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CURRENT UPDATE ON THE DIAGNOSIS OF *HELICOBACTER PYLORI* INFECTION – 2024-2025

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Abstract – This review provides an overview of the main articles published in the field of *Helicobacter pylori* (*H. pylori*) diagnosis over the past year, from April 2024 to June 2025. *Helicobacter pylori* is a bacterium linked to chronic gastritis, peptic ulcers, and gastric cancer. The diagnosis covers both invasive and non-invasive diagnostic techniques, including endoscopy, histopathology, urea breath tests, stool antigen tests, and serological tests. Recent advancements include the use of artificial intelligence for personalized treatment, magnetic-guided origami robots for phototherapy, and autoencoders for histopathological image analysis. The challenges posed by antimicrobial resistance and the importance of microbiome analysis are highlighted. Consequently, emerging technologies such as biosensors, point-of-care testing, and analysis of volatile organic compounds are encouraged for exploration.

Keywords: Antimicrobial resistance, Diagnosis, Eradication, Gastric cancer, *Helicobacter pylori*.

INTRODUCTION

Helicobacter pylori is a Gram-negative bacterium that infects over 40% of the global population, leading to conditions such as chronic gastritis, peptic ulcers, and gastric cancer[1,2]. Accurate and timely diagnosis is crucial for the identification of the *H. pylori* infection, prevention of complications, ensuring effective treatment, including medication choices and monitoring for eradication[3]. This review on *H. pylori* diagnosis gives insight into the recent advancements which focused on enhancing diagnostic accuracy, reducing invasiveness, addressing challenges like antibiotic resistance and ensuring patients receive the most appropriate care.

METHODS

Main articles published in the field of *Helicobacter pylori* diagnosis in the past year, from April 2024 to June 2025, were screened from PubMed and Google Scholar. Search words, such as *'H. pylori* diagnosis from April 2024 – June 2025', 'Diagnostic methods of *H. pylori* from April 2024 – June 2025', 'Diagnosis and *H. pylori* from April 2024 – June 2025', '*H. pylori* and Diagnosis from April 2024 – June 2025' were used.

INVASIVE DIAGNOSTIC TECHNIQUES

Endoscopy and Histopathology

Endoscopic biopsy remains the gold standard for diagnosing *H. pylori* infection. Histopathological examination enables direct visualization of bacteria in gastric mucosal samples. Recent studies have emphasized the importance of standardized biopsy protocols and the role of pathologists in interpreting results[4]. Several endoscopic techniques exist, including image-enhanced endoscopy, confocal laser endomicroscopy, among others.

Image-Enhanced Endoscopy (IEE)

IEE techniques, such as narrow-band imaging (NBI) and linked color imaging (LCI), have been evaluated for their effectiveness in detecting *H. pylori* during endoscopy. Studies indicate that IEE can enhance the visualization of gastric mucosal changes associated with *H. pylori* infection, potentially reducing the need for multiple biopsies and aiding in real-time diagnosis[5,6].

Confocal Laser Endomicroscopy (CLE)

CLE allows for real-time, *in vivo* microscopic examination of the gastric mucosa, enabling the detection of *H. pylori* and assessment of gastric lesions. This technique provides high-resolution images, assisting clinicians in identifying infection sites and guiding biopsy procedures[7,8].

Rapid Urease Test (RUT)

The RUT detects urease activity produced by *H. pylori*. While it offers rapid results, its sensitivity can be affected by factors such as the quality of the biopsy sample and the presence of proton pump inhibitors[9].

Fluorescence in situ hybridization (FISH)

Fluorescence in situ hybridization (FISH) is a powerful technique for diagnosing *H. pylori* infection and identifying clarithromycin resistance in *H. pylori* strains. It offers a rapid, accurate, and cost-effective method for detecting *H. pylori* in gastric biopsies, even in the presence of coccoid forms of the bacteria. FISH can also be used to identify clarithromycin resistance by targeting mutations in the 23S rRNA gene[10].

NON-INVASIVE DIAGNOSTIC TECHNIQUES

Urea Breath Test (UBT)

UBT measures the presence of labelled carbon dioxide after ingestion of a urea solution. It is highly sensitive and specific but may be influenced by recent antibiotic or proton pump inhibitor used[11,12].

Stool Antigen Test (SAT)

SAT detects *H. pylori* antigens in stool samples. It is non-invasive and suitable for both initial diagnosis and post-treatment monitoring. However, false positives can occur in cases of gastrointestinal bleeding[13].

