Increased production of interleukin 1β and hepatocyte growth factor may contribute to foveolar hyperplasia in enlarged fold gastritis

Y Yasunaga, Y Shinomura, S Kanayama, Y Higashimoto, M Yabu, Y Miyazaki, S Kondo, Y Murayama, H Nishibayashi, S Kitamura, Y Matsuzawa

Abstract

Background and Aims—It has been reported that eradication of Helicobacter pylori improves fold width in H pylori associated enlarged fold gastritis. The aim of this study was to clarify the mechanism of fold thickening in this condition.

Patients and Methods—In eight patients with enlarged fold gastritis and 13 patients without enlarged folds, the presence of H pylori infection, inflammatory infiltrates, mucosal plasia, and epithelial cell proliferation in the body mucosa were investigated, and production of transforming growth factor α (TGFα), hepatocyte growth factor (HGF), and interleukin 1β (IL 1β) was determined by a competitive reverse transcription/polymerase chain reaction method and in vitro short-term culture of biopsy specimens.

Results—In the patients with enlarged fold gastritis, inflammatory infiltrates including macrophages increased with H pylori colonisation in the body. Foveolar thickness and proliferating cell nuclear antigen (PCNA) labelling index were increased. Messenger RNA levels of HGF, but not TGFα, were increased, and release of HGF and IL 1β was increased. HGF release, which was positively correlated with IL 1β release and foveolar thickness, decreased in the presence of IL 1 receptor antagonist. After eradication of H pylori, inflammatory infiltrates, IL 1β and HGF release decreased with concomitant decreases in PCNA labelling index, foveolar thickness and fold width.

Conclusions—Increased IL 1β and HGF production caused by H pylori infection may contribute to fold thickening of the stomach by stimulating epithelial cell proliferation and foveolar hyperplasia in patients with enlarged fold gastritis.

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Keywords: Helicobacter pylori, enlarged fold gastritis, interleukin 1β, hepatocyte growth factor, foveolar hyperplasia.

Enlarged folds in the gastric body are not an uncommon finding on radiographic or endoscopic examinations in adults. They are typically associated with a variety of diseases including hypertrophic gastritis, Ménétrier’s disease, Zollinger-Ellison syndrome, primary gastric cell hyperplasia, carcinoma, and lymphoma. As a special form of gastritis accompanied by mucosal hyperplasia of the stomach has been reported, inflammation of the gastric mucosa is thought to affect proliferation and differentiation of gastric epithelial cells. However, the mechanism by which inflammation of the gastric mucosa causes mucosal hyperplasia of the stomach is unknown.

Transforming growth factor α (TGFα) and hepatocyte growth factor (HGF) are well known potent stimulators of gastric epithelial cell proliferation. TGFα, which is produced by gastric epithelial cells, was reportedly over-expressed in the gastric mucosa of a patient with Ménétrier’s disease. It also has been reported that TGFα transgenic mice showed a number of features characteristic of Ménétrier’s disease. Recently, HGF, which was originally identified as a growth factor for hepatocytes, has been shown to have the potential to stimulate growth of gastric epithelial cells. HGF production has been demonstrated by non-epithelial cells such as mesenchymal cells and granulocytes. Reportedly, HGF may be induced by interleukin 1β (IL 1β), a cytokine that plays a key part in the inflammatory and immunological responses.

Recently, Helicobacter pylori has been well known as a cause of chronic active gastritis, and it has been suggested that H pylori gastritis may be one of the causes of enlarged gastric folds. We have previously reported that eradication of H pylori improves inflammation of the gastric mucosa and fold width in H pylori positive patients with enlarged folds; these findings suggest that H pylori infection may cause gastritis accompanied with enlarged folds – that is, ‘enlarged fold gastritis’. In agreement with our findings, improvement in fold thickening after eradication of H pylori has been reported by Stolte et al. and Avunduk et al. To clarify the mechanism of thickening of the gastric folds in patients with enlarged fold gastritis, we investigated TGFα, HGF and IL 1β production in the gastric body mucosa as well as the presence of H pylori infection, inflammatory infiltrates, mucosal plasia, and epithelial cell proliferation in patients with enlarged fold gastritis.
TABLE 1  

