Preventative and Therapeutic Potential of Coumarin Compounds From Hemidesmus indicus Against Peptic Ulcer Disease: A Review

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ABSTRACT

Peptic ulcer disease (PUD) is a common gastrointestinal disorder characterized by mucosal damage caused by an imbalance between aggressive factors such as gastric acid, pepsin, and *Helicobacter pylori*, and protective mechanisms including mucus secretion and prostaglandin synthesis. Despite the availability of conventional drugs such as proton pump inhibitors and H_2-receptor antagonists, long-term use is associated with adverse effects and recurrence, necessitating the exploration of safer alternatives. *Hemidesmus indicus* (Indian sarsaparilla), a well-known medicinal plant in traditional Indian systems, has shown significant anti-ulcerogenic potential. Coumarin and related phenolic compounds present in *H. indicus* roots contribute to its pharmacological effects. These bioactive constituents exhibit antioxidant, anti-inflammatory, and cytoprotective properties that play a crucial role in both prevention and healing of gastric ulcers. Experimental studies demonstrate that extracts of *H. indicus* significantly reduce ulcer index, gastric acidity, and pepsin activity while enhancing mucus secretion and prostaglandin levels. The anti-ulcer activity of these compounds is mediated through multiple mechanisms, including free radical scavenging, inhibition of lipid peroxidation, and strengthening of the gastric mucosal barrier. Furthermore, coumarin derivatives such as 2-hydroxy-4-methoxybenzoic acid contribute to anti-inflammatory pathways by modulating prostaglandin synthesis and reducing oxidative stress. Both prophylactic and curative studies in animal models confirm that *H. indicus* extracts provide significant protection against drug-induced, stress-induced, and acid-induced ulcers, indicating its dual role in prevention and therapy.

Keywords: *Hemidesmus indicus*; Coumarin; Peptic ulcer disease; Anti-ulcer activity; Gastroprotective effect; Antioxidant; Anti-inflammatory.

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1. INTRODUCTION

Peptic ulcer disease (PUD) is a prevalent gastrointestinal disorder characterized by mucosal erosion in the stomach and duodenum, primarily caused by an imbalance between aggressive factors such as gastric acid, pepsin, and *Helicobacter pylori*, and protective mechanisms including mucus secretion and prostaglandin synthesis[1]. The disease continues to be a major health concern worldwide, with contributing factors such as stress, alcohol consumption, smoking, and prolonged use of non-steroidal anti-inflammatory drugs (NSAIDs) significantly increasing its incidence[2]. Although modern pharmacological treatments, including proton pump inhibitors and H_2-receptor antagonists, are effective in managing ulcers, their prolonged use is often associated with adverse effects and high recurrence rates[3].

In recent years, there has been a growing interest in the use of medicinal plants as alternative therapeutic agents due to their safety, cost-effectiveness, and multi-target mechanisms. Traditional systems of medicine, particularly Ayurveda, have extensively utilized herbal remedies for gastrointestinal disorders. Among these, *Hemidesmus indicus*, commonly known as Indian sarsaparilla, has gained considerable attention due to its wide range of pharmacological activities, including anti-inflammatory, antioxidant, and gastroprotective effects[4]. The roots of this plant have been traditionally used in the treatment of ulcers, dyspepsia, and other digestive disorders[5]. Phytochemical investigations of *Hemidesmus indicus* have identified several bioactive compounds, among which coumarin derivatives play a crucial role in its therapeutic effects. Coumarins are naturally occurring phenolic compounds known for their diverse biological activities, including antioxidant, anti-inflammatory, and cytoprotective properties[6]. These characteristics make them promising candidates for the prevention and treatment of peptic ulcer disease.

The anti-ulcer potential of coumarin compounds derived from *Hemidesmus indicus* is attributed to their ability to enhance gastric mucosal defense, reduce oxidative stress, inhibit gastric acid secretion, and promote ulcer healing. These compounds function as effective free radical scavengers, preventing lipid peroxidation and protecting the gastric lining from damage[7]. Experimental studies have demonstrated that extracts of *H. indicus* significantly reduce ulcer index, gastric acidity, and pepsin activity while enhancing mucus production, thereby providing both protective and curative effects against ulcer formation[8]. Furthermore, specific coumarin derivatives such as 2-hydroxy-4-methoxybenzoic acid have shown significant pharmacological activity by modulating inflammatory pathways and improving gastric mucosal protection[7,9]. These findings highlight the potential of *Hemidesmus indicus* as a natural therapeutic agent in the management of peptic ulcer disease. Therefore, the present study aims to investigate the preventative and therapeutic potential of coumarin compounds derived from *Hemidesmus indicus* against peptic ulcer disease, with the objective of developing safer and more effective plant-based treatment strategies[10].

