RESEARCH PAPER

Pharmacological Management of Postoperative Nausea and Vomiting: Drug Delivery Aspects

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ABSTRACT
Postoperative nausea and vomiting (PONV) remains one of the most common and distressing complications following surgical procedures, significantly affecting patient recovery, satisfaction, and healthcare costs. Regardless of the advances in anesthetic technique and drug management however, PONV continues to be experienced at ranges between 20-80 percentages in terms of patient, surgery and anesthesia factors. Pharmacological therapy of PONV has been worked upon a lot where the most relevant factor was the optimization of the delivery mechanisms of drugs so as to achieve the level of therapeutic activity and suppression of adverse effects. The researcher will in this paper explain the importance of antiemetic agents especially ondansetron and dexamethasone which can be used as prophylaxis and treatment of PONV and will also critically discuss the various forms of drug delivery routes like intravenous, oral and transdermal. Onset of action, bioavailability, patient compliance and patient outcome are some of the differences in comparative evaluation of these delivery methods. The study possesses the qualitative analytical methodology, which implies using secondary data (peer-reviewed data on clinical trials and pharmacological databases). It has demonstrated results that intravenous route has a strong bioavailability and quick onset thus making intravenous the route of administration to be best in immediate medical practice with the use of panoplied by oral delivery which has a slow absorption rate with erratic gastrointestinal functioning. The other solution that is being developed involving sustained release of drugs and a high degree of compliance to the drugs by the patient is transdermal but insufficient permeability of drugs and rapid onset of the treatment is still a concern. The use ondansetron and dexamethasone are proved to be more effective in comparison to the use of either one of the detoxifiers alone alongside the appropriate delivery arrangements. One concludes that the enhancement of drug delivery systems can be done to enhance the antiemetic properties and minimize the complications of PONV and that transdermal systems can be a future research focus.

Keywords: Postoperative nausea and vomiting, ondansetron, dexamethasone, drug delivery systems, intravenous administration, oral delivery, transdermal systems, antiemetic therapy
How to cite this article: Sehgal R, Sarkar A. Pharmacological Management of Postoperative Nausea and Vomiting: Drug Delivery Aspects. Int J Drug Deliv Technol. 2026;16(20s): 366-377. DOI: 10.25258/ijddt.16.20s.44
Source of support: Nil.
Conflict of interest: None

1. Introduction

1.1 Background of Postoperative Nausea and Vomiting

Perioperative care incorporates a significant clinical problem of postoperative nausea and vomiting that patients have reported to be much harder to tolerate than postoperative pain. It is characterized by a complex physiological response that is what includes the central nervous system, gastrointestinal tract and the vestibular. The occurrence of PONV varies depending on the unique risk factor such as gender, and history of motion sickness, of the patient was not a smoker, and subjected to opioids meaning the prevalence varies and the variables are related to the procedure of a surgery such as the type of surgery and the time.

The pathophysiology of PONV involves the activation of signals of vomiting center of the medulla oblongata by the signals of the chemoreceptor trigger zone, vomiting system, cerebral cortex, and the gastrointestinal tract. The neurotransmitters such as serotonin(5-HT3), dopamine, histamine, acetylcholine and substance p play a major role in the emetic responses(Kranke*et al*.,2011). They are of specific interest to serotonin receptors since they are involved in chemotherapy induced and postoperative nausea.

1.2 Importance of Pharmacological Management

To achieving positive patient outcomes, reduce hospitalization, and prevent complications, such as dehydration, electrolyte imbalance, wound dehiscence, and aspiration pneumonia, there is a need to control PONV. The necessity to strike different receptor pathways is the basis of both pharmacological treatment and prevention of PONV, and preference should be established on the necessity.

Ondansetron is a selective 5-HT3 receptor antagonist and is efficacious and with excellent safety profile leading to high usage. Dexamethasone is a corticosteroid that is an anti-inflammatory and antiemetic that is usually administered as an adjunctive therapy(Wiesmann *et al*.,2015). However, the effectiveness of such drugs is not as much about the pharmacodynamics of administration which means that the mode of delivery is effective as well.

1.3 Role of Drug Delivery Systems

The drug delivery systems play a vital role in determining the mode of introduction of the therapeutic effects, duration, and intensity. Regarding PONV, the intravenous, oral, and transdermal delivery choice had a potentially radical impact on a clinical outcome. The intravenous, and convenience, delivery method is used to achieve the rapid action and correct dosing of the drug but the gastrointestinal motility can interfere with the impact of the latter(Fero *et al*.,2011). The transdermal systems are acquired and sustained release, and it is more likely to attain compliance which is a desirable and attractive alternative in long term management.

1.4 Research Objectives

The primary objective of this study is to analyze the pharmacological management of PONV with a specific focus on drug delivery aspects(Naylor *et al*.,1994). The paper shall assist in the comparison of ondansetron and dexamethasone regarding the level of effectiveness when they are given in different modes of delivery, pharmacokinetic and pharmacodynamic interaction, and the emerging technologies in transdermal therapy.