<table>
<thead>
<tr>
<th>Sex (male/female)</th>
<th>Age (y)</th>
<th>Fold width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enlarged fold gastritis* (n=8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. pylori (+) (n=8)</td>
<td>5/3</td>
<td>42.5 (4.4), (30-68)</td>
</tr>
<tr>
<td>Non-enlarged fold (n=13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. pylori (+) (n=8)</td>
<td>4/1</td>
<td>43.8 (2.1), (39-50)</td>
</tr>
<tr>
<td>H. pylori (-) (n=8)</td>
<td>4/4</td>
<td>47.8 (2.9), (39-62)</td>
</tr>
</tbody>
</table>

Age and fold width are expressed as mean (SEM), (range). *Enlarged fold gastritis, gastritis accompanied with enlarged folds (the widest fold >5 mm); fp<0.01 < non-enlarged fold, H. pylori (-).

Methods

Patients

We identified eight patients with enlarged fold gastritis (all H. pylori positive) and 13 patients without enlarged folds (five H. pylori positive and eight H. pylori negative) (Table I). The group of eight patients demonstrated crowded, tortuous, and enlarged folds in the gastric body on a barium study performed as part of a mass screening for gastric carcinoma. Subsequently, they underwent endoscopic examination and were confirmed to have inflammation and H. pylori colonisation of the body mucosa. The other group of 13 patients without enlarged folds underwent endoscopic examination because of complaints of dyspepsia; they were divided into two groups according to the presence or absence of H. pylori infection. The width of the body fold was measured on double contrast radiographs in the supine position. Body folds were considered to be enlarged when the widest fold was greater than 5 mm according to the previous studies and the Sydney system. No patients had either peptic ulcer disease or gastric cancer. Hypoproteinaemia (total protein concentration <6.5 g/dl) was found in two of the patients with enlarged fold gastritis (6.3 and 6.4 g/dl). All patients had not received any antisecretory drugs before and during this study. Informed consent was obtained from all patients.

The diagnosis of H. pylori infection was based on successful culture (Department of Chemotherapy, Pharmacological Research Laboratory of Fujisawa Pharmaceutical Co, Osaka, Japan) or the results of a urease test (CLOtest, Delta West), or both, using biopsy specimens from the antrum and the greater curvature of the upper portion of the gastric body.

Assessment of inflammatory infiltrates

Biopsy specimens were fixed immediately with 4% paraformaldehyde. Thin sections of fixed tissues were stained with haematoxylin and eosin for visualisation of mononuclear and polymorphonuclear infiltration. Immunostaining for macrophage infiltration was performed with monoclonal mouse anti-human macrophage, CD68 (Dakocytomation, KP1). Infiltrations of mononuclear and polymorphonuclear cells, and macrophages were graded as follows: 0=None or minimal, 1=mild, 2=moderate, and 3=severe. Immunostaining for CD68 was performed using the peroxidase-antiperoxidase method. The anti-CD68 was used at a dilution of 1:50. The reaction was visualised using 3,3′-diaminobenzidine tetrachloride as a substrate. Negative control was used with mouse IgG (Dako) instead of the anti-CD68, and no detectable staining was seen. Lymphocytic gastritis was diagnosed when the number of intrapithelial lymphocytes was 30% or more of the number of epithelial cells in the areas of maximal lymphocytic concentration.

Measurement of mucosal and foveolar thickness

The mucosal and foveolar thicknesses of the body mucosa were measured on sections vertical to the mucosal surface using an image analysis system (Krypton-40, Flvovel). Values were expressed as the mean of measurements along three or more different foveolae. Glandular thickness was calculated by subtracting foveolar thickness from mucosal thickness.

Assessment of epithelial cell proliferation

Thin sections of 4% paraformaldehyde fixed tissues were used for proliferating cells with monoclonal mouse anti-proliferating cell nuclear antigen (PCNA) (Dako-PCNA, PC10). Epithelial cell proliferation in the body mucosa was assessed by calculating the percentage of PCNA positive nuclei of the total nuclei in the glandular neck regions (PCNA labelling index) after counting at least 1000 total nuclei using the image analysis system. Immunostaining for PCNA was performed using a microwave assisted streptavidin-biotin peroxidase method. The anti-PCNA was used at a dilution of 1:50. The reaction was visualised using 3,3′-diaminobenzidine tetrachloride as a substrate. Negative control was used with mouse IgG instead of the anti-PCNA, and no detectable staining was seen.

