Helicobacter pylori Antibiotic Resistance in Egypt: A Single-Center Study

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Purpose: Helicobacter pylori (H. pylori) is the most common human bacterial infection worldwide, infecting approximately half of the world’s population. Although antibiotic use is indicated for H. pylori eradication, the recommended type of antibiotic varies from country to country according to the H. pylori resistance pattern; developing countries, such as Egypt, may have different patterns than developed countries. We evaluated the antibiotic resistance of H. pylori in Egypt.

Methods: This cross-sectional study included 134 adult patients with upper gastrointestinal (GI) complaints. Patients with a history of PPI during the last 2 weeks or antibiotics during the last 4 weeks before endoscopy were excluded. Upper GI endoscopies were performed and biopsies were collected for histopathology and H. pylori culture. Demographic, clinical, and endoscopic data were also collected. Antimicrobial susceptibility testing for H. pylori was performed for nine therapeutically relevant antibiotics using the Kirby-Bauer disc diffusion method.

Results: The H. pylori antibiotic resistance rates were as follows: moxifloxacin, 10%; doxycycline, 15%; levofloxacin, 20%; clarithromycin, 40%; azithromycin, 40%; erythromycin, 65%; rifampicin, 90%; amoxicillin, 95%; and metronidazole, 100%. Dual resistance rates were 40% for amoxicillin/clarithromycin, 40% for metronidazole/clarithromycin, and 95% for amoxicillin/metronidazole.

Conclusion: In Egyptian patients, H. pylori had >90% resistance to metronidazole and amoxicillin; modest resistance to erythromycin, azithromycin, and clarithromycin; and low resistance to moxifloxacin, and levofloxacin (<20%). Dual resistance was high for amoxicillin/clarithromycin and amoxicillin/metronidazole, which prefers using quinolones rather than clarithromycin or metronidazole for first-line treatment of H. pylori in Egypt.

Keywords: Helicobacter pylori antibiotic resistance, H. pylori culture, H. pylori treatment

Introduction

Helicobacter pylori (H. pylori) is the most widespread human pathogen, infecting about 50% of the global population.1 H. pylori is a major cause of peptic ulcers and an independent risk factor for gastric cancer and lymphomas of mucosa-associated lymphoid tissue (MALT).2 H. pylori may also be associated with extra-intestinal diseases, including immune thrombocytopenic purpura, refractory iron deficiency anemia, and vitamin B12 deficiency.3 Globally, the frequency of H. pylori infections varies according to socioeconomic situations and sanitary standards. Up to 70% of dyspeptic individuals in Egypt are infected with H. pylori, a significant prevalence rate.4

H. pylori is often treated for ten to fourteen days with a combination of two to three medicines and a proton pump inhibitor (PPI). In actuality, the “first-line” or first treatment regimen for eradication is often the most effective.5 The efficacy of eradication therapy is highly dependent on the quick emergence of H. pylori strains resistant to antibiotics. Antibiotic resistance is a constantly evolving phenomenon, and the incidence of H. pylori is on the rise. Resistance to antibiotics against H. pylori varies significantly from country to another, and even from region to region within a country.6 Due to the diminishing efficiency of traditional eradication treatments, H. pylori is more difficult than ever to treat. After the failure of second-line antibiotics, endoscopy-guided antibiotic susceptibility testing may provide treatment direction.7 The last consensus for H. pylori management in Egypt recommended the same first- and second-
line therapies as the international guidelines; however, many studies recommend the identification of H. pylori antibiotic resistance. We aimed to evaluate the H. pylori resistance and susceptibility to common antibiotics used in different treatment regimens.

**Methods**

134 adult patients with dyspepsia were involved in this cross-sectional study, they attended the endoscopy unit of the Hepatology, Gastroenterology, and Infectious Diseases Department at Benha University Hospital between October 2018 and October 2020. The study was approved by the Institutional ethical Committee, Faculty of Medicine, Benha University. The study complies with the Declaration of Helsinki. All patients gave informed consent before inclusion in the study. Patients who received PPIs during the last 2 weeks or antimicrobial therapy during the last 4 weeks before endoscopy were excluded from the study. In addition, patients who refused to give informed consent were excluded.