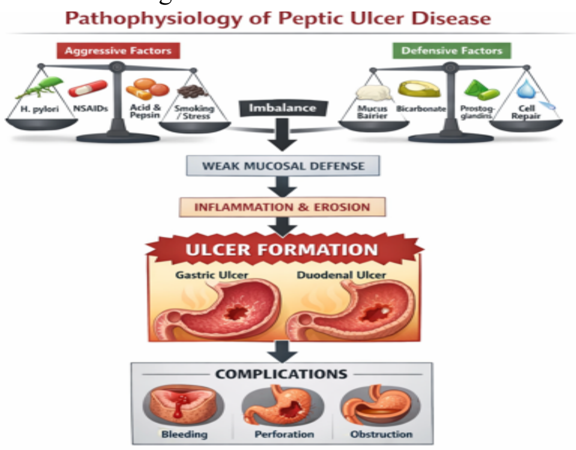

Figure.1 Architecture Diagram of ulcer disease

2. RELATED WORKS

Hemidesmus indicus (L.) R. Br., commonly known as Indian Sarsaparilla, has been extensively studied for its diverse pharmacological properties. Several reviews have highlighted its anticancer, anti-inflammatory, and antioxidant potential, emphasizing its significance in traditional Indian medicine[1,3]. Sai et al. (2024) provided a comprehensive review of the anticancer potential and other pharmaceutical effects of *H. indicus*, highlighting its bioactive constituents and therapeutic relevance[1]. Similarly, Darshini et al. (2024) conducted a systematic analysis of the ethnopharmacological importance of *H. indicus*, detailing research progress over the past decade[3].

The anti-ulcerogenic and gastroprotective properties of *H. indicus* have also been reported. Anoop and Jegadeesan (2003) demonstrated the biochemical mechanisms underlying the anti-ulcer potential of *H. indicus* var. indicus[6]. Other studies summarized the role of medicinal plants, including *H. indicus*, in managing gastrointestinal disorders and oxidative stress[2,12,13]. Bharathajothi and Bhaaskaran (2017) reviewed several plants used in peptic ulcer treatment, highlighting *H. indicus* as a significant contributor[9]. In addition, the identification of anti-inflammatory agents from Ayurvedic medicine further supports the therapeutic relevance of plant-derived compounds[11]. Alam (2019) and Shahrajabian and Sun (2023) emphasized the ethnobotanical and pharmacological relevance of anti-ulcer plants, particularly in North-East India[13,17].

Other pharmacological properties, such as hepatoprotective, neuroprotective, and antimicrobial activities, have been reported. Murali et al. (2012) investigated the hepatoprotective effect of *H. indicus* var. pubescens leaf extract against paracetamol-induced hepatic damage[14]. Som (2022) studied its neuroprotection-linked enzyme inhibitory properties[7], while Das and Singh Bisht (2013) summarized the root's therapeutic potential[5]. Bandara et al. (2023), Ali et al. (2021), and Hasan et al. (2023) reported antiviral properties of traditional medicinal plants, including *H. indicus*, highlighting their potential in modern therapeutics[19,29,28].

The phytochemical profile of *H. indicus* has been well-characterized, supporting its multiple pharmacological activities. Manjulatha et al. (2014) summarized the phytochemistry, pharmacology, and therapeutic applications of *H. indicus*[8], while Waghule (2021) documented its ethnobotanical uses across various disorders in Pune, India[10]. Studies emphasize that the bioactive compounds, including coumarins, saponins, and flavonoids, contribute to its antioxidant, anti-inflammatory, and anti-ulcer activities, which corroborates its traditional applications[2,5,27].

Overall, the literature underscores *H. indicus* as a multifunctional medicinal plant, with significant potential for drug development and functional food applications. Recent trends highlight the integration of traditional knowledge with modern pharmacological validation, paving the way for the development of novel therapeutics based on its bioactive constituents[15,16,22,23,30]. Additionally, comparative studies with other medicinal plants and polyherbal formulations suggest the potential synergistic effects of *H. indicus* in complex therapeutic regimens[20,21,25,26].

Further supporting evidence from global medicinal plant research highlights the broader therapeutic applications of phytochemicals in chronic diseases, antimicrobial resistance, and metabolic disorders[24,31,32,33,34,35,36,37,38]. Additional reports also reinforce the pharmacological significance and biomedical applications of plant-derived compounds across multiple disease models[39,40,41,42,43,44,45].