Determination of HGF and TGFα mRNA levels

In five patients with enlarged fold gastritis, four H. pylori positive and five H. pylori negative patients without enlarged folds, HGF and TGFα mRNA levels in the body mucosa were determined by a competitive reverse transcription/polymerase chain reaction method in which rat mRNA was used as an internal standard. Total RNA was extracted from biopsy specimens by the guanidinium thiocyanate/acid phenol method. To obtain an internal standard, total RNA was extracted from rat stomach. To amplify HGF mRNA, we used two pairs of primers: the sequences were 5′-CCAATACCATTTGGAAATGGA-3′ for the first step 5′ primer, 5′-CCATTTCACACTGCAGTTCG-3′ for the second step 5′ primer, 5′-TTCCAGGGAGCGCTGGGCTT-3′ for the first step 3′ primer, 5′-ACCTGACGTTTCTTGATCGA-3′ for the second step 5′ primer and 5′-CGGCCACACTGCTAGTGC-3′ for the second step 3′ primer. To amplify 28S ribosomal RNA (rRNA), a pair of primers were used: the sequences were 5′-CCATGTGGAACAGGCAGTGATG-3′ for the 5′ primer and 3′-CCGAGCTTGGGAGTTGTGGC-5′ for the 3′ primer.
Interleukin 1β and HGF in foetal hyperplasia

5'-CCCTGCCCTTCACAAGAAA-3' for the 3' primer. Although both human and rat cDNAs originating from HGF mRNA, TGFα mRNA and 28S rRNA were amplified by the same primers, only the human DNA fragments from HGF mRNA, TGFα mRNA, and 28S rRNA had the Bgl II, Eae I, and Eae I restriction endonuclease sites, respectively. The human and rat RNA mixtures were converted to cDNA with RAV-2 reverse transcriptase (Takara). Obtained cDNAs were amplified with respective primers and Thermus aquaticus DNA polymerase (Perkin-Elmer Cetus). The DNA fragments originating from HGF mRNA, TGFα mRNA, and 28S rRNA were digested with Bgl II (Nippon Gene), Eae I (Takara), and Eae I, respectively. Digested samples were separated into three peaks of DNA fragments using a high performance liquid chromatography column (TSK gel DEAE-NPR, 35 mm×4.6 mm internal diameter, Tosoh): two human fragments (smaller and larger) and a rat fragment. The peak height ratio of the larger human fragment to the rat fragment was used to determine the ratio of amplified DNA fragment from the human mRNA to that from the rat mRNA. As accurate quantitation of trace amounts of human total RNA obtained from biopsy specimens was difficult, the HGF or TGFα mRNA level was expressed as a relative HGF or TGFα mRNA/28S rRNA ratio.

**In vitro short-term culture**

HGF and IL 1β release from the body mucosa were examined using in vitro short-term culture of biopsy specimens from the greater curvature of the upper portion of the body.35 After washing in 0.01 M phosphate buffered saline, four specimens were cultured in 1 ml of culture medium at 37°C in a 95% air and 5% CO₂ humidified incubator for 24 hours. Culture medium consisted of RPMI 1640 (Research Foundation for Microbial Diseases of Osaka University) supplemented with 10% fetal bovine serum (BioWhittaker), 6 mg/l vancomycin hydrochloride (Sigma), and 2-5 mg/l amphotericin B (Sigma). Culture supernatants were collected, centrifuged at 10 000 g, and stored at -80°C until being assayed. The specimens were homogenised in 1 ml of 0.01 M phosphate buffered saline, and assayed for total protein concentration using the method involving bicinchoninic acid34 (BCA*- Protein Assay Reagent, Pierce).

In seven patients with enlarged fold gastritis, HGF release from the body mucosa was examined in the presence and absence of 1 μg/ml of recombinant human IL 1 receptor antagonist35 (R&D Systems) using four biopsy specimens, respectively. It had been ascertained that this IL 1 receptor antagonist inhibits HGF release in a dose dependent manner with a maximal effect at a dose of 1 μg/ml.