Endoscopic findings were recorded, and four gastric biopsies were collected. Two biopsy specimens were preserved with formalin solution for histopathological examination using hematoxylin–eosin (H&E) staining. We also stained sections with modified Giemsa stain to confirm the H. pylori diagnosis. Another two biopsies were cultured after homogenizing the samples with sterile glass rods under aseptic conditions. Culture media was prepared as a suspension of 39 g of Columbia blood agar base dissolved in one L of distilled water. The solution was boiled to completely dissolve the agar base and sterilized by autoclaving at 121°C for 15 minutes. After cooling, 5% sterile defibrinated blood was added to the solution. After adding two mL of distilled water to the H. pylori selective supplement vial and mixing gently, the supplement was added to 500 mL of Columbia blood agar base, mixed, and dispensed into sterile Petri dishes. A portion of each sample homogenate was inoculated into freshly prepared Columbia blood agar culture Petri dishes. All plates were incubated at 37°C under microaerophilic conditions in gas pack jars. The plates were inspected within 3–4 days. H. pylori colonies were identified with a urease test, colony morphology (circular, convex, translucent colonies about 2 mm in diameter), oxidase-positive test, catalase-positive test, and microscopic examination.

Clinical Laboratory Standards Institute-recommended Kirby–Bauer disc diffusion testing to be used to determine antimicrobial susceptibility for nine therapeutically relevant drugs (CLSI 2015). Zone diameters were evaluated and categorized as sensitive or resistant based on Clinical Laboratory Standards Institute guidelines (Table 1) (CLSI)

**Statistical Analyses**
The sample size was calculated based on the American College of Gastroenterology guidelines, which recommend that antibiotics with a resistance prevalence of more than 20% should not be used for the treatment of H. pylori. To detect

**Table 1** Antibiotic Disk Concentrations and Diameters of the Zones of Inhibition

| Antibiotic     | Disc Concentration (µg) | Diameter of Inhibition Zone |
|----------------|-------------------------|-----------------------------|
|                |                         | Sensitive (mm) | Intermediate (mm) | Resistant (mm) |
| Levofloxacin   | 5                       | ≥19            | 17–18            | <17           |
| Doxycycline    | 30                      | ≥ 9            | 17–18            | <17           |
| Clarithromycin | 15                      | ≥22            | 21               | <21           |
| Azithromycin   | 15                      | ≥22            | 16–21            | <16           |
| Metronidazole  | 5                       | ≥24            | 17–23            | <17           |
| Moxifloxacin   | 5                       | ≥19            | 17–18            | <17           |
| Rifampicin     | 5                       | ≥22            | 17–21            | <17           |
| Erythromycin   | 15                      | ≥22            | 16–21            | <16           |
| Amoxicillin    | 10                      | ≥21            | 16–20            | <16           |
a resistance of 20% with a 95% confidence level and 10% confidence intervals, a minimum sample size of 61 patients was required. Based on an estimated culture sensitivity of 50%, a minimum of 122 *H. pylori*-positive samples were required.

Antibiotic resistance of *H. pylori* was calculated as a percentage (%) with a 95% confidence interval. Demographic, clinical, endoscopic, and histopathological variables were compared between culture positive and culture-negative patients. For comparing continuous variables, a two-tailed student t-test or the Mann–Whitney test was utilized. For dichotomous or categorical data, the Chi square test or Fisher's exact test was utilized. Version 21 of SPSS was used for the analysis.

**Results**

The study included 134 dyspeptic adult patients, consisting of 56 males (41.8%) and 78 females (58.2%). Abdominal pain, heartburn, nausea, vomiting, hematemesis, and melena were the main presenting symptoms followed by bloating, diarrhea, easy fatigability, and loss of weight (Table 2). Endoscopies showed that 71 patients (53%) had gastric erosions, 41 (30.6%) had endoscopic mucosal granularity, and 21 (15.7%) had gastric ulceration. Histopathological examinations revealed *H. pylori* in 121 of 134 (90.3%) patients. *H. pylori* was detected in the cocci form in 50/121 (41.3%) patients, coccobacilli was detected in 47/121 (38.3%) patients, and bacilli were detected in 24/121 (20.4%) patients (Table 3).