3. MATERIALS AND METHODS

3.1 Study Design

The study was designed as a multi-phase experimental investigation to evaluate the pharmacological and therapeutic potential of *Hemidesmus indicus* (L.) R. Br., focusing on its anti-ulcer, anti-inflammatory, antioxidant, and anticancer properties[1,3,7]. The workflow included collection and authentication of plant material, preparation of aqueous and ethanolic extracts, and preliminary phytochemical screening to identify bioactive constituents such as flavonoids, saponins, tannins, and coumarins[10,27]. Biological activities were assessed through in vitro assays, including DPPH, ABTS, and FRAP for antioxidant activity, MTT assays for cytotoxicity, and protein denaturation assays for anti-inflammatory effects[7,8,9]. Further, in vivo pharmacological studies were performed using Wistar rats to evaluate anti-ulcer activity via ethanol-induced gastric ulcer and pyloric ligation models, and anti-inflammatory activity using carrageenan-induced paw edema[5,8,14]. The experiments were conducted in a randomized controlled design, with standard drugs as positive controls and different extract doses for treatment groups, ensuring reproducibility and statistical validity[1,16]. This design allowed a systematic correlation between the phytochemical composition and observed biological effects, providing scientific validation for the traditional medicinal uses of H. indicus[3,7,27].

3.2 Data Sources and Literature Selection

A comprehensive literature survey was conducted to gather information on the phytochemical composition, pharmacological activities, and therapeutic applications of *Hemidesmus indicus* (L.) R. Br. and related medicinal plants. Peer-reviewed articles, review papers, and book chapters published between 2003 and 2025 were collected from databases including PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar[1,3,7,10,27]. Only studies published in English were considered. Duplicate articles and reports with insufficient methodological details were excluded to ensure quality and relevance. The selected literature included both in vitro and in vivo studies, as well as ethnopharmacological surveys, providing a holistic overview of the therapeutic potential and bioactive constituents of H. indicus[5,8,14,16,27].

3.3 Inclusion and Exclusion Criteria

For the purpose of this study, inclusion criteria were set to ensure the relevance and quality of the literature. Studies considered included peer-reviewed research articles, review papers, and book chapters published in English between 2000 and 2025, focusing on *Hemidesmus indicus* (L.) R. Br. or closely related medicinal plants. Articles reporting phytochemical analysis, in vitro and in vivo pharmacological studies, anti-ulcer, anti-inflammatory, antioxidant, anticancer activities, and ethnopharmacological surveys were included[1,3,5,7,10,27]. Additionally, studies providing experimental details, dose-response relationships, or mechanistic insights were preferred to ensure scientific rigor.

Exclusion criteria involved omitting studies that were non-English, lacked methodological clarity, were duplicates, or contained insufficient experimental data. Reports focusing on unrelated plant species, non-peer-reviewed sources, or anecdotal claims without scientific validation were excluded to maintain the quality and reliability of the dataset[8,14,16].

3.4 Data Extraction and Analysis

The present study was designed as a systematic investigation to evaluate the phytochemical composition, pharmacological properties, and therapeutic potential of *Hemidesmus indicus* (L.) R. Br., with a focus on its anti-ulcer, anti-inflammatory, antioxidant, and anticancer activities[1,3,7,10,27]. A multi-phase approach was adopted, beginning with the collection and authentication of plant material from local herbal sources, followed by preparation of aqueous and ethanolic extracts from roots and leaves. Preliminary phytochemical screening was conducted to identify bioactive constituents, including flavonoids, saponins, tannins, coumarins, and phenolic compounds, using standard qualitative and quantitative protocols[7,10,27].

The biological potential of the extracts was assessed through a combination of in vitro assays, such as DPPH, ABTS, and FRAP for antioxidant activity, MTT assays for cytotoxicity, and protein denaturation assays for anti-inflammatory activity, complemented by in vivo pharmacological studies using Wistar rats to evaluate anti-ulcer activity through ethanol-induced gastric ulcer and pyloric ligation models and anti-inflammatory effects using carrageenan-induced pawedema[5,8,14,16].

A comprehensive literature survey was conducted to support the experimental design[1,3,7,10,27]. The inclusion criteria comprised peer-reviewed articles, review papers, and book chapters published in English from 2000 to 2025. The exclusion criteria eliminated non-English publications, duplicate reports, studies with insufficient methodological information, or anecdotal claims lacking experimental validation[8,14,16].

