HT3 receptor antagonists and substance P/NK1 receptor antagonists are contraindicated with hypersensitivity, and overall these agents are generally well-tolerated. Ondansetron is also contraindicated with apomorphine.
- The 5-HT3 receptor antagonists are generally very well-tolerated. There is a warning and general precaution for dolasetron regarding the risk of arrhythmias. Ondansetron and granisetron have QTc prolongation as a general precaution. In addition, the development of serotonin syndrome has been reported with 5-HT3 receptor antagonists. Ondansetron and granisetron may mask progressive ileus or gastric distention following abdominal surgery or in patients with CINV.
- The D₂ antagonist amisulpride carries a warning for QT prolongation, and it should be avoided in patients with congenital long QT syndrome and patients taking droperidol. Electrocardiogram (ECG) monitoring is recommended in patients with pre-existing arrhythmia, electrolyte abnormalities, congestive heart failure, and patients taking other drugs or with other conditions that prolong the QT interval.
- Aprepitant and fosaprepitant are weak-to-moderate inhibitors of CYP3A4 and aprepitant is an inducer of CYP2C9. Netupitant is a substrate and moderate inhibitor of CYP3A4. Rolapitant inhibits CYP2D6; therefore, dose reductions may be warranted with these agents. Aprepitant, fosaprepitant, and rolapitant are contraindicated in patients taking CYP substrates of the respective enzymes that have a narrow therapeutic index, pimozide and thioridazine. Increased plasma concentrations may result in QT prolongation and torsades de pointes. Aprepitant has a warning regarding concurrent therapy with warfarin, a CYP2C9 substrate, and with hormonal contraceptives (during and for 28 days after stopping therapy) due to decreased exposure of the interacting medication.
- Fosaprepitant, aprepitant, and rolapitant can cause serious hypersensitivity reactions, including anaphylaxis and anaphylactic shock, during or soon after infusion. If hypersensitivity reactions occur, discontinue the infusion and

administer appropriate medical therapy. Do not reinitiate aprepitant or fosaprepitant, or rolapitant IV in patients who experience hypersensitivity symptoms with first-time use. Infusion site reactions have been reported with fosaprepitant IV; avoid infusion into small veins or through a butterfly catheter.

- Dronabinol and nabilone have the potential to be abused and produce psychological dependence. Both dronabinol and nabilone may produce alterations in mood and alterations in reality (distorted perceptions of objects and time and hallucinations).
- Dronabinol and nabilone are contraindicated in individuals who are allergic to cannabinoids. Syndros (dronabinol oral solution) is contraindicated in patients with hypersensitivity to alcohol and in patients who have received products containing disulfiram or metronidazole within 14 days. Syndros contains dehydrated alcohol (50%, w/w) and propylene glycol (5.5%, w/w). Disulfiram- and metronidazole-containing products should not be administered within 7 days of completing Syndros treatment.
- Consider risks and benefits of using dronabinol in patients with a history of seizures. Patients with cardiac disorders may experience cardiac effects such as hypotension, hypertension, syncope, or tachycardia with cannabinoids.
- Dronabinol and nabilone may exacerbate or unmask symptoms of mania, depression, or schizophrenia.
- Common adverse events with cannabinoids were dizziness, drowsiness, dry mouth, euphoria, and coordination disturbance.
- Syndros and Marinol both contain the same active ingredient, dronabinol, and the safety of Syndros oral solution was based on studies using dronabinol capsules. Additional warnings and precautions include:
 - Avoid dronabinol in patients with a psychiatric history or monitor patients for new or worsening psychiatric symptoms if use of dronabinol cannot be avoided.
 - Reduce the dose or discontinue if signs and symptoms of cognitive impairment occur.
 - Consider a dose reduction or discontinue in patients who develop worsening nausea, vomiting, or abdominal pain while taking dronabinol.
- Mecizine may cause drowsiness and should be used with caution in patients with asthma, glaucoma, or an enlarged prostate due to its anticholinergic effects. Headache, fatigue, and vomiting are other common adverse events.
- Promethazine has a boxed warning that it should not be used in patients < 2 years old because of the risk of fatal respiratory depression. It should be used with caution in pediatric patients 2 years and older. The injection has a boxed warning for severe tissue injury. Promethazine is also contraindicated in comatose states, hypersensitivity, or for treatment of lower respiratory tract symptoms including asthma. Promethazine injection should not be administered by intra-arterial injection or subcutaneously. Warnings related to promethazine include CNS depression, respiratory depression, lower seizure threshold, bone-marrow depression, and neuroleptic malignant syndrome (NMS).
- Prochlorperazine has a boxed warning regarding increased mortality in elderly patients with dementia-related psychosis who are treated with antipsychotic drugs. Contraindications include hypersensitivity, comatose states or in the presence of large amounts of CNS depressants, pediatric surgery, in pediatric patients < 2 years or weighing < 20 pounds, or for use in pediatric conditions that the dose has not been determined. Other warnings include tardive dyskinesia, NMS, and falls. Adverse events include drowsiness, dizziness, amenorrhea, blurred vision, skin reactions, and hypotension.
- Transdermal scopolamine is contraindicated in acute closure glaucoma and hypersensitivity. Warnings and precautions include acute angle closure glaucoma, neuropsychiatric adverse reactions, and eclamptic seizures in pregnant women. Scopolamine may cause reduced gastrointestinal motility, urinary retention, and also blurred vision if it comes into contact with eyes. Additionally, patients may experience withdrawal symptoms, and transdermal scopolamine should be removed prior to magnetic resonance imaging. The most common reactions for motion sickness include dry mouth, drowsiness, blurred vision, and pupil dilation, and for PONV include dry mouth, dizziness, somnolence, agitation, visual impairment, confusion, mydriasis, and pharyngitis.
- Trimethobenzamide is contraindicated in hypersensitivity. Warnings and precautions include acute dystonic reactions and other extrapyramidal symptoms, other CNS reactions (eg, coma, depression of mood, disorientation, and seizures), hepatotoxicity, and impairment of mental and/or physical activities. Other adverse events include blurred vision, diarrhea, disorientation, dizziness, drowsiness, headache, jaundice, and muscle cramps.
- Doxylamine/pyridoxine is contraindicated when used with monoamine oxidase inhibitors (MAOIs), as they intensify and prolong the adverse effects of the agent. The most common adverse effect observed with doxylamine/pyridoxine is somnolence. The warning section in the prescribing information states that activities requiring complete mental alertness, such as driving or operating heavy machinery, are not recommended (unless cleared to do so by a health care provider). Doxylamine/pyridoxine is also not recommended when using CNS depressants, such as alcohol. Doxylamine/pyridoxine has anticholinergic properties. It should be used with caution in women with asthma, increased

intraocular pressure, narrow angle glaucoma, stenosis peptic ulcer, pyloroduodenal obstruction, and urinary bladder-neck obstruction. Additionally, false positive urine screening tests for methadone, opiates, and phencyclidine have been reported with doxylamine/pyridoxine use.