**HGF and IL 1β assays**

HGF and IL 1β concentrations in culture supernatants were determined using enzyme linked immunosorbent assays36 37 (HGF 'Otsuka' ELISA Kit and Human Interleukin 1β ELISA Kit, Otsuka). The minimum detectable concentrations of HGF and IL 1β were 10 pg/ml and 2 pg/ml, respectively. The intra and inter assay coefficient of variances were less than 15% and 10%, respectively. The IL 1β assay had no cross reactivity with interleukin 1α.

**Immunostaining for HGF**

Thin sections of 4% paraformaldehyde fixed tissues were immunostained for HGF with monoclonal mouse anti-human HGF (Hyb-T6912, Institute of Immunology Co, Tokyo, Japan).38 Immunostaining for HGF was performed by the peroxidase: antiperoxidase method. The anti-HGF was used at a dilution of 1:100. The reaction was visualised using 3,3'-diaminobenzidine tetrachloride as a substrate. Negative control was used with mouse IgG instead of the anti-HGF, and no detectable staining was seen.

**Treatment for H pylori infection**

The patients with enlarged fold gastritis (all H pylori positive) received triple agent therapy consisting of bismuth subnitrate or sub-carboxylate, 1 g thrice daily; metronidazole, 250 mg twice daily; and tetracycline hydrochloride, 250 mg four times daily for three weeks.15 At four to 23 (mean (SEM) 10.1 (2.8)) weeks after completion of this treatment schedule, fasting serum gastrin concentrations, endoscopic examinations, and gastric secretion studies were repeated. At seven to 25 (mean (SEM) 14.0 (2.0)) weeks after completion of treatment, an upper gastrointestinal barium study was repeated for reassessment of the size of the folds. Eradication of H pylori was considered successful in all patients.

**Statistical analysis**

All results are expressed as mean (SEM). Statistical analysis was performed using the Kruskal-Wallis test, the Mann-Whitney test, and the Wilcoxon signed rank test. Determinations of the Pearson’s correlation coefficient also were made. A p value of less than 0.05 was considered statistically significant.

**Results**

**H pylori status**

H pylori was present in all eight patients with enlarged fold gastritis and five of 13 patients without enlarged folds (Table I). H pylori was positive in both the antrum and the body except for two patients (one with enlarged fold gastritis and one without enlarged folds) who had positivity of H pylori only in the body.

**Inflammatory infiltrates**

Histological examinations demonstrated that the inflammatory infiltrates in the body mucosa of the patients with enlarged fold...
gastritis were significantly more severe than those in the \textit{H pylori} negative patients without enlarged folds (p<0-01) (Table II). When the patients with enlarged fold gastritis were compared with the \textit{H pylori} positive patients without enlarged folds, macrophage infiltration in the body mucosa was significantly more extensive in the patients with enlarged fold gastritis (p<0-05) (Fig 1). When the \textit{H pylori} positive patients without enlarged folds were compared with the \textit{H pylori} negative patients without enlarged folds, both mononuclear and polymorphonuclear infiltrates were significantly more severe in the \textit{H pylori} positive patients without enlarged folds (p<0-05 and p<0-01, respectively). Lymphocytic gastritis was not found in any patients.

\textbf{Mucosal hyperplasia and epithelial cell proliferation}

In the patients with enlarged fold gastritis, the mucosal and foveolar thicknesses of the body mucosa were significantly greater than those in both the \textit{H pylori} positive and negative patients without enlarged folds (p<0-01) (Table III) (Fig 2). Glandular thickness, however, did not significantly differ among the three groups. The foveolar/glandular thickness ratio in the patients with enlarged fold gastritis was significantly higher than that in the \textit{H pylori} negative patients without enlarged folds (p<0-01). There were no significant differences in mucosal, foveolar, and glandular thickness, and the foveolar/glandular thickness ratio between the \textit{H pylori} positive and negative patients without enlarged folds.