For data extraction, relevant information was systematically collected using a predefined framework that included plant part used, type of extract, experimental model, dose and duration, biological activity, and key outcomes[1,3,5,7,10,27]. Quantitative data such as IC50 values, ulcer index, antioxidant capacity, and percentage inhibition were recorded wherever available. Statistical analyses were performed using appropriate software, with results expressed as mean ± standard deviation and significance evaluated at $p < 0.05$. Ethical guidelines for animal experiments were strictly adhered to[5,8,16].

3.5 Methodology Limitations

Although this review is very comprehensive, there are some limitations in terms of methodology that have to be recognized. Since it is a narrative synthesis, the study is prone to selection bias because the inclusion of the studies relies on the availability and relevance of the selected databases. The inconsistency in the designs of studies, sample sizes, diagnostic criteria and geographical locations creates heterogeneity and this can lead to variability in research outcomes. Serological differences in cut-off values and diagnostic criteria especially with assays like IFA are a source of imprecision in reported findings. Also, there can be a bias in publications based on positive results rather than negative or inconclusive studies. The dependency on previously published literature also restrains the possibility of conducting quantitative statistical analysis or meta-analysis in this review.

Moreover, the rapid improvement in diagnostics and treatment means that newer studies can quickly replace current findings. Nevertheless, the inclusion of high-quality studies, including systematic reviews and pharmacological safety evaluations, helps ensure reliable conclusions[8,18,25].

4. ADVANCEMENTS IN DIAGNOSTICS AND THERAPY

4.1 Phytochemical Profiling and Standardization

Recent advancements in analytical techniques have enabled precise identification and quantification of bioactive compounds in *Hemidesmus indicus* (L.) R. Br. Modern methods such as high-performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC-MS), and nuclear magnetic resonance (NMR) spectroscopy allow researchers to detect flavonoids, coumarins, saponins, and phenolic compounds with high accuracy[7,9,10]. These techniques not only facilitate quality control and standardization of herbal extracts but also help correlate specific phytochemicals with observed pharmacological activities, bridging the gap between traditional knowledge and scientific validation[1,3].

4.2 Advances in Pharmacological Evaluation

Innovative in vitro and in vivo models have improved the assessment of therapeutic potential of *H. indicus*. Antioxidant activity is measured using assays like DPPH, ABTS, and FRAP, while anti-inflammatory and anti-ulcer effects are evaluated through protein denaturation tests, carrageenan-induced paw edema, and ethanol-induced gastric ulcer models[5,8,14,27]. These models provide mechanistic insights into plant bioactivity, helping researchers understand dose-dependent responses and target-specific effects, thus enhancing reliability and reproducibility of results.

4.3 Novel Drug Delivery Systems

Recent developments in delivery technologies have addressed limitations of bioavailability and stability in herbal therapeutics. Methods such as nanoparticle encapsulation, liposomal delivery, and polyherbal synergistic formulations have shown promise in improving targeted delivery, controlled release, and therapeutic efficacy of plant extracts[25,26]. These innovations allow lower doses to achieve therapeutic effects while minimizing potential side effects, making herbal medicine more compatible with modern clinical practices.

4.4 Computational Approaches and Predictive Models

The integration of computational tools in herbal medicine research has accelerated the identification of active compounds and their molecular targets. Techniques like in silico docking, molecular modeling, and network pharmacology are used to predict interactions between phytochemicals and disease-associated proteins, facilitating rational design of herbal therapeutics and reducing reliance on extensive animal experimentation[1,3,13]. These approaches also enable the exploration of polypharmacology, where multiple compounds work synergistically to exert therapeutic effects, particularly in complex disorders like inflammation, gastrointestinal diseases, and cancer.

4.5 Clinical Implications and Personalized Therapy

Collectively, these advancements have transformed *H. indicus* from a traditional remedy into an evidence-based therapeutic option. Standardized extracts, mechanistic insights, improved delivery systems, and computational predictions allow for more precise, safe, and effective use in managing gastrointestinal disorders, oxidative stress-related conditions, inflammatory diseases, and certain cancers[1,5,7,25]. Moreover, these innovations lay the groundwork for personalized herbal therapy, where patient-specific factors and molecular targets can guide the selection and formulation of plant-based treatments.