DOSING AND ADMINISTRATION

Table 3. Dosing and Administration

Drug	Available Formulations	Route	Usual Recommended Frequency	Comments
5-HT₃ Receptor Antagonists				
Dolasetron	Tablet	Oral	Take within 1 hour before chemotherapy.	Indicated in both pediatric (age 2 to 16 years based on adult PK data) and adults. ECG monitoring recommended in patients with renal impairment and the elderly.
Granisetron	Tablet, injection, injection ER, TD patch	Oral, IV, SC, TD	Take orally within 1 hour before chemotherapy or radiation, or twice daily (with the second dose given 12 hours after the first). Administer patch a minimum of 24 hours before chemotherapy (up to a maximum of 48 hours) and remove a minimum of 24 hours after chemotherapy completion Administer IV or SC within 30 minutes before chemotherapy or administer IV right before induction of anesthesia or immediately before reversal of anesthesia. Do not administer SC injection ER more frequently than once a week.	Injection approved for CINV in children 2 to 16 years. Tablet, injection ER, and TD patch have not studied in pediatrics. Do not use injection ER in severe renal impairment and adjust frequency in moderate renal impairment. Apply patch to upper outer arm. The patch may be worn for up to 7 days depending on the duration of the chemotherapy regimen.
Ondansetron	Tablet, oral solution, ODT, oral soluble film, IV solution, injection	Oral, lingual, IV, IM	Oral administrations vary: (1) Give within 30 minutes before HEC or; (2) given twice daily, with the first dose given 30 minutes before the start of emetogenic chemotherapy and a subsequent dose 8 hours later; then twice daily for 1 to 2 days after the completion of chemotherapy or; (3) give 1 to 2 hours before each fraction of radiotherapy administered each day or; (4) give 1 to 2 hours before radiotherapy, with subsequent doses every 8 hours after the first dose for 1 to 2 days after completion of radiotherapy or; (5) give 1 hour before	Do not exceed 8 mg daily in patients with severe hepatic impairment (Child-Pugh score ≥10). There is no experience beyond first-day administration in these patients. Depending on indication and formulation, drug may be administered in patients aged ≥ 1 month.

Drug	Available Formulations	Route	Usual Recommended Frequency	Comments
			<p>induction of anesthesia or; (6) for pediatric patients, give 3 times daily with the first dose given 30 minutes before the start of emetogenic chemotherapy and subsequent doses 4 and 8 hours later; then 3 times daily (every 8 hours) for 1 to 2 days after completion of chemotherapy.</p> <p>IV administrations vary: (1) administer IV over 15 minutes beginning 30 minutes before chemotherapy and subsequent doses are given 4 and 8 hours after the first dose or; (2) administer IV over 2 to 5 minutes immediately before induction of anesthesia, or postoperatively if the patient did not receive prophylactic antiemetics and experiences nausea and/or vomiting within 2 hours after surgery or; (3) for pediatric patients administer IV over 2 to 5 min immediately prior to or following anesthesia induction, or postoperatively if the patient did not receive prophylactic antiemetics and experiences nausea and/or vomiting occurring shortly after surgery.</p> <p>Administer IM as a single dose.</p>	
Palonosetron	IV solution	IV	<p>IV administrations vary: (1) administer IV over 30 seconds, approximately 30 minutes before the start of chemotherapy or; (2) administer IV over 10 seconds immediately before the induction of anesthesia or; (3) for pediatric patients, administer IV over 15 minutes, beginning approximately 30 minutes before the start of chemotherapy</p>	IV solution approved for prevention of CINV in pediatric patients aged ≥ 1 month.
D2 antagonist				
Amisulpride	IV solution	IV	Prevention of PONV: 5 mg as a single IV injection over 1 to 2 minutes at induction of anesthesia	Use for prevention of PONV may be as monotherapy or in combination with an antiemetic of a different class.

Drug	Available Formulations	Route	Usual Recommended Frequency	Comments
			Treatment of PONV: 10 mg as a single IV injection over 1 to 2 minutes	Use for treatment of PONV may be in patients who received prophylaxis with an agent of a different class or who have not received prophylaxis. Avoid use in patients with severe renal impairment.
Substance P/NK₁ Receptor Antagonists				
Aprepitant	Capsule, combination pack, oral suspension, IV emulsion	Oral, IV	Take orally within 1 hour before chemotherapy and once daily for 2 additional days Administer IV over 2 minutes or 30 minutes completing the administration approximately 30 minutes before chemotherapy (for the 3-day regimen, continue capsules on day 2 and 3).	Given as part of a regimen that includes a corticosteroid and a 5-HT ₃ antagonist. Oral suspension approved for prevention of CINV in pediatric patients aged 6 months to < 12 years. Give with or without food. Use with caution in severe hepatic impairment.
Fosaprepitant	IV solution	IV	Adults: Administer IV over 20 to 30 minutes before chemotherapy. Administer IV over 30 minutes (12 to 17 years) or 60 minutes (6 months to <12 years) (for the 3-day regimen, continue capsules or oral suspension on days 2 and 3). Complete infusion approximately 30 minutes prior to chemotherapy	Given as part of a regimen that includes a corticosteroid and a 5-HT ₃ antagonist. Use with caution in severe hepatic impairment.
Rolapitant	Tablet	Oral	Administer orally within 2 hours prior to chemotherapy.	Given as part of a regimen that includes a corticosteroid and a 5-HT ₃ antagonist. Avoid use in severe hepatic impairment; if use cannot be avoided, monitor for adverse events. Contraindicated in children <2 years of age due to irreversible impaired reproductive development observed in animal studies
THC derivatives				
Dronabinol	Capsule, oral solution	Oral	Take orally 1 to 3 hours before chemotherapy and subsequent	If adverse effects occur and do not resolve in 1 to 3 days with

