

# Comprehensive Insights into Gastric Ulcer Therapies: A Review of Current Approaches

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Received: 09/03/2024

Accepted: 28/04/2024

Published: 15/05/2024

## Abstract

Gastric ulcers represent a significant healthcare burden globally, necessitating comprehensive management strategies to optimize patient outcomes. This review provides an overview of current treatments for gastric ulcers, covering pharmacological and non-pharmacological interventions, novel therapeutic approaches, and future directions for research and innovation. The introduction outlines the epidemiology, etiology, and pathophysiology of gastric ulcers, highlighting the complex interplay of genetic, environmental, and lifestyle factors. Clinical presentation and complications are discussed, emphasizing the need for effective management strategies. Pharmacological treatments, including proton pump inhibitors (PPIs), histamine-2 receptor antagonists (H2RAs), mucosal protective agents, anti-inflammatory agents, and antibiotic therapy for *Helicobacter pylori* eradication, are reviewed in detail. Non-pharmacological interventions such as lifestyle modifications, endoscopic interventions, and surgical options offer complementary approaches to ulcer management. Novel therapeutic approaches, including emerging pharmacological agents, innovative endoscopic techniques, and integrative medicine approaches, hold promise for advancing ulcer treatment. Comparative effectiveness and safety analyses provide insights into treatment selection and individualized approaches. Challenges such as antibiotic resistance and adverse effects of pharmacological therapies underscore the need for continued research and innovation. Opportunities for personalized medicine and precision therapies offer the potential for improving treatment outcomes and reducing the burden of gastric ulcers worldwide. In conclusion, a multidimensional approach integrating pharmacological and non-pharmacological interventions is essential for effective gastric ulcer management. Future research should focus on addressing current challenges and advancing personalized therapeutic approaches to optimize patient care and outcomes.

**Keywords:** Gastric ulcers, Proton pump inhibitors, Histamine-2 receptor antagonists, Lifestyle modifications, Safety profiles.

*Journal of Applied Pharmaceutical Sciences and Research*, (2024);

DOI: 10.31069/japsr.v7i1.02

## Introduction

Gastric ulcers are defined as open sores or lesions that develop within the mucosal lining of the stomach, characterized by a breach in the gastric mucosa extending into the deeper layers of the stomach wall. These ulcers typically exhibit a round or oval shape and can vary in size from small erosions to larger defects.

### Epidemiology of Gastric Ulcers

Gastric ulcers are a prevalent gastrointestinal disorder, albeit with varying incidence rates across different geographic regions and population groups. The prevalence of gastric ulcers has declined over the past few decades, owing to improvements in hygiene, dietary habits, and the widespread use of potent acid-suppressing medications such as proton pump inhibitors (PPIs). However, they still impose a substantial health burden globally.

In the United States, the prevalence of gastric ulcers is estimated to be approximately 0.5 to 1% of the adult

population, with a slightly higher prevalence in men compared to women.<sup>1</sup> Internationally, the incidence and prevalence of gastric ulcers exhibit regional variations, with higher rates reported in developing countries where *Helicobacter pylori* infection rates are elevated and access to healthcare resources may be limited.<sup>2</sup>

Epidemiological data on gastric ulcers in India indicate that they remain a significant health concern, contributing to morbidity and healthcare costs across the country. However, specific prevalence rates can vary based on geographical location, socioeconomic factors, and access to healthcare services.

Several studies conducted in India have reported varying prevalence rates of gastric ulcers. A population-based study conducted in rural South India reported a prevalence rate of 6.3% for peptic ulcer disease, encompassing both gastric and duodenal ulcers.<sup>3</sup> Another study conducted in urban South India reported a similar prevalence rate of 6.0% for peptic ulcer disease among adults.<sup>4</sup>

The prevalence of *H. pylori* infection, a key risk factor for gastric ulcers, also varies across different regions of India. Studies have reported *H. pylori* prevalence rates ranging from 30% to 80% in various populations across.<sup>5,6</sup> Higher rates of *H. pylori* infection have been observed in rural and lower socioeconomic status populations, likely due to factors such as poor sanitation and overcrowding.