Serological Tests

Serological tests detect antibodies against *H. pylori*. While convenient, they cannot distinguish between current and past infections and are less reliable for post-treatment assessment[14].

MOLECULAR DIAGNOSTIC TECHNIQUES

Polymerase Chain Reaction (PCR)

PCR amplifies specific DNA sequences of *H. pylori*, allowing for precise detection. It is particularly useful in research settings and for detecting antibiotic resistance genes[15,16].

Next-Generation Sequencing (NGS)

NGS technology has revolutionized microbial diagnostics by enabling comprehensive genetic analysis. For *H. pylori*, NGS allows for the detection of antibiotic resistance genes and virulence factors, providing insights into the strain's pathogenic potential. While NGS offers high sensitivity and specificity, its high cost and the need for specialized equipment limit its widespread clinical application[17,18].

Artificial Intelligence in *H. pylori* Diagnosis and Treatment

Artificial intelligence (AI) has been increasingly integrated into diagnostic workflows to enhance accuracy and efficiency.

Autoencoders for Histopathological Image Analysis

In diagnostic pathology, researchers have developed an autoencoder-based method to detect *H. pylori* in immunohistochemically stained whole-slide images. This approach achieved a 91% accuracy rate, demonstrating the potential of AI to assist pathologists in identifying anomalous staining patterns indicative of *H. pylori* presence, even with a limited set of annotated data[19].

AI-Clinician for Personalized Treatment

A significant development in 2024 was the introduction of the *H. pylori* AI-Clinician, an artificial intelligence system trained on extensive patient data. This AI model demonstrated the ability to identify optimal treatment regimens tailored to individual patient profiles, such as recommending bismuth quadruple therapy over standard triple therapy for certain subgroups. The system utilized machine learning techniques to analyze patient variables, thereby enhancing treatment efficacy and patient outcomes[20,21].

Magnetic-Guided Origami Robots for Phototherapy

Innovative treatment strategies have emerged, including the development of a magnetic-guided, flexible origami robot designed for photodynamic therapy (PDT) targeting *H. pylori* in the stomach. This robot, equipped with wireless charging capabilities and LED illumination, can be remotely controlled to deliver localized PDT, offering a potential alternative to traditional antibiotic treatments, especially in the face of rising antibiotic resistance[22].

OTHER EMERGING TECHNOLOGIES IN *H. PYLORI* DIAGNOSIS

Biosensor Technologies

Advancements in biosensor technologies have led to the development of rapid, sensitive, and non-invasive diagnostic tools for *H. pylori* detection. Electrochemical, optical, piezoelectric, and thermal biosensors have shown promise in providing real-time results with high specificity[23,24].

Point-of-Care Testing (POCT)

The trend towards POCT allows for immediate testing and results delivery at the site of patient care, such as clinics and primary care settings. This approach is facilitated by innovative rapid tests, including antigen tests, lateral flow assay, molecular assays like loop-mediated isothermal amplification (LAMP) and portable PCR devices which enable quick detection of *H. pylori*, reducing the need for laboratory-based testing and expediting treatment initiation[25,26].

Volatile Organic Compounds (VOCs) Analysis

Emerging research has focused on analyzing VOCs in a patient's breath to detect *H. pylori* infection. *H. pylori* produce specific VOCs that can be identified using specialized equipment, offering a non-invasive diagnostic method. Although promising, this technique requires further validation to establish its clinical reliability[27,28].

Antimicrobial Resistance and Diagnostic Implications

The increasing prevalence of antimicrobial resistance (AMR) poses significant challenges in *H. pylori* management. Scholars have highlighted the importance of routine antimicrobial susceptibility testing, particularly for clarithromycin, to guide appropriate therapy[29].

Integration of Microbiome Analysis

Recent studies have explored the relationship between the gut microbiota and *H. pylori* infection. Alterations in the microbiome may influence *H. pylori* colonization and its associated pathologies. Microbiome analysis can offer insights into the host's microbial environment, potentially aiding in the diagnosis and treatment of *H. pylori* infection[30,31].

Global Perspectives and Guidelines

National and regional guidelines have been updated to address the evolving landscape of *H. pylori* diagnosis and treatment. Despite guidelines for *Helicobacter pylori* infection, detection, and treatment, recommendations to test patients before and after treatment are not generally followed. This could lead to significant implications, including missed opportunities for early detection and treatment of complications, and the risk of persistent infection and potential long-term peptic ulcer disease. Testing for *H. pylori* before treatment helps ensure the correct diagnosis and appropriate treatment plan, while post-treatment testing verifies eradication and prevents potential complications and the spread of resistance[32-34].