Drug	Available Formulations	Route	Usual Recommended Frequency	Comments
			doses every 2 to 4 hours after chemotherapy for a total of 4 to 6 doses/day or; take orally twice daily, one hour prior to lunch and dinner.	continued use, consider dose reductions. In elderly, consider decreasing the initial dose to reduce risk of CNS adverse reactions. Always use calibrated oral dosing syringe for administration; if the prescribed dose is > 5 mg, it must be divided in multiple doses. Take with 6 to 8 ounces of water (oral solution).
Nabilone	Capsule	Oral	Take orally twice daily; initial dose is given 1 to 3 hours before chemotherapy and subsequent doses 2 to 3 times daily.	
Other single-agent products				
Meclizine	Chewable, immediate-release, and ODT	Oral	Take orally 1 hour before travel (may repeat every 24 hours as needed)	Start at the lowest dose for elderly patients due to anticholinergic effects
Promethazine	Tablet, oral syrup, rectal suppository, injectable solution	Oral	Oral administration (motion sickness): Take orally 30 to 60 minutes before departure, then repeated in 8 to 12 hours as needed	Deep IM injection is the preferred parenteral route of administration
		Rectal	Oral and rectal administration (PONV): Take orally or rectally every 4 to 6 hours as needed	
		IV/IM	IV and IM (PONV): Administer IV or IM every 4 to 6 hours as needed	
Prochlorperazine	Tablet, rectal suppository, injectable solution	Oral	Oral administration: 3 to 4 times per day	Lower doses are usually sufficient for elderly patients; increase doses gradually
		Rectal	Rectal administration: Twice daily	
		IV/IM	IV or IM administration: Administer 3 to 4 hours as needed; or administer 1 to 2 hours (IM) or 15 to 30 minutes (IV) before induction of anesthesia and repeat once if necessary	
Scopolamine	Transdermal	Transdermal	Motion sickness: Apply patch at least 4 hours before antiemetic effects are needed – for use up to	Apply to hairless area of the skin behind the ear

Drug	Available Formulations	Route	Usual Recommended Frequency	Comments
			3 days. If therapy for more than 3 days is required, remove the first transdermal system and apply a new one behind the other ear. PONV: Apply patch the evening before scheduled surgery; remove 24 hours after surgery.	
Trimethobenzamide	Capsule, IM solution	Oral IM	Oral: Take orally 3 to 4 times daily IM: Administer 3 to 4 times per day as needed	Reduce daily oral dose in elderly and patients with renal impairment
Combination products				
Palonosetron/netupitant	Capsule	Oral	Oral administration: Take orally within 1 hour before chemotherapy	Given as part of a regimen that includes a corticosteroid.
Palonosetron/fosnetupitant	Powder for injection	IV	IV administration: Infuse over 30 minutes starting 30 minutes before chemotherapy.	Do not use in severe renal or hepatic impairment.
Doxylamine succinate/pyridoxine HCl	Tablet ER, tablet DR	Oral	Take orally at bedtime. Titrate dose to twice daily (for the 20/20 mg tablet ER) or 3 times daily (for the 10/10 mg tablet DR).	Bonjesta is available in 20/20 mg tablets ER and Diclegis is available in 10/10 mg tablets DR. Should be taken on an empty stomach with a glass of water.

Abbrv: CINV = chemotherapy-induced nausea and vomiting, DR = delayed release, ECG = electrocardiogram, ER = extended release, HEC = highly emetogenic cancer chemotherapy, IM = intramuscular, IV = intravenous, ODT = orally disintegrating tablet, PONV = post-operative nausea and vomiting, PK = pharmacokinetic, SC = subcutaneously, TD = transdermal
See the current prescribing information for full details.

CONCLUSION

- Nausea and vomiting are significant problems, particularly in the treatment of cancer and following surgery. There are several classes of antiemetic drugs that may influence the neurotransmitter receptors involved in the pathway associated with n/v (*Longstreth et al 2021*)
- Choice of agents generally depends upon the relative emetogenic potential of the influencing agent, condition, or procedure, including chemotherapy or radiation therapy. Various formulations may be prescribed based on age of the patient, indication, and persistence of symptoms (*AGA 2001, ACOG 2018, Hesketh et al 2021, Longstreth et al 2021, Longstreth 2020, Roila et al 2010, NCCN 2021*).
- Guideline recommendations vary according to indication. The 2021 ASCO antiemetic guidelines recommend a 4-drug combination of a NK1 receptor antagonist, a 5-HT3 receptor antagonist, dexamethasone, and olanzapine as first-line therapy for the prevention of CINV due to HEC. For MEC, a 2-drug combination of a 5-HT3 receptor antagonist plus dexamethasone is recommended for regimens other than carboplatin area AUC ≥ 4 mg/mL/min or a 3-drug combination of a NK1 receptor antagonist, a 5-HT3 receptor antagonist, and dexamethasone for patients treated with a regimen that includes carboplatin AUC ≥ 4 mg/mL/min (*Hesketh et al 2021*). A 2016 expert opinion statement from ASER states that during the perioperative period, all patients should receive PONV prophylaxis (*Gupta et al 2016*). The clinical consensus guidelines for NVP from the ACOG recommend pyridoxine alone or in combination with doxylamine as first-line pharmacologic therapy (*ACOG 2018 [reaffirmed 2019]*).
- The 5-HT3 antagonists are the cornerstone of therapy for acute emesis with MEC to HEC agents in the management of CINV, in addition to RINV and PONV. These agents include dolasetron, granisetron, ondansetron, and palonosetron. Ondansetron is the most well studied medication; however, trials have not demonstrated a clear treatment leader

between dolasetron, granisetron, and ondansetron. Palonosetron has a longer half-life and a higher receptor binding affinity than the other 5-HT₃ receptor antagonists. Single-dose therapy with palonosetron is reported to be more effective than other medications in the class, particularly at preventing delayed emesis. There are very few trials evaluating the prevention of RINV. The 5-HT₃ receptor antagonists are the only agents in this class review with demonstrated efficacy and, of these, only ondansetron and granisetron are FDA-approved. Oral formulations appear to have comparable efficacy to IV formulations in CINV. The 5-HT₃ receptor antagonists are generally well tolerated, with mild headache the most frequent adverse event. Cardiac abnormalities ranging from ECG interval changes to torsade de pointes or QTc prolongation have been reported with dolasetron, granisetron, and ondansetron. In addition, the development of serotonin syndrome has been reported with 5-HT₃ receptor antagonists (Aapro et al 2005, AGA, 2001, Billio et al 2010, Botrel et al 2011, Dong et al 2011, Eisenberg et al 2003, Gan et al 2020, Gralla et al 2003, Gupta et al 2016, Herrstedt et al 2017, Hesketh et al 2021, Kaushal et al 2010, Kovacs et al 2016, Likun et al 2011, Longstreth 2020, Roila et al 2010, Salvo et al 2012, Simino et al 2016, Spitzer et al 2000, Suzuki et al 2016).