Furthermore, lifestyle factors such as tobacco smoking, alcohol consumption, and dietary habits may contribute to the burden of gastric ulcers in India. The widespread use of non-steroidal antiinflammatory drugs (NSAIDs) for pain relief and self-medication practices also poses a significant risk for ulcer development in the Indian population.<sup>7</sup>

Challenges in the management of gastric ulcers in India include limited access to healthcare services, disparities in healthcare infrastructure between urban and rural areas, and issues related to affordability and adherence to treatment regimens. Additionally, the emergence of antibiotic resistance in *H. pylori* strains poses challenges for successful eradication therapy.

Gastric ulcers remain a prevalent gastrointestinal disorder in India, influenced by a complex interplay of environmental, socioeconomic, and lifestyle factors. Further research is needed to elucidate the epidemiology of gastric ulcers in different regions of India and to develop strategies for prevention, early detection, and optimal management of this condition.

### Etiology of Gastric Ulcers

The development of gastric ulcers is multifactorial, involving complex interactions between genetic predisposition, environmental factors, and various etiological agents. The primary factors implicated in the pathogenesis of gastric ulcers include:

#### *H. pylori* infection

*H. pylori* is a Gram-negative bacterium that colonizes the gastric mucosa and is recognized as a major causative factor in the development of gastric ulcers. *H. pylori* infection induces chronic gastritis, leading to alterations in gastric acid secretion, mucosal inflammation, and disruption of the gastric mucosal barrier, ultimately predisposing to ulcer formation.<sup>8</sup>

#### Non-steroidal antiinflammatory drugs

Non-steroidal antiinflammatory drugs (NSAIDs), including aspirin, ibuprofen, and naproxen, are commonly used medications associated with an increased risk of gastric ulcers. NSAIDs inhibit cyclooxygenase (COX) enzymes, thereby reducing prostaglandin synthesis and impairing gastric mucosal defense mechanisms, leading to mucosal injury and ulceration.<sup>9</sup>

#### Excessive gastric acid secretion

Hypersecretion of gastric acid, either due to genetic factors or secondary to conditions such as Zollinger-Ellison syndrome, can predispose individuals to the development of gastric ulcers. Excess acid production overwhelms the mucosal defense mechanisms, resulting in mucosal damage and ulcer formation.<sup>10</sup>

#### Lifestyle factors

Certain lifestyle habits, such as smoking, excessive alcohol consumption, and psychological stress, have been associated with an increased risk of gastric ulcers. These factors may exacerbate mucosal injury, impair mucosal healing processes, and contribute to ulcer development.<sup>11</sup>

Gastric ulcers are characterized by mucosal lesions within the stomach lining and are influenced by a combination of genetic susceptibility, environmental factors, and various etiological agents such as *H. pylori* infection, NSAID use, and excessive gastric acid secretion.

### Pharmacological Treatments

Gastric ulcers are mucosal defects that develop in the stomach lining, often leading to symptoms such as abdominal pain, dyspepsia, and gastrointestinal bleeding. Pharmacological treatments play a crucial role in the management of gastric ulcers, aiming to reduce gastric acid secretion, enhance mucosal protection, eradicate *H. pylori* infection, and promote ulcer healing. This review provides an overview of the pharmacological agents commonly used in the treatment of gastric ulcers, emphasizing their mechanisms of action, efficacy, safety profiles, and clinical utility.

#### Proton Pump Inhibitors

Proton pump inhibitors are potent inhibitors of gastric acid secretion, acting by irreversibly blocking the H<sup>+</sup>/

**Table 1:** Comparison of proton pump inhibitors for gastric ulcers<sup>12</sup>

Proton pump inhibitor	Generic name	Brand name	Dosage forms	Onset of action	Duration of action	Metabolism	Common adverse effects
Omeprazole	Omeprazole	Prilosec	Capsules, tablets, powder for suspension	1-2 hours	24 hours	Hepatic	Headache, diarrhea, abdominal pain
Esomeprazole	Esomeprazole	Nexium	Capsules, tablets, powder for suspension	1-2 hours	24-36 hours	Hepatic	Headache, nausea, flatulence
Lansoprazole	Lansoprazole	Prevacid	Capsules, solutabs, orally disintegrating tablets	1-2 hours	24 hours	Hepatic	Diarrhea, abdominal pain, nausea
Pantoprazole	Pantoprazole	Protonix	Tablets, powder for injection	2-3 hours	24 hours	Hepatic	Headache, diarrhea, abdominal pain
Rabeprazole	Rabeprazole	Aciphex	Tablets	1-2 hours	24 hours	Hepatic	Diarrhea, abdominal pain, nausea

K<sup>+</sup>-ATPase proton pump in gastric parietal cells. Proton pump inhibitors (PPIs), including omeprazole, esomeprazole, and pantoprazole, are considered first-line therapy for gastric ulcers due to their superior efficacy in promoting ulcer healing and symptom relief compared to other acid-suppressing agents.<sup>9</sup> Table 1 summarizes the key characteristics of commonly used PPIs in the treatment of gastric ulcers.