Global Trends and Market Insights

The global market for *H. pylori* diagnostics is experiencing growth, driven by advancements in diagnostic technologies and increasing awareness of *H. pylori*-related diseases. The integration of AI, the development of non-invasive diagnostic tools, and the emphasis on point-of-care testing are shaping the future of *H. pylori* diagnosis[21,24,26].

CONCLUSIONS

The period from 2024 to 2025 has witnessed significant advancements in the diagnosis of *Helicobacter pylori*. Innovations in non-invasive testing, integration of artificial intelligence, and the development of novel biosensor technologies have enhanced diagnostic accuracy and patient care. Addressing challenges such as antimicrobial resistance and ensuring equitable access to advanced diagnostic tools remain critical for global health initiatives.

Table 1 shows the summary of advancements in *Helicobacter pylori* diagnosis (2024-2025).

TABLE 1. SUMMARY OF ADVANCEMENTS IN *HELICOBACTER PYLORI* DIAGNOSIS (2024-2025).

Category	Technique/Trend	Main Features/Insights
Invasive diagnostic techniques	Endoscopy and Histopathology	Gold standard; visualizes bacteria; importance of standardized protocols and pathologist expertise
	Image-Enhanced Endoscopy (IEE)	Enhances visualization (NBI, LCI); aids real-time diagnosis; may reduce biopsies needed
	Confocal Laser Endomicroscopy (CLE)	Real-time, high-resolution microscopic imaging; guides biopsy; detects infection sites
	Rapid Urease Test (RUT)	Quick results; sensitivity affected by sample quality and medication use
	Fluorescence in situ Hybridization (FISH)	Detects *H. pylori* and clarithromycin resistance; rapid and accurate
Non-invasive techniques	Urea Breath Test (UBT)	Highly sensitive/specific; influenced by antibiotics or PPI use
	Stool Antigen Test (SAT)	Non-invasive; for diagnosis and monitoring; false positives with GI bleeding
	Serology	Detects antibodies; unable to distinguish current against past infection; less reliable post-treatment
Molecular diagnostics	Polymerase Chain Reaction (PCR)	Precise DNA detection; identifies resistance genes; mainly research use
	Next-Generation Sequencing (NGS)	Comprehensive genetic analysis; detects resistance/virulence factors; costly and specialized
Artificial intelligence	Histopathology Autoencoders	AI-based image analysis; 91% accuracy; assists in detecting *H. pylori* in slides
	AI-Clinician Systems	Personalizes treatment regimens; uses patient data for optimal therapy selection
Innovative therapies	Magnetic-Guided Origami Robots	Origami robot for photodynamic therapy; non-antibiotic, targeted treatment
Emerging diagnostic technologies	Biosensor Technologies	Rapid, sensitive, non-invasive; includes electrochemical, optical, thermal biosensors
	Point-of-Care Testing (POCT)	Immediate results at care sites; includes portable antigen/molecular tests (LAMP, PCR)
	VOC Analysis	Detects *H. pylori*-specific breath compounds; non-invasive, requires more validation
Antimicrobial resistance	Susceptibility Testing	Routine resistance screening (esp. clarithromycin) critical for therapy guidance
Microbiome integration	Microbiome Analysis	Studies gut flora's role in infection/ diagnosis; potential for personalized care
Global trends and guidelines	Guideline Updates	Emphasize pre/post-treatment testing; adherence remains suboptimal
Market insights	Technological Advancements	Growth in AI, POCT and non-invasive tools; shaping future diagnosis landscape
Conclusion	2024-2025 Developments	Non-invasive tests, AI, biosensors improve accuracy; AMR and equitable access are key challenges

Adapted from Higgins et al[20], 2024; Yuan et al[22], 2024; Jiang et al[21], 2025.

Conflict of Interests

The authors declare no conflict of interest.

Informed Consent

Not applicable due to the type of article.

Authors' Contributions

TFJ provided the literature used in the work and did the first draft of the article. AA and SIS corrected the draft, and all authors approved the final version of the article.

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Data Availability Statement

The data that support the findings of this review are available from the corresponding author upon request. Additional information regarding the methodology and analysis can be provided by the corresponding author upon reasonable request.

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