PCNA labelling indices in the body mucosa that were assessable in six patients with enlarged fold gastritis, one \textit{H pylori} positive patient without enlarged folds, and four \textit{H pylori} negative patients without enlarged folds, were 20-8 (2-7)%, 7-2%, and 9-0 (0-8)%, respectively. The PCNA labelling index in the patients with enlarged fold gastritis was higher than those in the \textit{H pylori} positive and negative patients without enlarged folds (11-46 (1-44) v 3-54 (0-54) v 4-38 (1-05), p<0-05 and p<0-01, respectively). However, a significant difference was not found in TGF\textalpha mRNA levels among the patients with enlarged fold gastritis and the \textit{H pylori} positive and negative patients without enlarged folds (0-49 (0-11) v 0-47 (0-06) v 0-50 (0-13)) (Fig 3).

\textbf{HGF and TGF\textalpha mRNA levels}

HGF mRNA levels in the body mucosa of the patients with enlarged fold gastritis were significantly higher than those in both the \textit{H pylori} positive and negative patients without enlarged folds (11-46 (1-44) v 3-54 (0-54) v 4-38 (1-05), p<0-05 and p<0-01, respectively). However, a significant difference was not found in TGF\textalpha mRNA levels among the patients with enlarged fold gastritis and the \textit{H pylori} positive and negative patients without enlarged folds (0-49 (0-11) v 0-47 (0-06) v 0-50 (0-13)) (Fig 3).

\textbf{Figure 1: Immunostaining for macrophages in the body mucosa with anti-human macrophage, CD68 before (A) and after (B) eradication of H pylori in the patients with enlarged fold gastritis. (A) Abundant CD68 immunoreactivity is visible in the lamina propria (original magnification \times 100). (B) CD68 immunoreactivity is considerably decreased (original magnification \times 100). Immunoperoxidase stain; paraffin wax embedded sections, methylgreen counterstain.}

\textbf{Figure 2: Haematoxylin and eosin staining of the body mucosa before (A) and after (B) eradication of H pylori in the patients with enlarged fold gastritis. (A) Thickened and tortuous foveola, and severe infiltration to the lamina propria by inflammatory cells are visible (original magnification \times 100). (B) The foveolar thickness and inflammatory infiltrates have decreased (original magnification \times 60).}
Interleukin 1β and HGF in foveolar hyperplasia

HGF and IL 1β release

HGF release from the body mucosa in the patients with enlarged fold gastritis was much greater than that in both the H pylori positive and negative patients without enlarged folds (5.74 (0.77) vs 1.24 (0.12) ng 24 hours/mg protein, p<0.05 and p<0.01, respectively) (Fig 4). In the patients with enlarged fold gastritis, IL 1β release from the body mucosa was also much greater than that in both the H pylori positive and negative patients without enlarged folds (478.1 (77.5) vs 81.8 (45.1) vs 2.8 (0.9) pg 24 hours/mg protein, p<0.01). When the H pylori positive patients without enlarged folds were compared with the H pylori negative patients without enlarged folds, HGF and IL 1β release both were greater in the H pylori positive patients without enlarged folds (p<0.01). A significant correlation was found between IL 1β and HGF release in the body mucosa of the patients with H pylori infection (r=0.854, p<0.01) (Fig 5).

Figure 3: Hepatocyte growth factor (HGF) (A) and transforming growth factor α (B) mRNA levels in the body mucosa of the H pylori negative and positive patients without enlarged folds and the patients with enlarged fold gastritis. Enlarged fold gastritis, gastritis accompanied with enlarged folds (the widest fold >5 mm). TGFα: transforming growth factor α, rRNA: ribosomal RNA, NS: not significant.

Figure 4: HGF (A) and interleukin 1β (IL 1β) (B) release from the body mucosa of the H pylori negative and positive patients without enlarged folds, and the patients with enlarged fold gastritis before and after eradication of H pylori.

HGF release also was significantly correlated with foveolar thickness (r=0.569, p<0.05).

HGF release from the body mucosa in the presence of an IL 1 receptor antagonist was significantly less than that in the absence of this IL 1 receptor antagonist in patients with enlarged fold gastritis (p<0.05) (Fig 6).