Several clinical trials and meta-analyses have demonstrated the efficacy of PPIs in achieving ulcer healing, reducing the risk of ulcer recurrence, and improving the quality of life in patients with gastric ulcers.<sup>12</sup> However, long-term use of PPIs may be associated with adverse effects such as increased risk of fractures, hypomagnesemia, and potential drug interactions.<sup>13</sup>

• **Histamine-2 Receptor Antagonists**

Histamine-2 Receptor Antagonists (H<sub>2</sub>RAs) competitively inhibit histamine H<sub>2</sub> receptors on gastric parietal cells, leading to decreased gastric acid secretion. While H<sub>2</sub>RAs, such as ranitidine and famotidine, have been widely used in the management of gastric ulcers, they are considered less effective than PPIs in promoting ulcer healing and symptom relief.<sup>14</sup> Figure 1 illustrates the mechanism of action of H<sub>2</sub>RAs in gastric acid suppression.

Clinical studies have shown that H<sub>2</sub>RAs may be effective as maintenance therapy for preventing ulcer recurrence in selected patients, particularly those with low-risk ulcers and

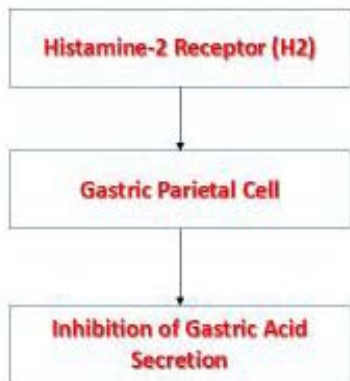


Figure 1: Mechanism of Action of Histamine-2 Receptor Antagonists

no evidence of *H. pylori* infection.<sup>15</sup> However, long-term use of H<sub>2</sub>RAs may be associated with tolerance and tachyphylaxis, limiting their utility in the management of gastric ulcers.

• **Mucosal Protective Agents**

Mucosal protective agents, such as sucralfate and colloidal bismuth compounds, exert their therapeutic effects by forming a protective barrier over ulcerated mucosa, enhancing mucosal defense mechanisms, and promoting ulcer healing. These agents are often used as adjunctive therapy in combination with acid-suppressing agents for the treatment of gastric ulcers.<sup>9</sup> Table 2 summarizes the key characteristics of mucosal protective agents commonly used in ulcer management.

Clinical trials have demonstrated the efficacy of mucosal protective agents in accelerating ulcer healing, reducing pain, and preventing ulcer recurrence in patients with gastric ulcers.<sup>9</sup> These agents are generally well-tolerated, with minimal systemic absorption and few adverse effects.