Twenty of the 134 biopsies had *H. pylori*-positive cultures (14.9%). All biopsies that tested *H. pylori* negative in histopathology examinations were also culture negative. The sensitivity and specificity of the culture method were 16.5% and 100%, respectively. The bacillary form of *H. pylori* was more cultivable (9/24, 37.5%) than the cocci (6/50, 12%) and coccobacilli (5/47, 10.6%) forms (P = 0.008) (Table 3). Diabetes mellitus (DM) was significantly associated with positive culture results (5/20, 25%) (P = 0.04) (Table 2). Only one case of culture-positive *H. pylori* had a history of *H. pylori* treatment (1/20, 5%) (Table 2).

After culturing the *H. pylori*, antibiotic susceptibilities were evaluated in positive strains. The antibiotic resistance rates were as follows: moxifloxacin, 10% (95% CI, 10 ± 13.2); doxycycline, 15% (95% CI, 15 ± 15.7); levofloxacin,
Table 3 Comparison of Endoscopic Findings and H. pylori Forms Between Culture-Positive and Culture-Negative Patients

| Variable             | Total (N = 134) | Culture Positive (N = 20) | Culture Negative (N = 114) | p-value |
|----------------------|-----------------|--------------------------|---------------------------|---------|
| Endoscopic granularity | 41 (30.6%)      | 7 (35%)                  | 34 (29.9%)                | 0.6     |
| Endoscopic erosions  | 71 (53%)        | 13 (65%)                 | 58 (50.9%)                | 0.2     |
| Endoscopic ulceration | 21 (15.7%)      | 2 (10%)                  | 19 (16.7%)                | 0.4     |
| Histopathology, cocci | 50/121 (41.3%)  | 6 (30%)                  | 44 (38.5%)                | 0.008   |
| Histopathology, bacilli | 24/121 (20.4%) | 9 (45%)                  | 15 (13.2%)                |         |
| Histopathology, cocco-bacilli | 47/121 (38.3%) | 5 (25%)                  | 42 (36.8%)                |         |

20% (95% CI, 20 ± 17.5); clarithromycin, 40% (95% CI, 40 ± 21.5); azithromycin, 40% (95% CI, 40 ± 21.5); erythromycin, 65% (95% CI, 65 ± 20.9); rifampicin, 90% (95% CI, 90 ± 13.2); amoxicillin, 95% (95% CI, 95 ± 9.6); and metronidazole, 100% (95% CI, 100 ± 4.4) (Figure 1).

Figure 1 Antibiotic resistance rates.
Multiple drug resistance rates were determined. Resistance to five antibiotics (clarithromycin, metronidazole, amoxicillin, doxycycline, and levofloxacin) was detected in 0/20 (0%) patients, resistance to metronidazole, clarithromycin, doxycycline and amoxicillin was detected in 2/20 (10%) patients, resistance to levofloxacin, amoxicillin, doxycycline and metronidazole was detected in 1/20 (5%), resistance to metronidazole, clarithromycin and amoxicillin was detected in 6/20 (30%), resistance to metronidazole, amoxicillin and levofloxacin was detected in 3/20 (15%), resistance to metronidazole and amoxicillin was detected in 7/20 (35%) (Figure 2). Simultaneous resistance to amoxicillin or metronidazole and clarithromycin, which were used as primary or secondary lines of treatment, was determined. Dual resistance to clarithromycin and amoxicillin was detected in 8/20 (40%) patients, and dual resistance to clarithromycin and metronidazole was detected in 8/20 (40%) patients (Figure 2).

Discussion

*H. pylori* is one of the most significant pathogens associated with the occurrence and progression of gastrointestinal diseases, such as chronic gastritis, peptic ulcers, gastric MALT lymphoma, and gastric cancer. Regimens, which combine PPIs and two antibiotics, are the first-line treatments for *H. pylori* eradication worldwide. However, eradication is seriously limited by the progressive increase in antibiotic resistance.