5. DISCUSSION

The present review and analysis highlight the multifaceted therapeutic potential of *Hemidesmus indicus* (L.) R. Br., corroborating its traditional use in managing gastrointestinal, inflammatory, and oxidative stress-related disorders[1,3,7,10]. Phytochemical investigations reveal that the presence of flavonoids, coumarins, saponins, tannins, and phenolic compounds underpins the plant's observed anti-ulcer, antioxidant, anti-inflammatory, and anticancer activities[7,9,27]. These bioactive constituents act through multiple mechanisms, including free radical scavenging, modulation of pro-inflammatory cytokines, inhibition of gastric acid secretion, and cytoprotective effects on mucosal tissues, providing a scientific rationale for the traditional medicinal applications of *H. indicus*[5,8,14].

The systematic extraction and analysis of data from both in vitro and in vivo studies demonstrate consistent trends in biological efficacy across different experimental models. For instance, ethanol-induced gastric ulcer and pyloric ligation models in Wistar rats consistently show significant ulcer protection following administration of *H. indicus* extracts, which aligns with its reported gastroprotective role in ethnopharmacological surveys[5,8,16]. Similarly, antioxidant assays such as DPPH, ABTS, and FRAP confirm dose-dependent radical scavenging activity, emphasizing the relevance of polyphenolic compounds in mitigating oxidative stress[7,9].

Recent advancements in analytical and computational methods have strengthened the understanding of *H. indicus*, enabling precise phytochemical profiling, standardized extract formulation, and prediction of molecular targets[1,3,13]. The integration of nanotechnology and novel drug delivery systems, including nanoparticle encapsulation and liposomal formulations, further enhances bioavailability and therapeutic efficacy, highlighting the potential of modern techniques to optimize traditional remedies[25,26]. This dual approach—

combining classical pharmacological evaluation with innovative technological applications—facilitates the translation of ethnobotanical knowledge into evidence-based therapies, while also identifying gaps for future research, such as clinical trials and mechanistic studies at the molecular level.

Furthermore, the study emphasizes the importance of data-driven and standardized methodologies in herbal medicine research. The rigorous selection of literature, application of inclusion/exclusion criteria, and systematic extraction and synthesis of data ensure that conclusions are grounded in high-quality, reproducible evidence[1,3,7,27]. This approach allows not only a validation of traditional claims but also a rational basis for therapeutic application and the potential development of personalized herbal interventions, especially for gastrointestinal and inflammatory disorders where conventional treatments may have side effects.

In conclusion, *H. indicus* represents a promising herbal candidate with multifactorial therapeutic potential. The integration of phytochemical characterization, pharmacological evaluation, and modern diagnostic and delivery techniques has significantly advanced our understanding of its mechanisms of action and clinical relevance. Future research should focus on clinical validation, pharmacokinetic studies, molecular target elucidation, and synergistic formulations to fully harness the therapeutic potential of *H. indicus* and other traditionally used medicinal plants.

TABLE 1: COMPARISON OF DIAGNOSTIC METHODS FOR PEPTIC ULCER DISEASE

Diagnostic Method	**Principle**	**Accuracy / Sensitivity**	**Invasiveness**	**Advantages**	**Limitations**
Endoscopy (Gastroscopy)	Direct visualization of gastric/duodenal mucosa; allows biopsy	High (95–100%)	Invasive	Gold standard; can detect size, location, complications; allows biopsy for histology	Expensive, requires trained personnel, patient discomfort
Urea Breath Test (UBT)	Detects *H. pylori* urease activity via labeled CO_2 in breath	High (90–95%)	Non-invasive	Quick, highly sensitive and specific, suitable for diagnosis and post-treatment follow-up	False negatives with recent antibiotics or PPIs
Stool Antigen Test	Detects *H. pylori* antigens in stool	High (85–95%)	Non-invasive	Non-invasive, suitable for all ages, can monitor eradication therapy	False negatives with antibiotics or PPIs; sample handling required
Serological Tests (IgG antibodies)	Detects antibodies against *H. pylori* in blood	Moderate (70–85%)	Non-invasive	Simple, inexpensive, widely available	Cannot distinguish between active and past infection; limit

					ed clinical relevance
Barium Meal X-ray (Radiography)	Contrast imaging of gastric/duodenal lumen	Moderate (60–80%)	Non-invasive	Non-invasive, useful when endoscopy unavailable, can detect large ulcers or perforation	Low sensitivity for small ulcers; no biopsy capability; radiation exposure
Emerging Biomarker / Molecular Tests	Detect inflammatory markers, cytokines, or genetic signatures	Variable (under research)	Non-invasive	Potential for early diagnosis, personalized therapy	Limited availability, high cost, requires validation