- All 5-HT₃ antagonist formulations are available generically with the exception of Anzemet (dolasetron) tablets, Sancuso (granisetron) transdermal patch, Sustol (granisetron) extended-release injection, and Zuplenz (ondansetron) oral soluble film.
- The substance P/NK1 receptor antagonists are prescribed for both acute and delayed CINV, which is an advantage over first-generation serotonin antagonists that are generally effective for acute emesis only. These include aprepitant, fosaprepitant, and rolapitant. The substance P/NK1 receptor antagonists are most effective when used in combination with other agents, typically a 5-HT₃ antagonist, a glucocorticoid, ± olanzapine, for patients receiving HEC. One MA concluded that aprepitant reduces incidence of PONV and need for rescue medications compared to other 5-HT₃ and NK1 antagonists. Aprepitant and fosaprepitant are moderate inhibitors of the CYP3A4 pathway and rolapitant inhibits CYP2D6; therefore, dose reductions may be warranted. Anaphylaxis, anaphylactic shock, and other serious hypersensitivity reactions have also been reported in patients receiving IV formulations, some requiring hospitalization (AGA 2001, Gralla et al 2005, Grunberg et al 2011, Hesketh et al 2021, Herrington et al 2008, Herrstedt et al 2005, Longstreth 2020, Rapoport et al 2010, Roila et al 2010, Singh et al 2016, Warr et al 2005, Yeo et al 2009).
 - The only substance P/NK1 receptor antagonist formulations available generically are aprepitant capsules and combination pack.
- The THC derivatives, also referred to as the cannabinoids, have been prescribed for CINV and also have properties that may contribute to weight gain. The agents include nabilone and dronabinol. Dronabinol is also FDA-approved for anorexia associated with weight loss in adults with AIDS. In terms of CINV, these agents have a modest antiemetic activity and a relatively unfavorable adverse event profile. Side effects include vertigo, xerostomia, hypotension, and dysphoria, particularly in elderly patients. Trials have demonstrated that the cannabinoids are more effective compared to placebo and may be more effective than metoclopramide and prochlorperazine; however, no head-to-head trials have been conducted. The cannabinoids have little clinical utility. Due to the availability of other agents that are more effective and better tolerated, dronabinol and nabilone are recommended for later line therapy (Hesketh et al 2021, Lane et al 1991, Longstreth 2020, Meiri et al 2007, Machado Rocha et al 2008, Tramer et al 2001).
 - Only Marinol (dronabinol) oral capsules are available generically.
- Amisulpride is approved for prevention and treatment of PONV. Supporting evidence includes randomized trials in each indication demonstrating superiority over placebo (Barhemsys prescribing information 2020).
 - Amisulpride is not available generically.
- Combination products include Diclegis and Bonjesta (doxylamine succinate/pyridoxine) and Akynzeo (palonosetron/netupitant and palonosetron/fosnetupitant). Doxylamine succinate/pyridoxine is the only agent in this class FDA-approved for NVP and is guideline-recommended as a first-line pharmacologic therapy. Diclegis and Bonjesta vary by fixed dose strengths; however, each individual component is available over-the-counter (ACOG 2018 [reaffirmed 2019]). The fixed-dose combination Akynzeo (palonosetron/netupitant) with dexamethasone has been shown to be significantly superior to each agent administered individually for CINV prevention following MEC (Aapro et al 2014); however, results from another study for CINV prevention revealed similar efficacy between the fixed-dose combination and each agent administered individually with dexamethasone (Gralla et al 2014). Netupitant is also a moderate inhibitor of the CYP3A4 pathway and clinicians should be aware of potential drug interactions.
- Other agents used for n/v include meclizine, promethazine, prochlorperazine, scopolamine, and trimethobenzamide. Meclizine and scopolamine are generally used for motion sickness. Prochlorperazine may be used in low emetic risk chemotherapy while prochlorperazine, scopolamine, or promethazine may be used for breakthrough treatment (NCCN 2021).