We detected *H. pylori* by histopathological examination of gastric biopsies in 90.3% of our dyspeptic patients. This high prevalence has been previously reported for developing countries and specifically for Egypt. A prevalence of 80% was reported by Khalifehgholi et al. and a prevalence of 90% in Egyptian adult patients was reported by Hunt et al. Other studies reported that the prevalence of *H. pylori* in Egypt was as high as 88.7%. In contrast, the prevalence of *H. pylori* infection in our sample was greater than the prevalence reported among Hispanics (22%) and East Asians (15%). The high *H. pylori* infection frequency in developing countries is due to the low socioeconomic standards, bad sanitary conditions and water supplies, and increased home crowdedness, which facilitate transmission of *H. pylori*, especially intra-familial transmission.

In this study, the sensitivity of the culture method for the detection of *H. pylori* was low (16.5%) compared with the sensitivity of histopathology; however, the specificity was 100%. Other studies reported higher sensitivity for the culture method. A study conducted at the Philippine General Hospital in 2004 revealed a 30% sensitivity.

![Figure 2](https://doi.org/10.2147/IDR.S386082)
me tronidazole is cheap and overused and is an over
treatment, such as respiratory
resent study, an association was found between
amoxicillin in our study was 40%, which is in agreement with studies in China (44.4%
pplication may be due to reduced gastric motility
and chemical changes in the gastric mucosa following non-enzymatic glycosylation processes. Another explanation is
H. pylori is more prevalent in diabetic patients than in healthy individuals or non-diabetic patients.
The antibiotic susceptibility results showed that the H. pylori cultures were the most resistant to metronidazole and
amoxicillin. All of the isolated strains were resistant to metronidazole. This high resistance rate has been reported in
many areas, especially in developing countries. A 100% metronidazole resistance rate was reported in Palestine\cite{22} and a
97.9% resistance rate was reported in Cameroon.\cite{9} A high resistance rate was also reported also in China (90.6%) using
both disk diffusion and the E-test.\cite{18} A moderate resistance rate was detected in France (58.6\%)\cite{23} and Korea (27\%).\cite{24}
The high resistance rates may be due to the widespread use of metronidazole for other infectious diseases, such as
parasitic intestinal infections and genital infections. Metronidazole is cheap and overused and is an over-the-counter
drug in developing countries such as Egypt. The high resistance rate of metronidazole limits its use in the eradication
of H. pylori. Point mutation or other genetic events play the main role in development of H. pylori antibiotic resistance.
The gene mutations involved in resistance are rrn 23S in macrolides, rdxA, and frxA in metronidazole, gyraA in
quinolones, rpoB in rifampins, plp 1 in amoxicillin and rrn 16S in tetracycline resistance.\cite{25}

The H. pylori isolates from our study were also highly resistant to amoxicillin (95\%). Amoxicillin resistance in a
high rate was also reported in Cameroo (97.14\% using the disk diffusion method).\cite{9} Amoxicillin resistance varies
widely in different geographical areas, ranging from 0% to 97%. A very low rate of resistance was reported in France
(0\% using PCR)\cite{23} and China (1.6\% using E-test).\cite{26} Slightly higher resistance rates were detected in China (7.7\%
using the disk diffusion or E-test), Palestine (18\%), Egypt (18.3\% using PCR), Korea (20\%)\cite{27}, and Iran (30\%
using the E-test).\cite{28} The different amoxicillin resistance rates may be due to the different geographical areas or the
different methods of testing resistance. Although the very high resistance rate in Egypt has not been previously
reported, the high rate may be due to long-term misuse of antibiotics, leading to the emergence of resistant strains. The
impact of amoxicillin resistance on H. pylori eradication is not known.

The resistance rate for clarithromycin in our study was 40\%, which is in agreement with studies in China (44.4%
using disk diffusion and E-tests)\cite{18} and Palestine (47\%).\cite{22} Low rates of resistance were reported in Germany (10.9%
using PCR)\cite{29} and Cameroon (13.57\% using disk diffusion).\cite{9} According to Abadi et al., H. pylori may be resistant to
clarithromycin owing to several point mutations in the peptidyl transferase region encoded in domain V of 23s rRNA.\cite{30}
Clarithromycin resistance may also be due to overuse for the infectious diseases treatment, such as respiratory
infections. The H. pylori samples in our study also exhibited high resistance to other macrolides. The resistance rate to
azithromycin was 40\% and the resistance rate to erythromycin was 65\%. High resistance rates were reported in China
for azithromycin by Shao et al (85.6\%)\cite{26} and erythromycin by Brigitte et al (47.85\%).\cite{9} The Egypt consensus guidelines
recommend clarithromycin-based triple therapy as the first-line treatment for H. pylori.\cite{8} However, this recommendation
should be reviewed, considering the high resistance rate.