2. Literature Review

Kranke (2011) evidently states that the pharmacological treatment of postoperative nausea and vomiting (PONV) is a complicated alignment between the therapeutic efficacy and clinical constraints. Although the author asserts that some of the widely used antiemetic agents like 5-HT3 receptor antagonists, dopamine antagonists, corticosteroids, and anticholinergics have been found to show efficacy, there is always a lack of such a single agent that can fully protect against PONV. Kranke emphasizes that PONV is a multifactorial disorder that involves patient factors, anesthetic factors, and surgical factors, and hence a multimodal method of treatment instead of depending on one drug is necessary. The concept of risk stratification is also discussed in the paper where it is argued that patients that have a higher profile of risks are more benefiting in combination therapy. The author however notes that there would be limitations in the form of adverse effects of drugs, cost, and fluctuation of patient response. The discussion about evidence-based guidelines is another valuable contribution of this work as it attempts to maximize the outcomes of the treatment without causing unjustified exposure to drugs. The author also admits that certain progress has not yet made it possible to fully remove PONV, which is why further research of innovative treatment methods and personalized care guidelines is necessary.

Wiesmann (2015) suggests that the problem of postoperative nausea and vomiting can be considered through the prism of an integrative approach that integrates the pathophysiological, pharmacological, and clinical management approaches. According to the author, PONV is caused by the stimulation of multifaceted neural mechanisms, including central nervous system and gastrointestinalor tract, specifically the chemoreceptor trigger zone and vomiting center. Wiesmann underlines that various neurotransmitters like serotonin, dopamine, histamine, and acetylcholine are very instrumental in this process hence the adoption of multiple pharmacological agents to various receptors. The review is a solid advocate of the multimodal approach, to incorporate both pharmacological and non-pharmacological interventions in order to attain maximum results. In addition, the author explains why treatment strategies should be individualized on the risk factors of a patient such as gender, smoking status, and history of motion sickness. Wiesmann also brings up newer development in antiemetic drugs and improved anesthesia technology that were also contributing to low incidence rates. Nevertheless, the author states that these improvements do not eliminate the fact that PONV remains a serious clinical problem, and treatment regimes and compliance with the existing guidelines still need improvement.

Fero (2011) suggests that the pharmacologic treatment of PONV has undergone progressive changes because of the introduction of newer antiemetic drugs and more knowledge regarding the risk-based prevention

policies. The author also stresses the need to detect high-risk patients with validated scoring systems, which enables the clinicians to take specific prophylaxis. Fero examines the effectiveness of different classes of drugs, such as the serotonin receptor-antagonists, neurokinin-1 receptor-antagonists, and corticosteroids, describing their effectiveness, mechanism of action, and clinical advantages. One of the most crucial aspects of the review is the focus on combination therapy that had been posed to yield better results than monotherapy. The author also touch upon issues connected with side effects, drug interactions, cost-effectiveness indicating that clinicians should be able to manage these aspects in order to choose the methods of treatment. More than that, Fero emphasizes the contribution of evidence-based guidelines to the standardization of care and better patient outcomes. Irrespective of such progress, the author also admits that patient response variability continues to be a problem, which is why the treatment approaches must be customized and the new therapies with antiemetics, as well as the novel ones, are to be investigated.

As Naylor (1994) acknowledges, physiology and pharmacology of postoperative nausea and vomiting has strong biology as both neural pathways and chemical mediators interact in a complex manner. The author offers a background knowledge of the regulation of vomiting reflex by the central nervous system especially via the control of vomiting center and chemoreceptor trigger zone. Naylor describes that these pathways, which bring about PONV, may be triggered by different stimuli, such as anesthetic agents, surgical manipulations, and gastrointestinal disturbances. The paper also explains the role played by major neurotransmitters like dopamine, serotonin, and histamine which are the foundation of pharmacological interventions. Naylor emphasizes the need to alter these neurotransmitter systems to be able to treat the symptoms. Despite the fact that the study was conducted long before the majority of modern innovations, it has its value due to the detailed discussion of the underlying mechanisms. Another point that the author highlights is that improved understanding of these physiological processes can be applied in the formulation of more effective therapies targeting antiemesis. This paper provided foundations to the further studies in the field and added to the further development of the existing treatment approaches.