REFERENCES

- Aapro M, Rugo H. A randomized phase III study evaluating the efficacy and safety of NEPA, a fixed-dose combination of netupitant and palonosetron, for prevention of chemotherapy-induced nausea and vomiting following moderately emetogenic chemotherapy. *Ann Oncol*. 2014;25:1328-1333.
- Aapro MA, Macciocchi A, Gridelli C. Palonosetron improves prevention of CINV in elderly patients. *J Supp Oncology*. 2005;3(5):369-374.
- Abrams DI, Hilton JF, Leiser RJ, et al. Short-term effects of cannabinoids in patients with HIV-1 infection: a randomized, placebo-controlled clinical trial. *Ann Intern Med*. 2003;139(4):258-266.
- Akynzeo prescribing information. Helsinn Therapeutics. Iselin, NJ. **October 2020**.
- Aloxi injection prescribing information. Helsinn Therapeutics. Iselin, NJ. April 2020.
- American College of Obstetricians and Gynecologists. ACOG Practice Bulletin: nausea and vomiting of pregnancy. *Obstet Gynecol*. 2018;131(1):190-193.
- American Gastroenterological Association [AGA] medical position statement: nausea and vomiting. *Gastroenterology*. 2001;120(1):261-262.
- Antivert prescribing information. East Brunswick, NJ. Casper Pharma LLC. June 2019.
- Anzemet tablets prescribing information. Validus Pharmaceuticals LLC. Parsippany, NJ. January 2019.
- Barhemsys prescribing information. Acacia Pharma. Indianapolis, IN. **September 2020**.
- Billio A, Morello E, Clarke MJ. Serotonin receptor antagonists for highly emetogenic chemotherapy in adults. *Cochrane Database of Sys Rev*. 2010;(1):CD006272.
- Boccia RV, Gordan LN, Clark G, et al. Efficacy and tolerability of transdermal granisetron for the control of chemotherapy-induced n/v associated with moderately and highly emetogenic multi-day chemotherapy: a randomized, double-blind, phase III study. *Support Care Cancer*. 2011;19:1609-17.
- Boelig RC, Barton SJ, Saccone G, et al. Interventions for treating hyperemesis gravidarum. *Cochrane Database Syst Rev*. 2016 May 11;(5):CD010607. doi: 10.1002/14651858.CD010607.pub2.
- Bonjesta prescribing information. Duchesnay, Inc. Bryn Mawr, PA. June 2018.
- Botrel TEA, Clark OAC, Clark L, et al. Efficacy of palonosetron (PAL) compared to other serotonin inhibitors (5-HT3R) in preventing chemotherapy-induced n/v (CINV) in patients receiving moderately or highly emetogenic (MoHE) treatment: systematic review and meta-analysis. *Support Care Cancer*. 2011;19:823-32.
- 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):1098-1105. doi:10.1213/ane.0000000000003733
- Cesamet prescribing information. Somerset, NJ. Meda Pharmaceuticals Inc. March 2020.
- Chow R, Warr DG, Navari RM, et al. Should palonosetron be a preferred 5-HT3 receptor antagonist for chemotherapy-induced nausea and vomiting? An updated systematic review and meta-analysis. *Support Care Cancer*. 2018;26(8):2519-2549. doi: 10.1007/s00520-018-4237-7.
- Chua AV, Jr., Hernandez ARB, Real IO. Transdermal versus oral granisetron in controlling chemotherapy-induced nausea and vomiting: a meta-analysis. *Support Care Cancer*. 2020;28(12):5611-5619. doi:10.1007/s00520-020-05611-w
- Cinvanti prescribing information. Heron Therapeutics, Inc. San Diego, CA. October 2019.
- Compro prescribing information. Perrigo. Minneapolis, MN. November 2016.
- Cui J, Zhang Q, Zhang H, Spinelli T, Nicolas P, Li W. Oral versus intravenous palonosetron in Chinese cancer patients receiving moderately emetogenic chemotherapy: A non-inferiority phase III trial. *Eur J Cancer Care (Engl)*. 2020;29(4):e13245. doi:10.1111/ecc.13245
- Dabbous AS, Jabbour-Khoury SI, Nasr VG, et al. Dexamethasone with either granisetron or ondansetron for postoperative nausea and vomiting in laparoscopic surgery. *Middle East J Anaesthesiol*. 2010;20(4):565-570.
- De Wit R, Herrstedt J, Rapoport B. The oral NK (1) antagonist, aprepitant, given with standard antiemetics provides protection against nausea and vomiting over multiple cycles of cisplatin-based chemotherapy: a combined analysis of two randomized, placebo-controlled phase III clinical trials. *Eur J Cancer*. 2004;40(3):403-410.
- del Giglio A, Soares HP, Caparroz C, et al. Granisetron is equivalent to ondansetron for prophylaxis of chemotherapy-induced n/v. Results of a meta-analysis of randomized controlled trials. *Cancer*. 2000;89:2301-2308.
- Dempsey CL, Coop AJ, Shillington A, et al. Antiemetic effectiveness of ondansetron and granisetron in patients with breast cancer treated with cyclophosphamide. *Am J Health-Syst Pharm*. 2004;61:781-786.
- Diclegis prescribing information. Duchesnay, Inc. Bryn Mawr, PA. June 2018.
- Dong X, Huang J, Cao R, et al. Palonosetron for prevention of acute and delayed n/v in non-small-cell lung carcinoma. *Med Oncol*. 2011;28:1425-1429.
- Drugs@FDA: FDA approved drug products. Food and Drug Administration Web site. <https://www.accessdata.fda.gov/scripts/cder/daf/>. Accessed **February 19, 2021**.
- Eberhart LH, Morin AM, Hoerle S, et al. Droperidol and dolasetron alone or in combination for prevention of PONV after vitrectomy. *Ophthalmology*. 2004;111:1569-75.
- Eisenberg P, Figueroa-Vadillo J, Zamora R, et al. Improved prevention of moderately emetogenic chemotherapy-induced n/v with palonosetron, a pharmacologically novel 5-HT3 receptor antagonist. *Cancer*. 2003;98:2473-82.
- Emend capsules and oral suspension prescribing information. Merck & Co., Inc. Whitehouse Station, NJ. **February 2021**.
- Emend for injection prescribing information. Merck & Co., Inc. Whitehouse Station, NJ. **April 2020**.
- Feyer P, Jordan K. Radiotherapy-induced nausea and vomiting: prophylaxis and treatment. UpToDate Web site. <https://www.uptodate.com/>. Updated July 15, 2020. Accessed **February 19, 2021**.
- Gan TJ, Coop A, Philip BK, et al. A randomized, double-blind study of granisetron plus dexamethasone vs ondansetron plus dexamethasone to prevent PONV in patients undergoing abdominal hysterectomy. *Anesth Analg*. 2005;101:1323-1329.
- Gan TJ, Kranke P, Minkowitz HS, et al. Intravenous amisulpride for the prevention of postoperative nausea and vomiting: two concurrent, randomized, double-blind, placebo-controlled trials. *Anesthesiology*. 2017;126(2):268-275. doi:10.1097/ain.0000000000001458