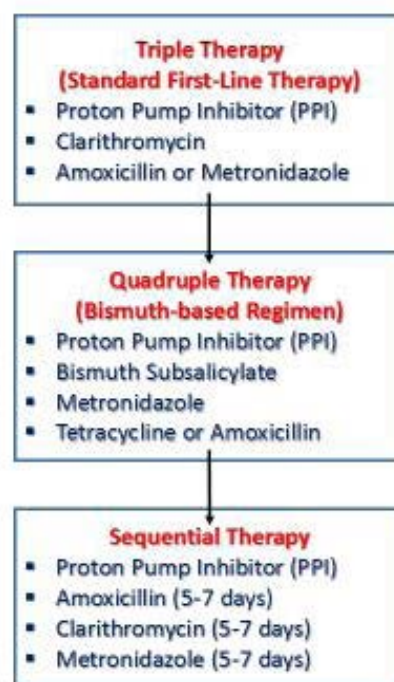


Figure 2: Recommended Treatment Regimens for *H. pylori* Eradication

Table 2: Mucosal protective agents for gastric ulcers

Mucosal protective agent	Generic name	Brand name	Dosage forms	Mechanism of action	Efficacy	Safety
Sucralfate <sup>9</sup>	Sucralfate	Carafate	Tablets, Suspension	Binds to damaged mucosa, forming a protective barrier and promoting ulcer healing	Effective in promoting ulcer healing and pain relief	Generally well-tolerated
Colloidal Bismuth Compounds <sup>9</sup>	Bismuth Subsalicylate	Pepto-Bismol	Tablets, Suspension	Forms a protective coating over ulcers, inhibits pepsin activity, and has antiinflammatory properties	Effective in promoting ulcer healing and symptom relief	Common adverse effects include constipation, black stools
Rebamipide <sup>18</sup>	Rebamipide	Mucosta	Tablets, Suspension	Stimulates prostaglandin and mucin synthesis, scavenges free radicals, and inhibits pro-inflammatory cytokines	Effective in promoting ulcer healing and reducing recurrence	Generally well-tolerated, with few adverse effects

### • Antibiotics for *H. pylori* Eradication

*H. pylori* infection is a major risk factor for the development of gastric ulcers, and eradication of *H. pylori* is a key component of ulcer management. Antibiotic therapy, often in combination with PPIs and other antimicrobial agents, is effective in eradicating *H. pylori* infection and preventing ulcer recurrence.<sup>16</sup> Figure 2 illustrates the recommended treatment regimens for *H. pylori* eradication.

Clinical guidelines recommend combination antibiotic therapy consisting of clarithromycin, amoxicillin, metronidazole, or levofloxacin, in addition to a PPI, for *H. pylori* eradication in patients with gastric ulcers.<sup>8</sup> However, increasing antibiotic resistance poses a challenge to successful *H. pylori* eradication, emphasizing the need for tailored treatment regimens and antimicrobial stewardship.

### Non-pharmacological Interventions

Gastric ulcers represent a significant clinical challenge, necessitating a multidimensional approach to management beyond pharmacological interventions. This note provides a comprehensive review of non-pharmacological interventions, encompassing lifestyle modifications, endoscopic interventions, and surgical options, with a focus on key strategies and their clinical implications (Table 3).

### Lifestyle Modifications

Lifestyle factors such as smoking, dietary habits, and stress play pivotal roles in the pathogenesis and exacerbation of gastric ulcers. Smoking cessation is paramount, as smoking not only impairs ulcer healing but also increases the risk of ulcer recurrence and complications.<sup>8</sup> Dietary changes, including avoidance of spicy, acidic, and irritating foods, can alleviate symptoms and prevent ulcer exacerbation. Additionally, stress reduction techniques such as mindfulness, relaxation therapies, and cognitive-behavioral interventions have been shown to improve ulcer healing and symptom management.<sup>17</sup>

Lifestyle factors significantly influence gastric ulcer development and healing. Smoking cessation, dietary modifications, and stress reduction are integral components of ulcer management.<sup>8</sup>

#### • Smoking Cessation

Smoking is a well-established risk factor for gastric ulcers, impairing ulcer healing and increasing recurrence rates. Table 1 summarizes the benefits of smoking cessation in ulcer management.

#### • Dietary Changes

Certain dietary factors, including spicy foods, alcohol, and caffeine, can exacerbate ulcer symptoms. Dietary