Kovac (2013) explained that the pharmacological and clinical practice developments have improved the management of postoperative nausea and vomiting to a much better extent. The author also pays much attention to the risk-based approach, according to which patients should be evaluated with the help of validated instruments to diagnose their predisposition to the development of PONV. Kovac emphasizes the usefulness of more recent antiemetic agents, such as second-generation 5-HT3 antagonists and neurokinin-1 receptor antagonists, with better performance and an extended time of action. The importance of combination therapy, especially in high-risk patients, is also highlighted in the review since the combination therapy covers multiple routes implicated in PONV. Moreover, the author talks about non-pharmacological measures like the reduction of the need of volatile anesthetics and opioids that can considerably decrease the incidence levels. The other issues discussed by Kovac include the question of cost and possible side-effectiveness, as well as the necessity of making balanced clinical decisions. Altogether, the article gives a thorough update on the existing practices and emphasizes the necessity of patient care and following the evidence-based recommendations.

As it is stated by Shaikh (2016), postoperative nausea and vomiting can be viewed as a small issue, nevertheless, in the reality, it is a multifactorial and complicated clinical issue that has a substantial effect on patient comfort and improvement. The author emphasizes that PONV is associated with severe complications that may include dehydration, electrolyte imbalance, and late discharge, and this raises the costs of health care. Shaikh emphasizes the necessity to learn about the range of risk factors that PONV is related to such factors as patient factors, surgery type, and anesthetic methods. The review stipulates the importance of multimodal management techniques whereby pharmacological and non-pharmacological choices are incorporated in order to implement improved outcomes. Other antiemetic drugs along with their mechanism are also addressed by the author with concessions to some limitations to their efficacy and some side effects. The second point that the paper has brought out is that clinical awareness and guideline compliance are important elements of documentation that can greatly improve patient outcomes. The author concludes that even though PONV is prevalent, it needs thorough and close management to reduce its effects on the care of patients.

Golembiewski (2005) notes that prevention and treatment of postoperative nausea and vomiting may need the use of systematic and evidence-based approach that incorporates the pharmacological and clinical interventions. The author notes that it is necessary to discover patient-specific risk factors and put appropriate prophylaxis in place. Golembiewski outlines the different classes of antiemetic therapy, such as serotonin antagonists, dopamine antagonists and corticosteroids, their efficacy and restrictions. The review is highly favourable of combination therapy, especially in patients at moderate to high risk, because it will increase efficacy through the multiple pathways. As well, the author targets non-pharmacological measures like proper hydration and reduced emetogenic anesthetics. Among the key contributions made to the field due to this work is its emphasis on cost-effectiveness and rational use of drugs which is a crucial factor in any clinical setting. Another matter that is put forward by the author is the necessity to obtain ongoing education and follow the guidelines to enhance patient outcomes. Nevertheless, the paper does not rule out that PONV is a noteworthy issue even now and requires research and continuous innovation in interventions.

3. Methodology

3.1 Research Design

The existing research design is a qualitative research involving the in-depth and interpretative analysis of the scholarly literature, which is related to the pharmacological treatment of postoperative nausea and vomiting, with specific emphasis on the drug delivery(Kovac *et al*.,2013). The qualitative approach is considered to be correct approach as the study is exploratory and integrative in character since it will attempt to generalize the findings of different clinical, pharmacological, and therapeutic research rather than generating first-order experimental findings. With its design, having a detailed explanation of the effects of the different drug delivery routes in influencing the efficacy of antiemetic agents such as ondansetron and dexamethasone is easy.

It will be structured as the narrative systematic review that entails the aspect of the evidence-based medicine to substantiate rigor and reliability. Information regarding the identification, screening and potential analysis of the appropriate literature were performed within the organized protocol and consequently minimized the source of bias and enhanced reproducibility. The design includes the pharmacodynamics, pharmacokinetic and clinical opinion on outcomes and it is possible to have a multi dimensional evaluation of drug delivery systems.

The study also has an analytical constituent of comparison where the different administration modes, intravenous, oral and transdermal, have standardized parameters that are applied on them(Shaikh *et al*.,2016). This helps one have a cross-sectional idea of the therapeutic performance in various clinical conditions. The justification behind qualitative synthesis is the thematic categorization where information is classified into thematic categories, which are drug efficacy, onset of action, bioavailability, patient compliance, and adverse effect profile.

As an effort to attain methodological validity, the research is coherent with systematic review stipulations of healthcare research studies. The degree of analytical rigor is very high since no meta-analytical statistical model is used to conduct the organized aggregation and interpretation of the findings. The design can also assist in identifying patterns, consistency and inconsistency of studies and hence contribute to a less obvious image of pharmacological interventions in the management of PONV.

Besides, the study design acknowledges clinical setting diversity, patient diversity, and surgical procedures(Golembiewski *et al*.,2005). The variations aiming at managing this variation have been addressed by critical selection and contextual interpretation of researches to make the inferences clinically relevant and generalizable. It is also possible to include emergent evidence via the qualitative paradigm in the context of transdermal drug delivery systems, which is only finding its path in the clinical practice.