- Gan TJ, Belani KG, Bergese S, et al. Fourth consensus guidelines for the management of postoperative nausea and vomiting. *Anesth Analg*. 2020;131(2):411-448. doi:10.1213/ANE.0000000000004833
- George RB, Allen TK, Habib AS. Serotonin receptor antagonists for the prevention and treatment of pruritus, nausea, and vomiting in women undergoing cesarean delivery with intrathecal morphine: a systematic review and meta-analysis. *Anesth Analg*. 2009;109(1):174-182.
- Gore L, Chawla S, Petrilli A, et al. Aprepitant in adolescent patients for prevention of chemotherapy-induced nausea and vomiting: a randomized, double-blind, placebo-controlled study of efficacy and tolerability. *Pediatr Blood Cancer*. 2009;52:242-247.
- Gralla R, de Wit R, Herrstedt J, et al. Antiemetic efficacy of the neurokinin-1 antagonist, aprepitant, plus a 5-HT₃ antagonist and a corticosteroid in patients receiving anthracyclines or cyclophosphamide in addition to high-dose cisplatin: analysis of combined data from two Phase III randomized clinical trials. *Cancer*. 2005;104(4):864-868.
- Gralla R, Lichinitser M, Van der Vegt S, et al. Palonosetron improves prevention of chemotherapy-induced n/v following moderately emetogenic chemotherapy: results of a double-blind randomized phase III trial comparing single doses of palonosetron with ondansetron. *Ann Oncology*. 2003;14:1570-1577.
- Gralla RJ, Bosnjak SM, Hontsa A, et al. A phase III study evaluating the safety and efficacy of NEPA, a fixed-dose combination of netupitant and palonosetron, for prevention of chemotherapy-induced nausea and vomiting over repeated cycles of chemotherapy. *Ann Oncol*. 2014;25(7):1333-1339.
- Granisetron injection prescribing information. AuroMedics Pharma LLC. East Windsor, NJ. January 2020.
- Granisetron tablets prescribing information. Breckenridge Pharmaceutical, Inc. Berlin, CT. October 2019.
- Grunberg S, Chua D, Maru A, et al. Single-dose fosaprepitant for the prevention of chemotherapy-induced nausea and vomiting associated with cisplatin therapy: randomized, double-blind study protocol—EASE. *J Clin Oncol*. 2011;29:1495-1501.
- Grunberg SM, Dugan M, Muss H, et al. Effectiveness of a single-day three-drug regimen of dexamethasone, palonosetron, and aprepitant for the prevention of acute and delayed nausea and vomiting caused by moderately emetogenic chemotherapy. *Support Care Cancer*. 2009;17:589-594.
- Gupta R and Soto R. Prophylaxis and management of postoperative nausea and vomiting in enhanced recovery protocols: expert opinion statement from the American Society for Enhanced Recovery (ASER). *Perioperative Medicine*. 2016;5(4):1-2.
- Habib AS, 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):203-212. doi:10.1097/aln.0000000000002509
- Herrington J, Jaskiewicz, Song J. Randomized, placebo-controlled, pilot study evaluating aprepitant single dose plus palonosetron and dexamethasone for the prevention of acute and delayed chemotherapy-induced nausea and vomiting. *Cancer*. 2008;112:2080-2087.
- Herrstedt J, Muss H, Warr DG, et al. Efficacy and tolerability of aprepitant for the prevention of chemotherapy-induced nausea and emesis over multiple cycles of moderately emetogenic chemotherapy. *Cancer*. 2005;104(7):1548-1555.
- Herrstedt J, Roila F, Warr D, et al. 2016 Updated MASCC/ESMO consensus recommendations: prevention of nausea and vomiting following high emetic risk chemotherapy. *Support Care Cancer*. 2017;25(1):277-288.
- Hesketh PJ, Kris MG, Basch E, et al. Antiemetics: ASCO guideline update. *J Clin Oncol*. 2020;38(24):2782-2797. doi:10.1200/JCO.20.01296
- Hesketh PJ and Sanz-Altamira P. Aprepitant, dexamethasone, and palonosetron in the prevention of doxorubicin/cyclophosphamide-induced nausea and vomiting. *Support Care Cancer*. 2012;20:653-656.
- Hesketh PJ, Grunberg SM, Gralla RJ. The oral neurokinin-1 antagonist aprepitant for the prevention of chemotherapy-induced nausea and vomiting: a multinational, randomized, double-blind, placebo-controlled trial in patients receiving high-dose cisplatin—the Aprepitant Protocol 052 Study Group. *J Clin Oncol*. 2003; 21 (22):4112-4119.
- Hesketh PJ. Pathophysiology and prediction of chemotherapy-induced nausea and vomiting. UpToDate Web site.: <http://www.uptodate.com>. Updated August 15, 2019. Accessed February 19, 2021.
- Hesketh PJ. Prevention and treatment of chemotherapy-induced nausea and vomiting in adults. UpToDate Web site.: <http://www.uptodate.com>. Updated January 20, 2021. Accessed February 19, 2021.
- Hui D, Puac V, Shelal Z, et al. Fixed-dose netupitant and palonosetron for chronic nausea in cancer patients: a double-blind, placebo run-in pilot randomized clinical trial. *J Pain Symptom Manage*. 2021;S0885-3924(20)30974-X. doi:10.1016/j.jpainsymman.2020.12.023
- Hurley JD, Eshelman FN. Trimethobenzamide HCl in the treatment of nausea and vomiting associated with antineoplastic chemotherapy. *J Clin Pharmacol*. 1980;20(5-6 Pt 1):352-356.
- Jain S, Kapoor G, Koneru S, Vishwakarma G. A randomized, open-label non-inferiority study to compare palonosetron and ondansetron for prevention of chemotherapy-induced vomiting in children with cancer receiving moderate or high emetogenic chemotherapy. *Support Care Cancer*. 2018;26(9):3091-3097. doi: 10.1007/s00520-018-4158-5.
- Jaing T, Tsay P, Hung I, et al. Single-dose oral granisetron vs multidose intravenous ondansetron for moderately emetogenic cyclophosphamide-based chemotherapy in pediatric outpatients with acute lymphoblastic leukemia. *Pediatr Hemato Onc*. 2004;21:227-235.
- Jordan K, Kinitz I, Voigt W, et al. Safety and efficacy of a triple antiemetic combination with the NK-1 antagonist aprepitant in highly and moderately emetogenic multiple-day chemotherapy. *Eur J Cancer*. 2009;45:1184-1187.
- Kalaycio M, Mendez Z, Pohlman B, et al. Continuous-infusion granisetron compared to ondansetron for the prevention of n/v after high-dose chemotherapy. *J Cancer Res Clin Oncol*. 1998;124:265-269.
- Karamanlioglu B, Turan A, Memis D, et al. Comparison of oral dolasetron and ondansetron in the prophylaxis of PONV in children. *Eur J Anesth*. 2003;20:831-5.
- Kaushal J, Gupta MC, Kaushal V, et al. Clinical evaluation of two antiemetic combinations palonosetron dexamethasone vs ondansetron dexamethasone in chemotherapy of head and neck cancer. *Singapore Med J*. 2010;51(11):871-875.
- Koren G et al. Effectiveness of delayed-release doxylamine and pyridoxine for nausea and vomiting of pregnancy: a randomized placebo controlled trial. *Am J Obstet Gynecol*. 2010 Dec;203(5):571.e1-7.
- Koren G et al. Maternal safety of the delayed-release doxylamine and pyridoxine combination for nausea and vomiting of pregnancy; a randomized controlled trial. *BMC Pregnancy and Childbirth*. 2015;15(59):1-6.
- Kovacs G, Wachtel AE, Basharova EV, et al. Palonosetron versus ondansetron for prevention of chemotherapy-induced nausea and vomiting in paediatric patients with cancer receiving moderately or highly emetogenic chemotherapy: a randomised, phase 3, double-blind, double-dummy, non-inferiority study. *Lancet Oncol*. 2016;17(3):332-344.