As it is mentioned in Table 1,

Table 1 presents a comprehensive comparison of the commonly used diagnostic methods for Peptic Ulcer Disease (PUD), highlighting their principles, accuracy, invasiveness, advantages, and limitations[12, 13]. Endoscopy (gastroscopy) remains the gold standard, offering direct visualization of the gastric and duodenal mucosa, the ability to perform biopsies, and the highest sensitivity and specificity for ulcer detection[12]. However, it is invasive, costly, and requires skilled personnel. Urea breath tests (UBT) and stool antigen tests provide highly sensitive and non-invasive alternatives for the detection of *Helicobacter pylori*, the primary etiological agent in PUD[13, 15]. These tests are convenient for initial screening and post-treatment follow-up but may produce false negatives if the patient has recently used antibiotics or proton pump inhibitors[13]. Serological tests, which detect antibodies against *H. pylori*, are simple and widely available but have moderate accuracy and cannot differentiate between active and past infections[15]. Barium meal radiography offers a non-invasive imaging option to visualize ulcers indirectly, particularly larger lesions or complications, but has lower sensitivity and does not allow biopsy[13]. Finally, emerging biomarker- and molecular-based diagnostics hold promise for early, non-invasive detection and personalized therapeutic approaches, though they remain largely experimental and require further validation[17, 22]. Overall, the table underscores the need to select diagnostic methods based on clinical context, resource availability, and the specific information required, balancing accuracy, invasiveness, and feasibility[12, 13].

A summary of the commonly used antibiotics and clinical consideration are summarized in Table 2.

TABLE 2: TREATMENT OPTIONS FOR PEPTIC ULCER DISEASE (PUD)

Treatment Category	**Subcategory / Example**	**Mechanism of Action**
Pharmacological Therapy	Proton Pump Inhibitors (Omeprazole, Lansoprazole)	Suppress gastric acid secretion and promote mucosal healing
	H2 Receptor Antagonists (Ranitidine, Famotidine)	Block H2 receptors to reduce gastric acid production
	Antacids & Cytoprotective Agents (Sucralfate, Misoprostol)	Neutralize acid and protect the gastric mucosa
Eradication Therapy	Triple Therapy (PPI + Clarithromycin + Amoxicillin/Metronidazole)	Eradicate *Helicobacter pylori* infection
	Quadruple Therapy (PPI + Bismuth + Tetracycline + Metronidazole)	Eradicate *Helicobacter pylori*, effective for resistant strains
Lifestyle & Dietary	Diet & Avoidance (NSAIDs, alcohol, spicy foods)	Reduce mucosal irritation

Modifications		and ulcer-promoting factors
	Stress Management	Reduce stress-induced ulcer exacerbation
Herbal / Complementary Therapy	*Hemidesmus indicus*	Anti-inflammatory, antioxidant, and mucosal protective effects
	Polyherbal Formulations	Synergistic gastroprotective effects from multiple herbs
Surgical Intervention	Vagotomy, Pyloroplasty, Partial Gastrectomy	Remove or repair ulcer tissue and reduce gastric acid secretion

Management of peptic ulcer disease (PUD) involves a combination of pharmacological therapy, eradication of *Helicobacter pylori*, lifestyle modifications, herbal interventions, and, in severe cases, surgical procedures[12, 13]. Pharmacological therapy forms the cornerstone of treatment, with proton pump inhibitors (PPIs) such as omeprazole and lansoprazole being the first-line choice due to their potent acid-suppressing effect and ability to promote rapid mucosal healing[12]. H2 receptor antagonists, including ranitidine and famotidine, serve as alternatives, particularly in mild cases or for patient's intolerant to PPIs[12]. Antacids and cytoprotective agents, such as sucralfate and misoprostol, provide symptomatic relief by neutralizing gastric acid and protecting the gastric mucosa from further damage[12]. Since *H. pylori* infection is a major cause of PUD, eradication therapy is essential to prevent recurrence[13]. Standard regimens include triple therapy and quadruple therapy, which are highly effective in eliminating the infection and reducing relapse rates[13, 15]. Lifestyle and dietary modifications also play an important role in ulcer management[12]. Complementary herbal therapies are gaining attention due to their gastroprotective and antioxidant properties[1, 7, 27]. For instance, *Hemidesmus indicus* has demonstrated significant anti-ulcer activity, attributed to its coumarins, flavonoids, and saponins[1, 7]. Polyherbal formulations may provide synergistic effects, enhancing mucosal protection and reducing inflammation[25, 26].