3.2 Data Sources

This information was retrieved in this study due to an intensive and extensive search in numerous scientific and medical databases to enable inclusion of quality and peer reviewed literature. These sources used include the PubMed and Scopus-based journals, Web of Science, and Google Scholar, with reference to which is adequate to address the research on biomedical and pharmacological studies. In addition, the clinical trial repositories applied to identify information about clinical trials that were in progress and already completed in the treatment of PONV were ClinicalTrials.gov and the World Health Organization International Clinical Trials Registry Platform.

The search strategy was to get as many studies as possible that deal with the pharmacology facet in the

treatment of PONV and ondansetron in particular, dexamethasone and various drug delivery systems(Kovac *et al*.,2000). Other keywords, search terms, included; postoperative nausea and vomiting, ondanestron, dexamethasone, drug delivery, intravenous administration, administration via mouth, transdermal systems and antiemetic therapy. The search was narrowed down further by using a Boolean operator, such as AND, OR, and NOT, to ensure that the search is narrowed.

In order to ensure that the data is topical, the search was limited to the works that had been written within the last twenty years, which corresponds to the topicality. This era is characterized by the most recent advancements in the pharmacological and drug delivery technology and remains nonetheless with the efforts of people who demonstrated what the existing clinical practice is about. Randomized controlled trials, systematic reviews, meta-analyses, and high-impact observational studies were preferred because they contain solid evidence and reliable evidence.

Pharmacological databases and drug monographs also were used to obtain a more detailed information on pharmacokinetic and pharmacodynamic properties of the drugs selected plus published articles(Meyer *et al*.,2023). It also consulted reports by the regulatory agencies as well as guidelines by other organizations such as the World Health Organization and the American Society of Anesthesiologists so as to include the universal clinical recommendations.

The data collection process consisted of a number of stages, which involved initial identification, title screening, reviewing of the full text and selecting the contents. Duplication of researches was removed and those studies that passed ordinarily set inclusion criteria were analyzed. Information about different databases and sources has a difference in the attainment of coverage and reduction of the likelihood of publication bias.

3.3 Inclusion and Exclusion Criteria

Inclusion criteria in this study was well spelled based on how the studies have been selected and will be relevant, good and consistent(Tubog*et al*.,2024). To view through studies that would be close to pharmacological management of postoperative nausea and vomiting by specifically addressing the medicines of ondansetron and dexamethasone as well as the delivery system involved was chosen as inclusion criteria.

The considered research articles were the ones that explored the effectiveness of ondansetron and dexamethasone, safety and pharmacokinetics with respect to PONV. Research that suggested other methods of administration of drugs like intravenous, oral and transdermal was given special consideration. The inclusion criteria considered adults and pediatrics provided that the research had clinically useful information regarding the use of antiemetic therapy.

Randomized controlled trials were considered priority because they have high level of evidence then systematic review and meta-analyses becomes priority. Cohort and sad studies were not omitted as long as they provided interesting information concerning the clinical outcome in the real world(Pota *et al*.,2025). The English language was selected so that it would be possible to choose only the studies that will be interpreted and analyzed accordingly.

Studies which were out of scope of the research were eliminated using the inclusion criteria. The articles involving nausea and vomiting, which were not of postoperative nature such as chemotherapy-induced nausea or motion induced nausea were filtered out but were provided to give some necessary information regarding the pharmacological characteristics that can be applied to PONV. In addition, papers which were not formulated with dexamethasone or ondansetron were also filtered and papers which did not have sufficient methodological coverage or clinical significance.

There was no consideration of cases, editorial, and opinion pieces since they had less generalizability and were not empirically based(Goldson *et al*.,2025). Small sample size studies or those studies which were poorly analyzed were also checked and removed when they were not acting in accordance to the accepted criteria. It also had investments in duplicate publications and research, which had duplication of data sets and was therefore removed to get rid of duplication.

These were the criteria to ensure that not a single study but high-quality and relevant studies were included in the final dataset thereby enhancing the validity and reliability of analysis. In this respect systematic selection was conducted in such a manner that minimized any kind of bias and encouraged openness.

3.4 Analytical Framework

The theoretical basis of the study on the critical theory will be based on comparative and thematic analysis of the drug delivery procedure pharmacological and clinical parameters under different treatment of postsurgical nausea and vomiting. It is a viewpoint that comprises the pharmacodynamic, pharmacotropic, and clinical prospect of

implementation and provides a comprehensive analysis of the therapeutic effectiveness.

One of the elements of the analysis which is made of pharmacokinetic parameters is the bioavailability, action onset, peak plasma concentration, half-life, and therapeutic effect. These parameters have a significant role to play in the determination of speed and effectiveness of a drug in PONV symptom relief(Jumaev*et al*.,2025). Some of the features that intravenous route is evaluated in relation to include immediate availability in the body and quick onset whereas oral and transdermal is evaluated in relation to the properties of absorption and extended release pattern.

The pharmacodynamic problems are also handled particularly the mechanism of action of ondansetron and dexamethasone. These medications react with some receptor mechanisms such as serotonin receptors in order to obtain a clear image on their antiemetic mechanism. The combined effect of the therapy is investigated to determine its impact on the overall effectiveness.