**Table 3:** Summarizing non-pharmacological interventions for gastric ulcers

Intervention	Description	Indications	Techniques/Approaches	Outcomes
Lifestyle modifications <sup>8,17</sup>	Smoking cessation	Active smoking Previous or current smokers	Behavioral counseling, pharmacotherapy	Improved ulcer healing, reduced recurrence risk
	Dietary changes	Dietary triggers (spicy, acidic foods, alcohol) Patients with ulcer symptoms Post-gastrectomy patients	Dietary counselling	Symptom relief, prevention of ulcer exacerbation
	Stress reduction	High-stress individuals Patients with stress-related symptoms	Mindfulness, relaxation therapies, cognitive-behavioral interventions	Improved ulcer healing, symptom relief
Endoscopic interventions <sup>13</sup>	Hemostasis for Bleeding Ulcers	Active bleeding ulcers High-risk lesions (e.g., Forrest Ia, Ib)	Injection therapy, thermal coagulation, hemoclip application	Achieving hemostasis, prevention of rebleeding
	Mucosal resection	Early-stage malignant or precancerous lesions Lesions confined to the mucosal layer	Endoscopic mucosal resection (EMR)	Removal of precancerous or early-stage lesions
	Ablation techniques	Dysplastic lesions Early-stage cancer	Argon plasma coagulation (APC), radiofrequency ablation (RFA)	Destruction of abnormal tissue, treatment of dysplastic lesions or early-stage cancer
Surgical options <sup>8</sup>	Partial gastrectomy	Refractory ulcers Complications (e.g., perforation, obstruction) Suspected malignancy	Removal of the affected portion of the stomach, reconstruction of gastrointestinal continuity	Symptom relief, prevention of ulcer recurrence
	Vagotomy	Recurrent ulcer Intractable symptoms	Severing the vagus nerve to reduce acid secretion	Decreased acid production, reduced ulcer recurrence
	Pyloroplasty	Delayed gastric emptying Residual pyloric stenosis after surgery	Widening of the pyloric channel to improve gastric emptying	Improved gastric emptying, resolution of symptoms

modifications involving avoidance of these triggers and adoption of a balanced diet rich in fruits, vegetables, and whole grains are beneficial for ulcer healing.

- **Stress Reduction**

Psychological stress can exacerbate ulcer symptoms and delay healing. Stress reduction techniques such as mindfulness, relaxation therapies, and cognitive-behavioral interventions have been shown to improve ulcer outcomes.

- **Endoscopic Interventions**

Endoscopic interventions offer minimally invasive approaches for managing gastric ulcers, particularly in cases of active bleeding or high-risk lesions. Hemostasis techniques, including injection therapy, thermal coagulation, and hemoclip application, are effective in achieving immediate hemostasis and preventing rebleeding in bleeding ulcers.<sup>13</sup> Moreover, advanced endoscopic procedures such as mucosal resection and ablation techniques, including argon plasma coagulation and radiofrequency ablation, enable the removal or destruction of precancerous or malignant lesions, thus reducing the risk of cancer development.

Endoscopic procedures offer minimally invasive approaches for managing gastric ulcers, particularly in cases of bleeding or high-risk lesions.<sup>13</sup>

**Hemostasis for Bleeding Ulcers:** Endoscopic hemostasis techniques, including injection therapy, thermal coagulation, and hemoclip application, are effective in achieving immediate hemostasis and preventing rebleeding.

**Mucosal Resection:** Endoscopic mucosal resection (EMR) involves the removal of precancerous or early-stage malignant lesions confined to the mucosal layer, reducing the risk of cancer development.

**Ablation Techniques:** Advanced endoscopic ablation techniques, such as argon plasma coagulation (APC) and radiofrequency ablation (RFA), enable the destruction of abnormal tissue, offering therapeutic options for dysplastic lesions and early-stage cancer.

- **Surgical Options**

Surgical intervention may be indicated in cases of refractory ulcers, complications such as perforation or obstruction, or malignancy suspicion. Surgical techniques for gastric ulcer management include partial gastrectomy, vagotomy, and pyloroplasty, aimed at reducing acid secretion, restoring gastric emptying, and removing diseased tissue.<sup>8</sup> While surgical options are associated with potential risks and complications, they can provide durable symptom relief and long-term ulcer resolution, particularly in selected patients.

Surgical intervention may be warranted in selected cases of gastric ulcers, particularly those refractory to medical or endoscopic therapy, or complicated by perforation, obstruction, or malignancy suspicion.

**Indications:** Surgical options include partial gastrectomy, vagotomy, pyloroplasty, and antrectomy, depending on the ulcer location, size, and associated complications.

**Techniques:** Surgical techniques involve the removal of diseased tissue, reconstruction of gastrointestinal continuity, and restoration of gastric function.

**Outcomes:** Surgical outcomes vary depending on patient factors, ulcer characteristics, and surgical expertise, with potential benefits including symptom relief, ulcer resolution, and prevention of complications.

Non-pharmacological interventions play crucial roles in the comprehensive management of gastric ulcers. Lifestyle modifications, endoscopic interventions, and surgical options offer diverse strategies for ulcer prevention, symptom relief, and complication management. Integrated approaches incorporating these interventions, guided by individual patient characteristics and ulcer severity, are essential for optimizing outcomes and improving patient quality of life.

