The differential diagnosis between Helicobacter pylori (H pylori)-associated chronic gastritis and low-grade B-cell gastric lymphoma of mucosa-associated lymphoid tissue (MALT) and the assessment of endoscopic biopsy specimens after treatment of lymphoma can be problematic. Although immunocytochemistry can be used to identify clonal B-cell populations, which are characteristic of MALT lymphoma, its application to small biopsy specimens and the subsequent interpretation can be difficult. The polymerase chain reaction (PCR) can detect clonal B-cell populations by analysis of the Ig heavy chain gene in routinely fixed paraffin-embedded tissue (PCR) can detect clonal B-cell populations by analysis of the Ig heavy chain gene in routinely fixed paraffin-embedded material and might provide a useful tool in the assessment of these specimens. We have investigated the value of histology and PCR in the diagnosis of lymphoma and its follow-up in formalin-fixed paraffin-embedded gastric endoscopy biopsy specimens from 69 sequential patients selected on the basis of a dense mucosal lymphoid infiltrate associated with H pylori infection. Histologic evidence of MALT lymphoma was identified in 13 cases, 9 of which showed PCR-detected monoclonality. In 12 of 13 cases, H pylori was eradicated, and in 11 of 12 cases, histologic regression of the lymphoma followed. PCR evidence of monoclonality disappeared in 6 of 9 originally monoclonal cases. This was synchronous with histologic remission in 1 case, but lagged in the remaining 5 cases by up to 28 months. Two of the 3 of the 9 cases originally monoclonal by PCR that have not shown molecular regression have monoclonal-amplified products 17 and 24 months after negative histology. In 3 cases, the histology of the biopsies was considered indeterminate or discordant. In 1 of these cases, the histologic features were obscured by crush artefact. In a second case, there was molecular evidence of monoclonality in the absence of histologic features suggestive of lymphoma; this persisted after H pylori eradication. An additional single case originally diagnosed as reactive developed a PCR detectable clonal population 29 months after original evaluation in the absence of histologic features of lymphoma but in the presence of persistent H pylori infection. These findings suggest that the histologic assessment of gastric biopsies remains the method of choice for the diagnosis of lymphoma in gastric endoscopic biopsies with a dense mucosal lymphoid infiltrate. PCR provides a useful technique to support the diagnosis if clonal amplification products are found. The significance of PCR detected clonality in the absence of histologic evidence of lymphoma is uncertain but may represent a stage of tumor progression/regression when the clonal population is insufficient to be detected by conventional histology. This is supported by the evidence that PCR-detectable monoclonality can persist after treatment and the disapparition of histologically detectable lymphoma.

LOW-GRADE GASTRIC lymphoma of mucosa-associated lymphoid tissue (MALT) has been shown to be associated with colonization of the gastric mucosa by Helicobacter pylori (H pylori) in more than 90% of cases. In gastric biopsies with a dense mucosal lymphoid infiltrate, the distinction between a reactive lymphoid population and a low-grade MALT lymphoma can be difficult and is greatly helped by the demonstration of B-cell monoclonality. Monoclonality can be inferred by the immunocytochemical demonstration of Ig light chain restriction, which is possible using conventional formalin-fixed paraffin-embedded biopsy specimens. However, the interpretation of the staining in small, often crushed, biopsies is frequently difficult. The development of the polymerase chain reaction (PCR) for the identification of clonal B-lymphocyte populations by the analysis of Ig heavy chain gene and its application to paraffin-embedded material could potentially provide a specific and sensitive tool for the identification of neoplastic B-cell populations and therefore be of use in the distinction between florid H pylori-associated gastritis and low-grade MALT lymphoma.

The assessment of monoclonality is fundamental in the management of patients with lymphoma both in the diagnosis and in the evaluation of response to treatment. Recent studies have shown rapid histologic regression of gastric MALT lymphoma after the eradication of H pylori that has been accompanied by PCR evidence of loss of the monoclonal B-cell population. In this study, we have formally evaluated the role of histology and PCR in the diagnosis of routinely fixed, paraffin-embedded gastric biopsies with a dense lymphoid infiltrate and in the follow-up of cases of low-grade MALT lymphoma treated by H pylori eradication.