Clinical outcome measures is another significant part of the framework. They include PONV incidence and severity, the use of rescue medication, patient satisfaction and adverse events(Satapathy *et al*.,2024). It is comparatively examined in a bid to comprehend how other delivery channels affect the effects in different clinical environments.

The framework also involves patient-centered factors compliance, convenience and tolerability. The use of oral route and transdermal is considered in terms of their dose of convenience and tolerability of patients, and the use of intravenous route is tested in terms of the degree of clinical practicability and resources.

The synthesis of the data is conducted in a manner of thematic approach since the outcomes of different studies are aggregated on the platform of similar themes and tendencies in the categories. This will facilitate the occurrence of the common patterns and variation in the literature(Mieszczański*et al*.,2025). Cultural aspects such as the nature of surgery, anesthesiaconditions and risk factors of the patient are also taken into consideration by analyzing and can influence the efficacy of antiemetic treatment.

In order to accomplish the recommendations, the research involves cross-validation of the findings through comparison of the findings of different sources. The contradicting pieces of evidence are posed with critical glance, and options are discussed. Research gaps are also realized within the framework particularly in the area of new drug delivery technologies e.g. transdermal systems.

The analysis framework, in general, provides a multi-dimensional and systematic approach to the evaluation of PONV pharmacological management. It enables the comparison of the systems of drug delivery in detail and makes the evidence-based conclusions which can assist to define their drawbacks and merits in comparison to each other.

4. Results and Analysis

4.1 Comparative Effectiveness of Ondansetron and Dexamethasone

The comparative study of ondansetron and dexamethasone lays down the distinctive but complimentary impacts on the pharmacological control of nausea and vomiting that become experienced following the operation. Ondansetron, another, selective serotonin 5-HT3 receptor antagonist, is very effective in prophylaxis of acute PONV, particularly within the initial 6 to 12 hours of the postoperative phase. It does this by inhibiting both central nervous system and gastrointestinal tract serotonin receptors thereby interfering with emetogenic signals that are provoked by surgical stress and anesthetics.

One of the antiemetic agents aiding with the process of antiemetic control is the corticosteroid dexamethasone, and its action takes place through the following mechanisms, which include prohibition of the prostaglandin synthesis, inhibition of inflammation, and control of neurotransmitter activity(Xie *et al*.,2023). It is also more predominant in its antiemetic activity in the later phase of PONV when the same occurs in the latter part outside the immediate postoperative state. Its pharmacological properties justify its use as a prophylaxis drug that may be used in advance of the appearance of anesthesia state.

Ondansetron binds with dexamethasone in a synergistic manner and is able to cover a variety of various emetic pathways(Kaye *et al*.,2025). Clinical evidence does show that combination therapy becomes highly effective to reduce the incidence and severity of PONV when compared to monotherapy. Such reduction is particularly notable within high-risk groups of patients, and multimodal antiemetic treatment needs to be implemented. Statistically significant results of comparisons of studies indicate that the reduction in the incidence of PONV compared to controls lies in the range of 20-40 percent when it is used in combination therapy and is the reason why it has clinical superiority.

4.2 Intravenous vs Oral Delivery

The route that the antiemetic agents take their delivery is essential in determining the treatment success of the antiemetic agents. The effects of intravenous delivery are rapidity of action that in most occasions occurs in minutes since they find direct transit into the blood(Arjmand *et al*.,2025). The pathway offers 100 percent bioavailability; hence it is the desirable one in an emergency postoperative setting where the symptoms should be suppressed at very rapid rates. Ondansetron IV also reaches high plasma concentration very fast and therefore produces silent nausea and vomiting.

In comparison, oral presentation has its advantage in aspects of convenience, low cost, and ease of administration of administration where outpatient or ambulatory surgical setup occurs. The GI factors which influenced the pharmacokinetic profile of an oral route are however,; gastrointestinal emptying time, intestinal motility, and first-pass hepatic metabolism. This is among the reasons why drugs are very unpredictable and slow acting as the drug takes time of 30 to 60 minutes to have an effect.

The use of oral ondansetron also does not work effectively in such patients who already have a nausea or vomiting issue since it may render the drugs hard to absorb and swallow. It is also in such situations that the credibility of oral presentation is questioned hence necessitating other methodologies(Alorfi*et al*.,2023). The comparative evidence has revealed that intravenous delivery provides better consistency and predictability as a route of therapy whereas oral route should be used in the maintenance therapy of stable patients.

4.3 Transdermal Systems

The new route of treatment of PONV is known as transdermal drug delivery system, which gives a controlled amount of release of drugs within a long period of time. These systems utilise the skin as a route to assimilate drugs in the system, and evade the gastrointestinal and first-pass metabolism. This results in a high bio-availability and low fluctuation in plasma concentration of drugs.