Effects of eradication of H pylori

After eradication of H pylori in the patients with enlarged fold gastritis, the width of the body folds in the patients with enlarged fold gastritis, which had been much greater than those in...
The results of this study indicate that patients with enlarged fold gastritis show a significant increase in the expression of HGF, particularly in the foveolar region. This increase is associated with a decrease in glandular thickness and an increase in the mean thickness of the glandular mucosa, suggesting that HGF plays a role in the remodeling of the gastric mucosa.

**Discussion**

The immunostaining for HGF reveals a high level of expression in the inflamed body mucosa, with a greater intensity in the foveolar region compared to the glandular region. This suggests that HGF is involved in the hyperplasia of the foveolar region, which is a characteristic feature of enlarged fold gastritis.

The thickness of the mucosa and foveolar regions also shows significant changes after eradication of *H. pylori*. The thickness of the mucosa decreased significantly, while the thickness of the foveolar region increased. This suggests that the hyperplasia of the foveolar region is due to the increased expression of HGF, which is in turn due to the presence of *H. pylori*.

**Immunostaining for HGF**

In the patients with enlarged fold gastritis, HGF immunoreactivity was observed in the lamina propria and in the foveolar region. The immunoreactivity was stronger in the foveolar region compared to the glandular region, indicating that HGF is involved in the hyperplasia of the foveolar region.

**Figure 6**

The figure shows the release of HGF from the body mucosa in the absence and presence of an interleukin 1 receptor antagonist in the patients with enlarged fold gastritis. The presence of the antagonist significantly decreases the release of HGF, indicating that HGF is produced in response to the presence of interleukin 1.

**Figure 7**

The figure shows the immunostaining for HGF in the body mucosa of patients with enlarged fold gastritis. The staining is intense in the foveolar region, indicating that HGF is produced in response to the presence of *H. pylori*.

**Figure 8**

The figure shows the immunostaining for HGF in the body mucosa of patients with enlarged fold gastritis after eradication of *H. pylori*. The staining is decreased in the foveolar region, indicating that the hyperplasia of the foveolar region is due to the increased expression of HGF before eradication.
in patients with hypertrophic lymphocytic gastritis, which is a rare type of gastritis characterised by a considerable increase in intraepithelial lymphocytes (30% or more of the number of epithelial cells).\(^3\)\(^{26}\)\(^40\) Enlarged fold gastritis in this study resembled hypertrophic lymphocytic gastritis with the presence of a comparatively severe grade of chronic active inflammation and foveolar hyperplasia. However, intraepithelial infiltration of polymorphonuclear cells, rather than lymphocytes, was found in this study, and no cases were compatible with lymphocytic gastritis. Hypertrophic lymphocytic gastritis may be regarded as a rare type of enlarged fold gastritis. Wolfson et al\(^3\) have reported that patients previously diagnosed with Ménétrier's disease actually represent at least two diseases: (1) hypertrophic lymphocytic gastritis and (2) massive foveolar hyperplasia and minimal inflammation (classic Ménétrier's disease). They have shown that medians (range) of mucosal thickness and foveola/gland ratio in patients with classic Ménétrier's disease are 5-5 mm and 2.5-12.5 mm and 9-5 mm (3-15), respectively. In our study, those in the patients with enlarged fold gastritis were 0-960 (0-706–1-214) mm and 0-818 (0-563–1-234), respectively. Therefore, enlarged fold gastritis in our study is considered to be distinguishable from classic Ménétrier's disease. Our finding that two patients with enlarged fold gastritis had hypoproteinemia may suggest that enlarged fold gastritis is one of the causes of protein loosing gastropathy as well as Ménétrier's disease and lymphocytic gastritis.\(^40\)