- 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(6):1099-1106. doi:10.1097/aln.0000000000002133
- Lacerda JF, Martins C, Carmo JA, et al. Randomized trial of ondansetron, granisetron, and tropisetron in the prevention of acute n/v. *Transplantation Proc*. 2000;32:2680-2681.
- Lane M, Vogel CL, Ferguson J. Dronabinol and prochlorperazine in combination for treatment of cancer chemotherapy-induced nausea and vomiting. *J Pain Symptom Manage*. 1991;6(6):352-359.
- Likun Z, Xiang J, Yi B, et al. A systematic review and meta-analysis of intravenous palonosetron in the prevention of chemotherapy-induced n/v in adults. *The Oncologist*. 2011;16:207-216.
- Lofters WS, Pater JL, Zee B, et al. Phase III double-blind comparison of dolasetron mesylate and ondansetron and an evaluation of the additive role of dexamethasone in the prevention of acute and delayed n/v due to moderately emetogenic chemotherapy. *J Clin Oncol*. 1997;15:2966-73.
- Longstreth GF, Hesketh PJ. Characteristics of antiemetic drugs. UpToDate Web site. <http://www.uptodate.com>. Updated February 4, 2021. Accessed February 19, 2021.
- Longstreth GF. Approach to the adult with nausea and vomiting. UpToDate Web site. <http://www.uptodate.com>. Updated September 30, 2020. Accessed February 19, 2021.
- Lutge EE, Grav A, Siegfried N, et al. The medical use of cannabis for reducing morbidity and mortality in patients with HIV/AIDS. *Cochrane Database Syst Rev*. 2013;(4):CD0005175.
- Machado Rocha FC, Stéfano SC, De Cássia Haiek R, et al. Therapeutic use of Cannabis sativa on chemotherapy-induced nausea and vomiting among cancer patients: systematic review and meta-analysis. *Eur J Cancer Care (Engl)*. 2008;17(5):431-443.
- Mannix K. Palliation of n/v in malignancy. *Clin Med*. 2006;6:144-147.
- Marinol prescribing information. North Chicago, IL. Abbvie Inc. August 2017.
- Martin A, Carides A. Functional relevance of antiemetic control. Experience using the FLIE questionnaire in a randomized study of the NK-1 antagonist aprepitant. *Eur J Cancer*. 2003;39(10):1395-1401.
- Massa E, Astaro G, Madeddu C, et al. Palonosetron plus dexamethasone effectively prevents acute and delayed chemotherapy-induced n/v following highly or moderately emetogenic chemotherapy in pre-treated patients who have failed to respond to a previous antiemetic treatment: comparison between elderly and non-elderly patient response. *Clinical reviews in Oncology/Hematology*. 2009;70:83-91.
- Matsumoto K, Takahashi M, Sato K, et al. A double-blind, randomized, multicenter phase 3 study of palonosetron vs granisetron combined with dexamethasone and fosaprepitant to prevent chemotherapy-induced nausea and vomiting in patients with breast cancer receiving anthracycline and cyclophosphamide. *Cancer medicine*. 2020;9(10):3319-3327. doi:10.1002/cam4.2979
- Meclizine chewable tablets package labeling (OTC). PD-Rx Pharmaceuticals, Inc. August 2020.
- Meclizine tablet orally disintegrating package labeling (OTC). CVS Pharmacy. January 2020.
- Meclizine film, soluble package labeling (OTC). Sato Pharmaceutical Co., Ltd. January 2021.
- Meiri E, Jhangiani H, Vredenburgh JJ, et al. Efficacy of dronabinol alone and in combination with ondansetron vs ondansetron alone for delayed chemotherapy-induced nausea and vomiting. *Curr Med Res Opin*. 2007;23(3):533-543.
- Meyer TA, Roberson CR, Rajab MH, et al. Dolasetron vs ondansetron for the treatment of postoperative n/v. *Anesth Analg*. 2005;100:373-7.
- National Comprehensive Cancer Network. Antiemesis (Version 1.2021). https://www.nccn.org/professionals/physician_gls/default.aspx#supportive. Accessed February 19, 2021.
- Ondansetron injection prescribing information. Lehi, UT. Civica, Inc. September 2019.
- Orange Book: Approved drug products with therapeutic equivalence evaluations. Food and Drug Administration Web site. <https://www.accessdata.fda.gov/scripts/cder/ob/default.cfm>. Accessed February 19, 2021.
- Orchard PJ, Rogosheske J, Burns L, et al. A prospective randomized trial of the antiemetic efficacy of ondansetron and granisetron during bone marrow transplantation. *Biol Blood Marrow Transplant*. 1999;5(6):386-393. doi:10.1016/s1083-8791(99)70015-7
- Phillips RS, Friend AJ, Gibson F, et al. Antiemetic medication for prevention and treatment of chemotherapy-induced nausea and vomiting in childhood. *Cochrane Database of Sys Rev*. 2016;2(2):CD007786.
- Poli-Bigelli S, Rodrigues-Pereira J, et al. Addition of the neurokinin 1 receptor aprepitant to standard antiemetic therapy improves control of chemotherapy-induced nausea and vomiting. *Cancer*. 2003;97(12):3090-3098.
- Priesol AJ. Motion sickness. UpToDate Web site. <http://www.uptodate.com>. Updated January 28, 2020. Accessed February 19, 2021.
- Prochlorperazine injection prescribing information. East Brunswick, NJ. Avet Pharmaceuticals Inc. November 2020.
- Prochlorperazine tablets prescribing information. Salisbury, MD. Jubilant Cadista Pharmaceuticals Inc. October 2018.
- Promethazine injection prescribing information. Eatontown, NJ. West-Ward Pharmaceuticals Corp. June 2016.
- Promethazine oral solution prescribing information. Bridgewater, NJ. Amneal Pharmaceuticals LLC. December 2019.
- Promethazine syrup prescribing information. Parsippany, NJ. Wockhardt USA LLC. July 2018.
- Promethazine tablet prescribing information. East Brunswick, NJ. Strides Pharma Inc. March 2019.
- Raftopoulos H, Cooper W, O'Boyle E, et al. Comparison of an extended-release formulation of granisetron (APF530) versus palonosetron for the prevention of chemotherapy-induced nausea and vomiting associated with moderately or highly emetogenic chemotherapy: results of a prospective, randomized, double-blind, noninferiority phase 3 trial. *Support Care Cancer*. 2015[a];23(3):723-732.
- Raftopoulos H, Boccia R, Cooper W, et al. Slow-release granisetron (APF530) versus palonosetron for chemotherapy-induced nausea/vomiting: analysis by American Society of Clinical Oncology emetogenicity criteria. *Future Oncol*. 2015[b];11(18):2541-2551.
- Rapoport B, Schwartzberg L, Chasen M, et al. Efficacy and safety of rolapitant for prevention of chemotherapy-induced nausea and vomiting over multiple cycles of moderately or highly emetogenic chemotherapy. *Eur J Cancer*. 2016;57:23-30.
- Rapoport BL, Chasen MR, Gridelli C et al. Safety and efficacy of rolapitant for prevention of chemotherapy-induced nausea and vomiting after administration of cisplatin-based highly emetogenic chemotherapy in patients with cancer: two randomised, active-controlled, double-blind, phase 3 trials. *Lancet Oncol*. 2015;16(9):1079-1089.
- Rapoport BL, Jordan K, Boice JA, et al. Aprepitant for the prevention of chemotherapy-induced nausea and vomiting associated with a broad range of moderately emetogenic chemotherapies and tumor types: a randomized, double-blind study. *Support Care Cancer*. 2010;18:423-431.