The analysis of the transdermal systems reveals that they maintain therapeutic drug levels of prolonged durations usually to the extent of above 24 hours. The resultant sustained release profile reduces the number of times of dose of patients and increases patient adherence where medication frequency may become inconvenient as in the case of the postoperative case(Miller *et al*.,2024). Some of the benefits of Transdermal patches are the reduction of pain (increased comfort by the patients) and reduction of the number of side effects caused systemically.

However, the operation of transdermal delivery is not ideal since it is not fast as compared to the intravenous delivery of the drug since the drug will first have to overcome the barrier of the skin before it can be delivered to the systemic circulation. This limitation hinders its use in acute treatment of PONV in which the symptom management is only required but also within a limited time. In addition to that, variations in drug absorption to temperature and hydration changes in the environment and in skin permeability can occur.

The issues aside, transdermal systems still stand a high potential as an part of a multi-modal antiemetic protocol, particularly in both the long-term prophylaxis and in patients who cannot take their medications orally(Öbrink*et al*.,2025). Further advances in the formulation technology, including the introduction of permeation enhancers, microneedle systems, etc. will contribute to the improvement of the current deficits and make transdermal delivery more clinically applicable.

4.4 Pharmacokinetic Considerations

Clinical effectiveness of the antiemetic drugs within the different route of delivery is also the epicenter of the pharmacokinetic parameters. Under intravenous administration, absorption and first-pass metabolism are avoided and an immediate systemic availability and high plasma concentration is obtained(Zhang *et al*.,2024). This leads to the rapid time taken to respond to the therapy and predictability of the reaction of the drugs, thus are most reliable within the emergency care set up.

Oral administration conversely is susceptible to hepatic first pass metabolism which reduces the quantity of drug that reaches the systemic circulation. The orally given ondansetron is less bioavailable than intravenous ondansetron and there is also the problem of gastrointestinal variability to raise inconsistent drug levels. Peak plasma concentration also would be delayed and this implies that a long duration would be before achieving a therapeutic effect sets in.

Transdermal systems provide a special pharmacokinetic characteristic, which possesses a slow absorption rate and plasma concentrations are constant. This restricts the differences in the peaks and the troughs as well as reducing the possibility of undesired effects which are dose related(Hermanns *et al*.,2022). However, providing the adequate permeability of drugs across the skin is not a simple one as well, particularly in the situations when the

physicochemical properties of the molecule are unfriendly.

The distributions of the different delivery routes are indicated in the following table.

Table 4.1 Comparative Pharmacokinetic and Clinical Parameters of Drug Delivery Routes

Parameter	Intravenous (IV)	Oral Delivery	Transdermal System
Onset Time (minutes)	1–5	30–60	60–180
Bioavailability (%)	100	50–70	60–80
Peak Plasma Time (minutes)	5–10	60–120	180–360
Duration of Action (hours)	4–8	6–12	24–72
First-pass Metabolism	Absent	Present	Absent
Plasma Concentration Stability	Moderate	Variable	High
Patient Compliance	Low	Moderate	High
Suitability for Acute PONV	High	Moderate	Low
Suitability for Maintenance	Moderate	High	High

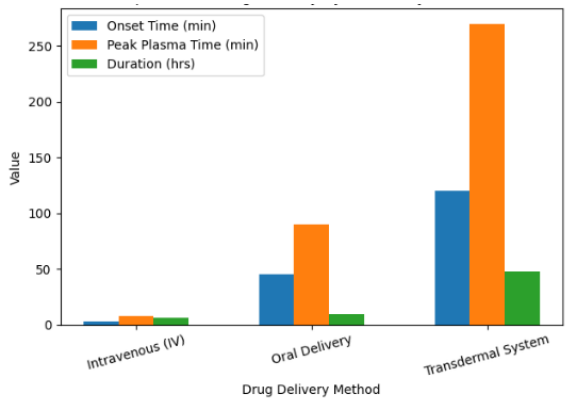

Figure: Comparative Pharmacokinetic and Clinical Parameters of Drug Delivery Routes

According to the facts presented in the table, it shows the special advantages and disadvantages of all delivery routes. IV Delivery does very well in the development of rapid onset and complete bioavailability and cannot be controlled in acute administration. Oral delivery provides a compromise in both efficacy and convenience and is limited by absorption alterations(Xu *et al*.,2025). Transdermal systems offer enhanced compliance and delivery of the drugs that makes it a highly viable option to long term treatment.

Overall, the discussion and results are characterized by the importance of appropriate drugs in accordance with the appropriate delivery systems to optimize the treatment regimes in the PONV treatment(Rahman *et al*.,2022). The integration of the drug-like properties and the efficacy of administration is the basic factor in the association of the effective and regular regulation of antiemetics in a variety of clinical settings.