Non-pharmacological interventions play integral roles in the comprehensive management of gastric ulcers. Lifestyle modifications, endoscopic procedures, and surgical options offer diverse strategies for ulcer prevention, symptom relief, and complication management. A tailored approach, guided by individual patient characteristics and ulcer severity, is essential for optimizing outcomes and improving patient quality of life.

### Novel Therapeutic Approaches

Gastric ulcers remain a significant health concern globally, necessitating continuous exploration of novel therapeutic approaches beyond conventional treatments. This note provides an overview of emerging pharmacological agents, innovative endoscopic techniques, and integrative medicine approaches for the management of gastric ulcers, highlighting their potential benefits and clinical implications (Figure 3).

#### Emerging Pharmacological Agents

Advances in pharmacology have led to the development of novel therapeutic agents targeting various pathways involved in ulcer pathogenesis. Growth factors and targeted molecular therapies represent promising avenues for ulcer treatment.<sup>18</sup>

- **Growth Factors**

Growth factors such as epidermal growth factor (EGF) and basic fibroblast growth factor (bFGF) play critical roles

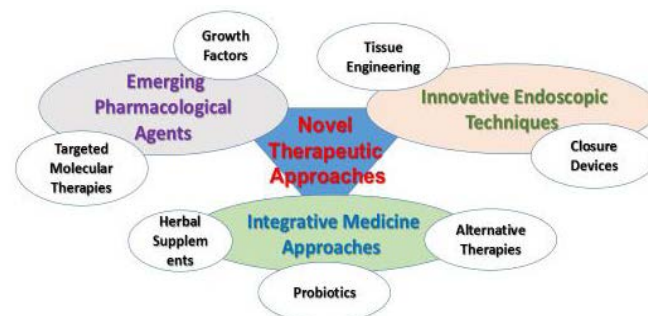


Figure 3: Illustrating the novel therapeutic approaches for gastric ulcers

in mucosal repair and regeneration. Administration of exogenous growth factors or agents stimulating endogenous growth factor production holds the potential for promoting ulcer healing and reducing recurrence.

#### Targeted Molecular Therapies

Targeted therapies directed against specific molecular targets implicated in ulcer development and progression offer precision in treatment. Examples include inhibitors of vascular endothelial growth factor (VEGF), matrix metalloproteinases (MMPs), and inflammatory cytokines. These agents aim to mitigate mucosal injury, promote tissue repair, and suppress inflammatory responses.

#### Innovative Endoscopic Techniques

Endoscopic interventions continue to evolve, enabling minimally invasive approaches for ulcer management and tissue repair. Closure devices and tissue engineering hold promise for enhancing endoscopic therapeutic capabilities.<sup>13</sup>

- *Closure Devices*

Novel endoscopic closure devices provide efficient and reliable methods for managing ulcer perforations, fistulas, and mucosal defects. These devices facilitate immediate closure of ulcer craters and promote tissue apposition, reducing the risk of complications and promoting healing.

#### Tissue Engineering

Tissue engineering approaches involve the use of biomaterials, scaffolds, and stem cells to regenerate damaged gastric mucosa. Biocompatible materials facilitate tissue repair and regeneration, offering potential alternatives to conventional therapies and promoting long-term tissue integrity.

#### Integrative Medicine Approaches

Integrative medicine encompasses a holistic approach to ulcer management, incorporating herbal supplements, probiotics, and alternative therapies to enhance treatment outcomes and patient well-being.<sup>19</sup>

- *Herbal Supplements*

Herbal remedies, such as licorice root, aloe vera, and chamomile, possess antiinflammatory, antioxidant, and mucoprotective properties. These supplements aid in ulcer healing, symptom relief, and mucosal protection, complementing conventional therapies.

- *Probiotics*

Probiotics, including *Lactobacillus* and *Bifidobacterium* species, exert beneficial effects on gastrointestinal health by modulating gut microbiota and enhancing mucosal immunity. Supplementation with probiotics promotes ulcer healing, reduces inflammation, and prevents recurrence.

#### Alternative Therapies

Various alternative therapies, such as acupuncture, acupuncture, and traditional Chinese medicine (TCM),

offer adjunctive approaches to ulcer management. These therapies focus on restoring balance and harmony within the body, addressing underlying imbalances contributing to ulcer pathogenesis.