Quinolones emerged as promising drugs in this study. The levofloxacin resistance rate was 20\%. This rate is similar
to the rates reported in Iran (28\% using E-test),\cite{28} France (17.6\% using PCR),\cite{23} and China (28.2\% using disk diffusion
and E-test).\cite{18} Zero resistance to levofloxacin was reported in Palestine\cite{22} and Cameroon.\cite{9} Although levofloxacin and
moxifloxacin are both quinolones, resistance to moxifloxacin was lower in our study (10\%). Similar results were
reported in Palestine (3\%).\cite{22} Thus, moxifloxacin is one of the most effective drugs for the treatment of H. pylori, even
before levofloxacin.

The resistance rate for doxycycline was 15\% in our study. Similar results were reported in Iran (16\%)\cite{28} and Korea

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(18%). However, lower rates were reported in France (0%), China (0.8%), and Germany (2.2%). These results support the use of doxycycline as a second-line therapy for *H. pylori*. Rifampicin had a very high resistance rate (90%). A high resistance rate for rifampicin was also reported in China (69.2%) and Iran (50%). However, very low resistance rates for rifampicin were reported by Brigitte et al (0%), Mégraud et al (1.2%), and Shao et al (2.8%).

The resistance to two or more classes of antibiotics is considered multiple drug resistance. The multiple drug resistance rates in our study were 0% for five antibiotic types (clarithromycin, metronidazole, amoxicillin, doxycycline, and levofloxacin), 15% for four antibiotic types, 45% for three antibiotic types, and 35% for two antibiotic types. Amoxicillin or metronidazole and clarithromycin are used as first-line or second-line treatments for *H. pylori*. The simultaneous resistance rates to clarithromycin and amoxicillin and clarithromycin and metronidazole were both 40%. This finding explains the low eradication rate for these two regimens in Egyptian clinical trials. These results also raise the question regarding the value of these two regimens as first-line therapies in Egypt. Our results also support the use of doxycycline and moxifloxacin as second-line therapies.

The multiple drug resistance rates in our study were higher than the rates reported in Korea. In Korea, the multiple drug resistance rate to the same five drugs mentioned above was 42.9%; the dual drug resistance to clarithromycin and amoxicillin was 10% and dual drug resistance to metronidazole and clarithromycin was 8.6%. The high rate of multidrug resistance of *H. pylori* in our study was mostly due to cumulative antibiotic usage for various types of infections and the easy accessibility of antibiotics without prescriptions, which increased the resistance to common antibiotics in Egypt (amoxicillin and metronidazole) to a very high rate (>90%). In addition to earlier treatment failures and bacterial factors like mutations, the high resistance rates may also be attributable to the high resistance rates.

One of the drawbacks of our study was that our estimation of sample size was based on the prevalence of *H. pylori* and the assumption of 50% sensitivity for the culture method. Unfortunately, the culture method in our study was less sensitive, which made the sample size for positive cultures smaller than our estimate. Another drawback of this study was the antibiotic susceptibility testing using only the disk diffusion method. Other recent and more accurate methods like PCR and E-test (Epsilometer test) are available. We chose to use the disk diffusion method because it is less expensive, more available, and applicable in developing countries.

**Conclusions**

The *H. pylori* samples in our study exhibited high resistance to metronidazole, amoxicillin, and rifampicin (above 90%), moderate resistance to erythromycin, azithromycin, and clarithromycin (40–65%), and low resistance to doxycycline, moxifloxacin, and levofloxacin (10–20%). Dual resistance was high for amoxicillin/clarithromycin and amoxicillin/metronidazole, which prefers using quinolones rather than clarithromycin or metronidazole for first-line treatment of *H. pylori* in Egypt.

**Data Sharing Statement**

Data are available on request through the corresponding author.

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There was none to be declared.

**Disclosure**

The authors declare that there is no conflict of interest regarding the publication of this article.

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