5. Discussion

5.1 Clinical Implications

The result of the comparative study of the anti emetic agents and mode of delivery bears a great clinical implication especially in perioperative treatment of post operative nausea and vomiting. Pharmacological effectiveness in PONV is partly determined by the intrinsic properties of the administered pharmacological agents and to a significant extent by how and route of administration(Jana *et al*.,2022). The emphasis is on the importance of patient-centered clinicians who have a context-centered approach when choosing therapeutic practices.

Intravenous mode of administration remains an important component of acute postoperative therapy since it is rapid acting and absorption is high. During the acute postoperative phase when the affected patients are still recovering after anesthesia and may not be in a condition to take the medication orally, the intravenous route offers a therapeutic mode of administration with immediate efficacy and ensures the dependability of symptoms control(Gan *et al*.,2022). At-risk patients should receive particular attention; these may be hospitalized patients who took a major operation or are taking opioid-based painkilling medications, or have recently had PONV. In the scope of clinical decision-making and timely intervention, the capability of obtaining predictable plasma levels of drugs by using the intravenous routes could be improved.

Rather, oral delivery systems have come to pass to play a major role in the later days following an operation; especially in the ambulatory surgical departments. Once patients are healed to the extent of being able to communicate orally, they can use oral antiemetics as an active and non-surgical means of continued symptom control. In this regard, oral

ondansetron comes into play since it gives the patient the independence to make his own choice and eliminates a lasting clinical follow-ups. Nevertheless, owing to this gastrointestinal absorption discrepancy, caution must be exercised when selecting the patient because any form of gastric emptying stagnation or post operative stalemate may overrule the influence of the drug.

Transdermal drug delivery systems provide a twist of TPNV administration with controlled release of drugs in an organized manner. They are also particularly useful where a greater duration of antiemetic protection is necessary, as might be the case with more prolonged surgery or those with a slow recovery curve. We can preserve consistent plasma drug levels and, thus, the treatment effect does not change and the risk of breakthrough symptoms is reduced(Homayouni*et al*.,2022). Moreover, transdermal equipment is less patient-non-compliant (no need to take regularly) which also contributes to the outpatient situation.

Multimodal antiemetic model permits a wider range of different methods of delivery to be applied so as to accomplish a more complex and a more comprehensive treatment of PONV. An example is intravenous therapy during an acute postoperative phase and oral maintenance therapy thereafter to ensure continuity of care and to ensure optimization of therapeutic action(Zeng *et al*.,2025). Such a practice coincides with current clinical practice that promotes the consideration of risk stratification and treatment planning of people by clinicians.

5.2 Advantages of Combination Therapy

Dexamethasone combined with ondanserton is considered one of the keystones of contemporary antiemetics (in particular, PONV). This compound is more effective than either of the two medicines in separate, but possibly related pathways of the emetic response as a result of the complementative effects of the two medicines in what is believed to be different pathways(Burfeind *et al*.,2022). Ondansetron interacts with the selective serotonin 5-HT3 receptors, and thus prevents gastrointestinal tract-to-central nervous system and central nervous system-to-central nervous system afferent signalling. However, dexamethasone does lead to alterations in inflammatory processes and neurochemicals, which makes it a contributing factor to a reduced delayed emetic reaction.

Synergetic interaction between these agents permits a more complete inhibition of emetogenic stimuli leading to a marked decrease in incidence and severity of PONV. In many clinical trials combination therapy has proved to be more effective than monotherapy, although the combination therapy itself has peculiar efficacy in the group of patients, who have been identified as high risk by the scoring systems typically applied. Combination therapy can reduce PONV occurrence with greater patient comfort as well as reduced recovery period, less patient hospitalization, and less health care expenditure.

The dose can also be optimized another benefit of the combination therapy. Applying the concept of two agents, one of each course of action, the necessary treatment effect may be obtained at lower doses of both agents(Kranke*et al*.,2011). In this manner, dose-dependent ondansetron-induced adverse effects like Headache and QT prolongation might be prevented, in addition to the hyperglycemia and immunosuppression caused by dexamethasone. Less side effects enhance safety of treatment regimen.

Combination therapy also needs time to manifest its optimum benefits. Dexamethasone is commonly used as an anesthesia builds, and ondansetron is commonly used near the end of the operation, to generate an immediate postoperative effect. This time will help treat both these acute stages and delayed stages of PONV.

Moreover, the combination therapy may be implemented along with the principles of multimodal analgesia and enhanced recovery after surgery plans, which presuppose the provision of several actions directed to guarantee that people obtain the best results. Combination antiemetic therapy reveals such protocols.

5.3 Limitations of Current Delivery Systems

To date, even with the enhancement of pharmacological treatment and drug administration routes, the list of limitations to the overall efficiency of the PONV treatment is quite extensive(Wiesmann *et al*.,2015). There are some problems related to all delivery routes and should be taken into account in clinical practice.