Novel therapeutic approaches hold promise for advancing the management of gastric ulcers, offering innovative strategies to promote healing, reduce recurrence, and improve patient outcomes. Emerging pharmacological agents, innovative endoscopic techniques, and integrative medicine approaches represent exciting avenues for further research and clinical application, fostering a comprehensive and personalized approach to ulcer management.

#### Comparative Effectiveness and Safety

Gastric ulcers require effective management strategies to achieve optimal outcomes while minimizing adverse effects. This note aims to evaluate the comparative effectiveness and safety profiles of various treatment modalities, highlighting factors influencing treatment selection and the importance of individualized approaches.

#### Comparative Efficacy of Different Pharmacological Treatments

Numerous pharmacological agents are available for the treatment of gastric ulcers, including PPIs, H<sub>2</sub>RAs, antacids, and cytoprotective agents. Comparative studies have assessed the efficacy of these treatments in promoting ulcer healing, relieving symptoms, and preventing recurrence.<sup>20</sup>

#### Safety Profiles and Adverse Effects

Each treatment modality carries specific safety concerns and adverse effects that must be considered during treatment selection. Common adverse effects associated with pharmacological treatments include gastrointestinal disturbances, renal impairment, electrolyte disturbances, and drug interactions.<sup>9</sup>

#### Factors Influencing Treatment Selection and Individualized Approaches

Several factors influence treatment selection, including ulcer severity, patient comorbidities, medication tolerability, cost, and patient preferences. Individualized approaches, guided by these factors, are essential for optimizing treatment outcomes and patient satisfaction.<sup>8</sup>

Comparative effectiveness and safety analyses provide valuable insights into the selection of appropriate treatment modalities for gastric ulcers. Proton pump inhibitors are generally considered first-line therapy due to their superior efficacy and safety profiles. However, individualized approaches are crucial, considering patient-specific factors and preferences to optimize treatment outcomes and minimize adverse effects.

#### Challenges and Future Directions

Gastric ulcers pose significant challenges in treatment efficacy and long-term outcomes, necessitating continuous

efforts toward innovation and personalized therapeutic approaches. This note explores the current challenges faced in gastric ulcer management and outlines future directions for addressing these challenges.

#### Antibiotic Resistance and Treatment Failure in *H. pylori* Eradication

*H. pylori* (infection is a major contributor to gastric ulcer development, and antibiotic therapy is the cornerstone of eradication (Table 4). However, increasing antibiotic resistance poses a significant challenge, leading to treatment failure and recurrent infections.<sup>21</sup>

#### Adverse Effects and Long-term Complications of Pharmacological Therapies

Pharmacological therapies for gastric ulcers, such as proton pump inhibitors (PPIs) and non-steroidal antiinflammatory drugs (NSAIDs), are associated with adverse effects and long-term complications (Table 5). Prolonged PPI use has been linked to increased risk of bone fractures, *Clostridium difficile* infection, and hypomagnesemia, while NSAIDs can cause gastrointestinal bleeding, renal impairment, and cardiovascular events.<sup>22</sup>

#### Opportunities for Personalized Medicine and Precision Therapies

Advancements in molecular profiling and pharmacogenomics offer opportunities for personalized medicine and precision therapies in gastric ulcer management. Tailoring treatment strategies based on individual patient characteristics, including genetic polymorphisms, microbiome composition, and host factors, can improve treatment efficacy and minimize adverse effects.<sup>23</sup>

**Table 4:** Antibiotic resistance rates in *H. pylori* infection<sup>21</sup>

Antibiotic	Resistance Rate (%)
Clarithromycin	15–25
Metronidazole	40–65
Levofloxacin	10–25

**Table 5:** Adverse effects and long-term complications of pharmacological therapies<sup>22</sup>

Pharmacological therapy	Adverse effects	Long-term complications
Proton pump inhibitors	Hypomagnesemia	Increased risk of bone fractures
	<i>Clostridium difficile</i> infection	Hypomagnesemia <i>Clostridium difficile</i> infection
Non-steroidal anti-inflammatory drugs (NSAIDs)	Gastrointestinal bleeding	Renal impairment
	Renal impairment	Cardiovascular events
	Cardiovascular events	

#### Future Research Directions and Areas for Innovation

Future research in gastric ulcer management should focus on several key areas, including:

- Development of novel antimicrobial agents with enhanced efficacy and reduced resistance.
- Identification of biomarkers for predicting treatment response and guiding personalized therapy.
- Exploration of alternative treatment modalities, such as targeted biologics and microbiome-based therapies.
- Investigation of non-pharmacological interventions, including dietary modifications, lifestyle interventions, and integrative medicine approaches.