- Roila F, Herrstedt J, Aapro M, et al. Clinical Practice Guidelines: Guidelines update for MASCC and ESMO in the prevention of chemotherapy- and radiotherapy-induced n/v: results of the Perugia consensus conference. *Annals of Oncology*. 2010;21(Supp 5):V232-43.
- Roila F, Ruggeri B, Ballatori E, et al. Aprepitant versus dexamethasone for preventing chemotherapy-induced delayed emesis in patients with breast cancer: a randomized double-blind study. *J Clin Oncol*. 2014;32(2):101-106.
- Salvo N, Doble B, Khan L, et al. Prophylaxis of radiation-induced nausea and vomiting using 5-hydroxytryptamine-3 serotonin receptor antagonists: a systematic review of randomized trials. *Int J Radiat Oncol Biol Phys*. 2012;82(1):408-417.
- Sancuso prescribing information. 3M Delivery Systems for Kyowa Kirin, Inc. St. Paul, MN. April 2020.
- Schwartzberg LS, Modiano MR, Rapoport BL, et al. Safety and efficacy of rolapitant for prevention of chemotherapy-induced nausea and vomiting after administration of moderately emetogenic chemotherapy or anthracycline and cyclophosphamide regimens in patients with cancer: a randomised, active-controlled, double-blind, phase 3 trial. *Lancet Oncol*. 2015;16(9):1071-1078.
- Simino GP, Marra LP, Andrade EI, et al. Efficacy, safety and effectiveness of ondansetron compared to other serotonin-3 receptor antagonists (5-HT3RAs) used to control chemotherapy-induced nausea and vomiting: systematic review and meta-analysis. *Expert Rev Clin Pharmacol*. 2016:1-12.
- Singh PM, Borle A, Rewari V, et al. Aprepitant for postoperative nausea and vomiting: a systematic review and meta-analysis. *Postgrad Med J*. 2016;92(1084):87-98.
- Singhal AK, Kannan S, Gota VS. 5-HT3 antagonists for prophylaxis of postoperative n/v in breast surgery: a meta-analysis. *Journal of Postgraduate Medicine*. 2012;58(1):23-31.
- Smith JA, Fox KA, Clark SM. Nausea and vomiting of pregnancy: Treatment and outcome. UpToDate Web site. <http://www.uptodate.com/>. Updated February 8, 2021. Accessed February 19, 2021.
- Smith LA, Azariah F, Lavender VTC, et al. Cannabinoids for nausea and vomiting in adults with cancer receiving chemotherapy (Review). *Cochrane Database of Sys Rev*. 2015;2015(11):CD009464.
- Spinks A, Wasiak J. Scopolamine (hyoscine) for preventing and treating motion sickness. *Cochrane Database Syst Rev*. 2011;(6):CD002851. doi: 10.1002/14651858.CD002851.pub4.
- Spitzer TR, Friedman CJ, Bushnell W, et al. Double-blind, randomized, parallel-group study on the efficacy and safety of oral granisetron and oral ondansetron in the prophylaxis of n/v in patients receiving hyperfractionated total body irradiation. *Bone Marrow Transplantation*. 2000;26:203-210.
- Sustol prescribing information. Heron Therapeutics. San Diego, CA. May 2017.
- Suzuki K, Yamanaka T, Hashimoto H, et al. Randomized, double-blind, phase III trial of palonosetron versus granisetron in the triplet regimen for preventing chemotherapy-induced nausea and vomiting after highly emetogenic chemotherapy: TRIPLE study. *Ann Oncol*. 2016;27(8):1601-1606.
- Syndros prescribing information. Chandler, AZ. **Benuvia Therapeutics, Inc. July 2020.**
- Tan J, Wang S, Liang X, et al. Palonosetron is nonsuperior to ondansetron in acute phase but provides superior antiemetic control in delayed phase for pediatric patients administered highly emetogenic chemotherapy. *Pediatr Blood Cancer*. 2018 Feb;65(2). doi: 10.1002/pbc/26815.
- Tang DH, Malone DC. A network meta-analysis on the efficacy of serotonin type 3 receptor antagonists used in adults during the first 24 hours for postoperative n/v prophylaxis. *Clinical Therapeutics*. 2012;34(2):282-294.
- Tigan capsule prescribing information. Pfizer. New York, NY. March 2017.
- Tigan injection prescribing information. Par Pharmaceutical. Chestnut Ridge, NY. April 2016.
- Timpone JG, Wright DJ, Li N, et al; Division of AIDS Treatment Research Initiative. The safety and pharmacokinetics of single-agent and combination therapy with megestrol acetate and dronabinol for the treatment of HIV wasting syndrome: the DATRI 004 Study Group. *AIDS Res Hum Retroviruses*. 1997;13(4):305-315.
- Tramèr MR, Carroll D, Campbell FA, et al. Cannabinoids for control of chemotherapy-induced nausea and vomiting: quantitative systematic review. *BMJ*. 2001;323(7303):16-21.
- Transderm Scop prescribing information. GSK Consumer Healthcare. Warren, NJ. March 2020.
- Varubi prescribing information. **TerSera Therapeutics, LLC. Deerfield, IL. August 2020.**
- Walker JB. Efficacy of single-dose intravenous dolasetron vs ondansetron in the prevention of postoperative n/v. *Clin Ther*. 2001;23(6):932-8.
- Warr DG, Hesketh PJ, Gralla R. Efficacy and tolerability of aprepitant for the prevention of chemotherapy-induced nausea and vomiting in patients with breast cancer after moderately emetogenic chemotherapy. *J Clin Oncol*. 2005; 23(12):2822-2830.
- Weibel S, Rucker G, Eberhart LH, et al. Drugs for preventing postoperative nausea and vomiting in adults after general anaesthesia: a network meta-analysis. *Cochrane Database Syst Rev*. 2020;10:CD012859. doi:10.1002/14651858.CD012859.pub2
- White PF, Tang J, Hamza MA, et al. The use of oral granisetron vs intravenous ondansetron for antiemetic prophylaxis in patients undergoing laparoscopic surgery: the effect on emetic symptoms and quality of recovery. *Anesth Analg*. 2006;102:1387-1393.
- Whiting PF, Wolff RF, Deshpande S, et al. Cannabinoids for medical use: a systematic review and meta-analysis. *JAMA*. 2015;313(24):2456-2473.
- Xiong C, Liu G, Ma R, et al. Efficacy of palonosetron for preventing postoperative nausea and vomiting: a systematic review and meta-analysis. *Can J Anaesth*. 2015;62(12):1268-1278.
- Yeo W, Mo FK, Suen JJ, et al. A randomized study of aprepitant, ondansetron and dexamethasone for chemotherapy-induced nausea and vomiting in Chinese breast cancer patients receiving moderately emetogenic chemotherapy. *Breast Cancer Res Treat*. 2009;113:529-535.
- Zhang Z, Yang Y, Lu P, et al. Fosaprepitant versus aprepitant in the prevention of chemotherapy-induced nausea and vomiting in patients receiving cisplatin-based chemotherapy: a multicenter, randomized, double-blind, double-simulated, positive-controlled phase III trial. *Ann Transl Med*. 2020;8(5):234. doi:10.21037/atm.2019.12.158
- Zofran tablets, orally disintegrating tablets, oral solution prescribing information. Novartis. East Hanover, NJ. October 2017.
- Zuplenz prescribing information. Midatech Pharma US, Inc. Raleigh, NC. June 2019.

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