Intravenous delivery mode is good but it is also an invasive mode and also involves the use of skilled people to administer the drugs. It is also linked to strain on health care budgets since even in outpatient care facilities it deserves venous access and continuous observation, which in turn restricts its use in outpatient care facilities. There are also certain risks such as infection, thrombophlebitis and dosing errors when being delivered intravenously, so every precaution should be taken.

There is easy control in delivery of speech and there is a high degree of interactive change in absorption of

the drugs(Naylor *et al*.,1994). Gastrointestinal motility and food presence and individual variations in metabolic processing could contribute to the pharmacokinetic properties of the orally administered drugs. In the post-operative environment, oral routes also become unreliable due to the possibility of nausea and vomiting. Patients lose the capacity to ingest oral medication and get the optimal possible treatment results.

Transdermal systems promise well, but there are issues with drug permeability, as well as slow drug action. The stratum corneum provides the skin with a shield against the effects of drugs and restricts the variety of drugs that may be administered through the skin. Moreover, transdermal systems might not be relevant in the management of acute symptoms because of time taken to achieve therapeutic plasma levels. Both drug absorption and efficacy have also been known to depend on skin characteristics between patients, such as skin thickness, hydration and temperature.

Inter-individual variability of drug response is another weakness of all delivery systems. Pharmacodynamics and pharmacokinetics can cause unrelated treatment responses when genetic factors, comorbidities, and administered drugs interact(Kovac *et al*.,2013). This heterogeneity presupposes the topicality of individual modes of treatment and indicates boundaries of the traditional regimes of doses.

Economies also play a role in the choice of delivery system. It might also face the extra expense of here incurring a more expensive intravenous route because it requires and demands greater clinical resources and manpower than the other sickly dermal apparatuses can be coupled with expensive production prices. One of the issues of healthcare decision making is whether a trade off can be possible between cost-efficacy and clinical efficacy.

5.4 Future Directions

Dynamic nature of technologies involved in drug delivery offers many opportunities in enhancing pharmacological control of PONV. The next path to pursue is probably the development of innovative methods of delivery to overcome the constraints of the current modalities and increase the effectiveness of therapy and patient comfort.

Transdermal delivery systems will continue to be an area of research and there will be research undertaken to enhance drug permeability and to reduce ramp-on time. Transdermal drug delivery will be increased significantly with the addition of iontophore and microneedle technology and the introduction of permeation enhancers. More precisely, microneedle patches provide less-toxic to injected skin with drug into a dermal stratum going around stratum corneum(Shaikh *et al*.,2016). The technology merges the merits of transdermal and parenteral to deliver a quick onset and release.

Another potential area of innovation is that of nanotechnology drug delivery systems. Examples of nanocarriers used to improve drug solubility, stability, and delivery include nanoemulsions, nanoparticles and liposomes. It is possible to treat antiemetic agents more accurately and efficiently using the systems to enhance the pharmacodynamics and pharmacokinetics of the compounds. Nanotechnology can also help in developing soluble mixtures that can be applied to deliver multiple drugs at a time to further enhance any treatment results.

Personalised medicine will improve the future of PONV management(Golembiewski *et al*.,2005). It is possible to identify patients who are more likely to respond to a particular drug or drug delivery system, with the assistance of clinical decision making that includes pharmacogenomic data. In this approach, drugs can be tailored to fit individual genetic profiles to maximize the effect and minimize adverse effects.

Even intelligent drug delivery platforms and digital health solutions can contribute to changing postoperative care. Smart patches and gadgets that might provide the opportunity to track all physiological parameters and manage the release of medications in real time would help antiemetic treatment to have a new diagnostic tool. The technologies belong to a wider movement of technology-oriented, patient-centered care.

Moreover, the long-run safety, effectiveness and cost-effectiveness of new delivery systems needs additional clinical studies(Kovac *et al*.,2000). A wider and more heterogeneous set of patients will be required to develop standard guidelines and to introduce new technologies into regular clinical practice.

In general, pharmacological innovation and innovative drug delivery system, along with custom-made health care solutions, will turn out to be the future of the PONV management. Future studies and new technologies in these fields must result in an important increase in patient outcomes, and they can support redesigning the standards of perioperative treatment.

6. Conclusion

Treatment of the resulting postoperative nausea and vomiting is managed jointly with effective antiemetic

agents combined with the best delivery system. Oncansetron and dexamethasone will continue to play a first-line role in PONV treatment because there is an established level of efficacy and safety. One of the elements that will decide which therapeutic effect of a drug will be achieved is the delivery path, intravenous delivery will be the least complex as it will have to be speedy as much as possible, oral delivery will be the least complex and transdermal system will be used in order to make the drug release as long as possible. Combinatory therapy is better and has lesser PONV effects in high-risk patients. It is expected that in the future, as development of drug delivery technologies progresses, it will become possible to support the outcomes of the patients and continue the PONV management process in clinical practice.

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