Addressing the challenges of antibiotic resistance, adverse effects of pharmacological therapies, and the need for personalized treatment approaches are essential for advancing gastric ulcer management. Future research and innovation hold promise for improving treatment outcomes, enhancing patient care, and reducing the burden of gastric ulcers worldwide.

## Discussion

Gastric ulcers pose a significant burden on public health worldwide, with varying prevalence rates across different regions. In India, the prevalence of gastric ulcers remains a concern, influenced by factors such as *H. pylori* infection, lifestyle habits, and access to healthcare services. Epidemiological studies in India have reported varying prevalence rates, highlighting the need for further research to understand the regional disparities and develop targeted interventions.

The etiology of gastric ulcers involves a complex interplay of genetic predisposition, environmental factors, and etiological agents such as *H. pylori* infection and NSAIDs. Understanding these underlying mechanisms is crucial for developing effective treatment strategies.

Pharmacological treatments play a central role in the management of gastric ulcers, with PPIs considered first-line therapy due to their superior efficacy in promoting ulcer healing and symptom relief. However, long-term use of PPIs may be associated with adverse effects, highlighting the importance of careful risk-benefit assessment.

H<sub>2</sub>RAs and mucosal protective agents are alternative treatment options for gastric ulcers, although their efficacy may be inferior to PPIs. Antibiotic therapy for *H. pylori* eradication is essential in cases of *H. pylori*-associated ulcers, but increasing antibiotic resistance poses challenges for successful eradication.

Non-pharmacological interventions, including lifestyle modifications, endoscopic interventions, and surgical options, complement pharmacological therapies in the comprehensive management of gastric ulcers. Smoking cessation, dietary changes, and stress reduction are integral components of ulcer management, while endoscopic interventions offer minimally invasive approaches for

hemostasis and tissue repair. Surgical options may be warranted in refractory cases or complications.

Emerging therapeutic approaches, such as growth factors, targeted molecular therapies, innovative endoscopic techniques, and integrative medicine approaches, hold promise for advancing ulcer management. Personalized medicine strategies based on individual patient characteristics and treatment response may improve treatment efficacy and minimize adverse effects.

## Conclusion

The management of gastric ulcers encompasses a comprehensive approach involving pharmacological and non-pharmacological interventions tailored to individual patient needs. PPIs stand as the cornerstone of treatment due to their superior efficacy in promoting ulcer healing and symptom relief. However, H<sub>2</sub>RAs, mucosal protective agents, and antibiotics for *H. pylori* eradication also play important roles in ulcer management.

In clinical practice, healthcare providers must consider various factors, including ulcer severity, patient comorbidities, medication tolerability, and cost, when selecting treatment modalities. Moreover, lifestyle modifications, endoscopic interventions, and surgical options offer complementary approaches for symptom management and complication prevention.

Looking ahead, future research should focus on addressing challenges such as antibiotic resistance, adverse effects of pharmacological therapies, and disparities in healthcare access. Advances in personalized medicine, novel therapeutic agents, and integrative interventions hold promise for improving treatment outcomes and reducing the burden of gastric ulcers globally.

In conclusion, a multifaceted approach integrating pharmacological and non-pharmacological interventions, guided by individual patient characteristics, is essential for optimizing ulcer management. Continued research and innovation are imperative to enhance treatment efficacy, minimize adverse effects, and improve patient care in the realm of gastric ulcer management.

## Acknowledgment

The authors are thankful to the Faculty of Pharmacy, Dr. APJ Abdul Kalam Technical University, Lucknow (U.P.) for providing the required support and time to complete this review work.

## Conflict of Interest

The authors declare no conflict in interest.

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**How to cite this article:** Pujari NM, Khushtar M, Mishra A, Gupta D. Comprehensive Insights into Gastric Ulcer Therapies: A Review of Current Approaches. *Journal of Applied Pharmaceutical Sciences and Research*. 2024; 7(1): 4-12 Doi : 10.31069/japsr.v7i1.02