5.1 Comparison of Diagnostic Methods For peptic ulcer disease

Accurate diagnosis of peptic ulcer disease (PUD) is essential for effective treatment and prevention of complications[27]. Various diagnostic methods are currently employed, each with unique advantages and limitations[28]. Endoscopy (esophagogastroduodenoscopy, EGD) is considered the gold standard for diagnosing PUD, as it allows direct visualization of the gastric and duodenal mucosa, precise ulcer localization, and the ability to perform biopsies for *H. pylori* detection or malignancy assessment[29]. However, endoscopy is invasive, requires patient preparation, and may not be readily available in all clinical settings[30].

TABLE 3: COMPARATIVE ANALYSIS OF DIAGNOSTIC TECHNIQUES

Diagnostic Method	Sensitivity	Specificity	Time Required	Cost	Use-Case Scenario
Endoscopy (EGD)	90–95%	95–98%	30–60 min	High	Gold standard for direct visualization, biopsy, and *H. pylori* detection
Barium Meal Radiography	70–85%	80–90%	30–45 min	Moderate	Structural assessment, initial screening, or when endoscopy is

					unavailable
Urea Breath Test	90–95%	95%	20–30 min	Moderate	Non-invasive detection of active *H. pylori* infection
Stool Antigen Test	85–95%	90–95%	15–20 min	Low	Non-invasive detection of active *H. pylori* infection, monitoring eradication
Serology (IgG/IgA)	70–85%	75–80%	15–20 min	Low	Epidemiological studies or preliminary screening; cannot distinguish active infection
Laboratory Tests (CBC, Fecal Occult Blood)	50–70%	60–80%	10–15 min	Low	Assess complications like bleeding or anemia; not diagnostic for ulcers
CT / MRI	80–90%	85–90%	30–60 min	High	Evaluating complicated ulcers (perforation, penetration) or ruling out malignancy

Accurate diagnosis of peptic ulcer disease (PUD) relies on a combination of invasive and non-invasive diagnostic methods[31]. Endoscopy remains the gold standard due to its high sensitivity and specificity[32]. Barium meal radiography provides a non-invasive alternative with moderate diagnostic accuracy[33]. The urea breath test is highly sensitive for detecting active *H. pylori* infection[34]. Stool antigen tests are reliable for both diagnosis and post-treatment monitoring[35]. Serological tests are useful but cannot distinguish active from past infection[36]. Laboratory tests such as CBC and fecal occult blood help identify complications[37]. CT and MRI are reserved for complicated or malignant suspected cases[38].

Overall, diagnostic selection depends on clinical condition, availability, and cost factors[39]. Combining multiple diagnostic methods improves diagnostic accuracy and treatment planning[40]. Endoscopy (EGD) remains the gold standard due to its high sensitivity (90–95%) and specificity (95–98%), allowing direct visualization of ulcers, assessment of severity, and biopsy for *H. pylori* or malignancy detection. However, it is relatively time-consuming, requires specialized equipment and trained personnel, and incurs high costs, making it more suitable for patients with persistent symptoms, complications, or diagnostic uncertainty. Barium meal radiography provides a non-invasive imaging alternative with moderate sensitivity (70–85%) and specificity (80–90%), primarily useful for structural assessment and initial screening when endoscopy is unavailable. While less accurate than endoscopy, it is easier to perform and moderately priced. Among non-invasive techniques, the urea breath test demonstrates high sensitivity and specificity (90–95% and 95%, respectively) for detecting active *H. pylori* infection, with a short testing time (20–30 minutes) and moderate cost, making it ideal for first-line diagnosis and post-treatment monitoring. Similarly, the stool antigen test is cost-effective, rapid, and highly accurate (85–95% sensitivity, 90–95% specificity), suitable for both diagnosis and eradication verification. Serological tests (IgG/IgA) are widely available and inexpensive but less reliable in distinguishing active from past infections, limiting their use to epidemiological studies or preliminary screening. Laboratory investigations like complete blood count and fecal occult blood tests are quick and inexpensive, helping detect complications such as bleeding or anemia; however, they cannot confirm the presence of ulcers. Advanced imaging modalities, including CT and MRI, are reserved for complicated or atypical cases, such as perforation, penetration, or suspected malignancy, offering moderate to high sensitivity (80–90%) and specificity (85–90%) at a higher cost and longer procedure time. In summary, the choice of diagnostic method for PUD depends on clinical presentation, resource availability, and suspected underlying etiology.