This study also shows that IL 1β and HGF release from the body mucosa is increased in patients with enlarged fold gastritis. In addition, this study shows that macrophage infiltration in the body mucosa is significantly increased in patients with enlarged fold gastritis. IL 1β is known to be produced mainly by activated monocytes/macrophages, and has been reported to induce HGF release in human fibroblasts in vitro.\(^12\)^\(^{13}\)^\(^{14}\) This study further shows that HGF release significantly correlated with IL 1β release in patients with enlarged fold gastritis and \(H\) \(p\) \(y\) \(l\) \(o\) \(r\) positive patients without enlarged folds, and is significantly decreased in the presence of an IL 1 receptor antagonist in patients with enlarged fold gastritis. These findings strongly suggest that HGF is induced by IL 1β in enlarged fold gastritis. These results also suggest that infiltration and activation of macrophages result in raised IL 1β and HGF release in this condition. Furthermore, the results of this study suggest that HGF producing cells are mainly polymorphonuclear leucocytes and less often macrophages in the body mucosa of patients with enlarged fold gastritis. This is consistent with reports stating that HGF immunoreactivity is present in granulocytes in the bone marrow, spleen, and diseased liver, as well as in macrophages in the lymph nodes, respiratory tract, and liver (Kupffer cells).\(^8\)\(^{11}\)

TGFα and HGF are well known, potent growth factors, which induce a mitogenic response in gastric epithelial cells.\(^1\)^\(^5\)\(^3\) It also has been shown that severe foveolar hyperplasia occurs in transgenic mice overexpressing TGFα in the stomach, suggesting that TGFα plays a part in the pathogenesis of Ménétrier's disease.\(^6\)\(^7\) There have been no reports about the association between HGF and the hyperplastic state of gastric mucosa. In this study, HGF mRNA levels, but not TGFα mRNA levels, in the body mucosa were increased in the patients with enlarged fold gastritis. This study also showed that HGF release from the body mucosa was significantly increased in the patients with enlarged fold gastritis. Moreover, foveolar thickness of the body mucosa significantly correlated with HGF release in patients with enlarged fold gastritis and \(H\) \(p\) \(y\) \(l\) \(o\) \(r\) positive patients without enlarged folds. These results suggest that HGF is possibly involved in foveolar hyperplasia through stimulating epithelial cell proliferation in enlarged fold gastritis. Furthermore, this study suggests that HGF may be induced by IL 1β in enlarged fold gastritis. Recently, it has been shown that intestinal epithelial cells (IEC-18 and Caco-2) express the type I IL 1 receptor and that IL 1β increases proliferation of Caco-2 cells.\(^41\)^\(^{42}\)

However, it has not been shown whether IL 1β increases epithelial cell proliferation in the stomach directly. IL 1β may participate in gastric epithelial cell proliferation, at least through stimulating HGF release.

This study further demonstrates that eradication of \(H\) \(p\) \(y\) \(l\) \(o\) \(r\) in patients with enlarged fold gastritis decreases inflammatory infiltrates, including macrophages, IL 1β, and HGF release, with concomitant improvement in epithelial cell hyperproliferation, foveolar hyperplasia, and fold enlargement. However, foveolar thickness and fold width after eradication were still greater than those values in \(H\) \(p\) \(y\) \(l\) \(o\) \(r\) positive and negative patients without enlarged folds. These results suggest that \(H\) \(p\) \(y\) \(l\) \(o\) \(r\) infection causes infiltration and activation of macrophages, leading to increased IL 1β and HGF release in enlarged fold gastritis. It is unclear why macrophage infiltration was increased, especially in a
subset of patients with *H pylori* gastritis such as those in this study. This may be dependent on the strain of *H pylori* or immunological reactivity of the host. Decreased, but still raised, HGF release after eradication, despite the disappearance of polymorphonuclear cells, may reflect HGF production by activated macrophages that remained in the lamina propria.

Previously, we have reported that acid secretion is decreased in *H pylori* positive patients with enlarged fold gastritis. Inhibition of acid secretion and increase in epithelial cell proliferation in patients with enlarged fold gastritis seem advantageous to the host because of reducing the mucosal injury caused by acid and pepsin, and promoting mucosal regeneration. However, it remains unclear whether the raised gastric pH may be for or against *H pylori*. On the other hand, chronic inflammation, hyperplasia, and long-standing epithelial cell hyperplasia and hyperplastic state may be favourable to gastric carcinogenesis because of an increase in inflammatory mutagens, the intraepithelial formation of N-nitroso compounds, and the chance of mutation. Thus, further study is needed to clarify whether or not the risk of gastric carcinoma is increased in enlarged fold gastritis, and eradication of *H pylori* reduces the risk.

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