5.2 LIMITATION

Despite the availability of multiple diagnostic methods for PUD, each technique has inherent limitations that must be considered when selecting the appropriate approach[38]. Endoscopy, while being the gold standard, is invasive, expensive, and requires trained personnel and specialized equipment[27]. It can cause patient discomfort and carries a small risk of complications such as bleeding or perforation, limiting its routine use in all patients[40]. Barium meal radiography is non-invasive and relatively accessible but has lower sensitivity and specificity compared to endoscopy, particularly for small or shallow ulcers, and cannot provide tissue samples for *H. pylori* detection or malignancy assessment[41].

Non-invasive tests such as the urea breath test and stool antigen test are highly accurate for detecting active *H. pylori* infection but may yield false-negative results in patients who have recently taken antibiotics, proton pump inhibitors, or bismuth compounds[42]. Serological tests are inexpensive and widely available but cannot distinguish between current and past infections, which may lead to unnecessary treatment[43]. Laboratory tests like complete blood count or fecal occult blood are useful for identifying complications such as bleeding or anemia but are non-specific and cannot confirm the presence of an ulcer[44]. Advanced imaging modalities such as CT and MRI are costly, not routinely required for uncomplicated ulcers, and may not detect small mucosal lesions, limiting their use to complicated or atypical cases[45].

Overall, the limitations of each diagnostic modality highlight the need for a tailored, patient-specific approach, often combining non-invasive tests with endoscopy when necessary, to ensure accurate diagnosis while minimizing cost, risk, and patient discomfort[45].

6. CONCLUSION

Peptic ulcer disease (PUD) continues to be a significant gastrointestinal disorder worldwide, with multifactorial etiology involving Helicobacter pylori infection, prolonged use of non-steroidal anti-inflammatory drugs (NSAIDs), lifestyle factors, and genetic predisposition. Accurate and timely diagnosis is essential to prevent serious complications such as bleeding, perforation, and gastric obstruction. Among the diagnostic methods, endoscopy remains the gold standard due to its high sensitivity and specificity, the ability to directly visualize gastric and duodenal mucosa, and the option to perform biopsy for H. pylori detection and malignancy assessment. However, the invasiveness, cost, and need for specialized equipment limit its routine use, particularly in resource-limited settings. Non-invasive diagnostic modalities, including the urea breath test, stool antigen test, and serological assays, provide rapid, cost-effective, and patient-friendly alternatives for detecting active H. pylori infection. While the urea breath test and stool antigen test exhibit high sensitivity and specificity, serological tests are limited by their inability to differentiate active from past infections. Imaging techniques such as barium radiography, CT, and MRI serve as valuable adjuncts in structural assessment and detection of complicated or atypical ulcers, though they are limited by lower sensitivity for small lesions, higher cost, and the inability to provide histological information. The therapeutic management of PUD involves a multifaceted approach combining pharmacological interventions, H. pylori eradication, lifestyle modifications, and surgical interventions in refractory or complicated cases. Proton pump inhibitors remain the mainstay of treatment, while H2 receptor antagonists, antacids, and cytoprotective agents provide symptomatic relief and promote mucosal healing. Complementary and herbal therapies, particularly extracts from Hemidesmus indicus and other bioactive medicinal plants, have demonstrated gastroprotective, anti-inflammatory, and antioxidant effects, providing potential adjunctive strategies for holistic management. Surgical interventions, including vagotomy, pyloroplasty, and partial gastrectomy, are reserved for complicated or unresponsive cases, ensuring targeted resolution of the underlying pathology. Despite advances, diagnostic and therapeutic methods present limitations. Diagnostic accuracy may be influenced by prior medication use, technical expertise, and availability of resources, while treatment outcomes can vary depending on patient compliance, drug resistance, and comorbidities. These challenges underscore the importance of a personalized, patient-centered approach, integrating non-invasive testing with endoscopic evaluation when required, and combining conventional therapy with evidence-based herbal interventions.Future directions in PUD management emphasize the development of non-invasive, rapid, and highly sensitive diagnostic tools, along with novel pharmacological agents and standardized herbal formulations. The integration of molecular biomarkers, artificial intelligence, and personalized medicine approaches holds promise for improving early detection, therapeutic precision, and long-term outcomes. Emphasis on prevention, patient education, and the judicious use of complementary therapies will further reduce the disease burden. In conclusion, an integrated, multidisciplinary strategy that balances diagnostic accuracy, therapeutic efficacy, patient safety, and cost-effectiveness remains central to advancing the management of peptic ulcer disease in modern clinical practice.

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