MATERIALS AND METHODS

Diagnostic procedures. All gastric biopsies showing a dense mucosal lymphoid infiltrate were retrieved from the surgical files of the Department of Histopathology, Ospedale S. Orsola, Brescia, Northern Italy for the period between 1991 and 1993. Sixty-nine cases were obtained (36 female and 33 male patients; age range, 16 to 84 years) and sections from routinely processed paraffin-embedded tissue were stained with hematoxylin and eosin (H&E) and a modified giemsa stain to detect H pylori. These were reviewed by four histopathologists (A.S., G.F., A.C.W., and P.G.I.). The H pylori status was noted and the lymphoid infiltrate was assessed for features of low-grade MALT lymphoma using established criteria. To assess alterations in the histologic appearances in subsequent biopsies, the confidence of a diagnosis of lymphoma was objectively scored using
Table 1. Histologic Scoring for Diagnosis of MALT Lymphoma

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>Histologic Features</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>Normal</td>
<td>Scattered plasma cells in lamina propria. No lymphoid follicles.</td>
</tr>
<tr>
<td>1</td>
<td>Chronic active gastritis</td>
<td>Small clusters of lymphocytes in lamina propria. No lymphoid follicles. No LELs.</td>
</tr>
<tr>
<td>2</td>
<td>Chronic active gastritis with florid lymphoid follicle formation</td>
<td>Prominent lymphoid follicles with surrounding mantle zone and plasma cells. No LELs.</td>
</tr>
<tr>
<td>3</td>
<td>Suspicious lymphoid infiltrate in lamina propria, probably reactive</td>
<td>Lymphoid follicles surrounded by infiltrates of CCL cells that infiltrate diffusely in lamina propria and occasionally into epithelium.</td>
</tr>
<tr>
<td>4</td>
<td>Suspicious lymphoid infiltrate in lamina propria, probably lymphoma</td>
<td>Lymphoid follicles surrounded by CCL cells that infiltrate diffusely in lamina propria and into epithelium in small groups.</td>
</tr>
<tr>
<td>5</td>
<td>Low-grade B-cell lymphoma of MALT</td>
<td>Presence of dense diffuse infiltrate of CCL cells in lamina propria with prominent LELs.</td>
</tr>
</tbody>
</table>

Data from Wotherspoon et al.6

Abbreviations: CCL, centrocyte-like; LEL, lymphoepithelial lesion.

In each case, PCR was performed on DNA extracted from unstained sections from the same paraffin blocks using primers to the joining region and the framework (Fr) 3 part of the variable region. Electrophoresis on 10% polyacrylamide gels, stained with ethidium bromide, and/or omeprazole. When eradication was achieved, alternative antibiotic regimes were devised based on the results of an antibiogram.

Sixty-nine patients were identified in whom gastric biopsies showed a dense mucosal lymphoid infiltrate. All patients had initially presented with nonspecific upper gastrointestinal symptoms. H pylori organisms were identified in the initial biopsy specimens in all cases by examination of the H&E- and/or giemsa-stained sections.

**RESULTS**

The clinical, histologic, and molecular data are summarized in Table 2. In 7 patients, the predominant symptom was epigastric pain that was associated with hematemesis in a single case. Two cases had a previous history of duodenal ulcer. Gastroscopy showed active or healed ulceration in 6 cases (3 single and 3 multiple), erosions in 2, gastritis in 4, and a normal appearance in 1 case. Ulcers and erosions were located in the antrum and body in 5 cases and in the distal body in 1. The histologic appearances could not discriminate between cases of reactive and chronic gastritis or to obtain an antibiotic regimen.

Patients with histologic or molecular evidence of low-grade MALT lymphomas underwent repeat endoscopy at approximately 6-month intervals after H pylori eradication. On each occasion, the procedure was undertaken by the same endoscopist (F.B.) who performed several biopsies from the same gastric region previously involved by lymphoma. Biopsy specimens were assessed histologically by the same four pathologists and PCR was performed using the primer combinations that had previously produced a monoclonal pattern. Amplification products from all specimens from an individual case were run side by side on a single gel to confirm the persistence or disappearance of the clonal population. Cases in which the initial biopsies were assessed as showing a reactive lymphoid infiltrate were followed-up by endoscopy and biopsy only after a specific request by the patient.
lymphoid infiltrate and low-grade MALT lymphoma. In all cases, staging procedures showed that the lesion was confined to the stomach (stage IE).

Retrospective examination of previous biopsies in 4 patients showed histologic evidence of lymphoma 9 to 52 months before the commencement of anti-H pylori therapy. In these cases, the histologic appearances of lymphoma remained unaltered until antibiotic therapy was instituted.

Eradication of H pylori was achieved in 12 cases (92%), of which 4 required more than one antibiotic combination. In 1 case, eradication was not achieved despite 5 different antibiotic combinations. Histologic regression (score 2 to 3) was seen in 11 of 12 (92%) patients and was evident in the first posttreatment biopsy performed 2 to 4 months after eradication in 8 cases. The biopsy appearances in regressed cases were characterized by an "empty" lamina propria composed of loose connective tissue with scattered plasma cells but devoid of organized collections of lymphoid cells, with loss of gastric glands that had previously been destroyed by the neoplastic infiltration (Fig 1A and B). In 3 cases, histologic regression preceded complete eradication of H pylori organisms. All 11 cases remained disease and infection free 25 months later showed no histologic evidence of lymphoma, and PCR of this material produced a clonal pattern.

In the single case (case no. 13) in which H pylori eradication has not been achieved, the histlogic appearances have fluctuated after different antibiotic therapies (score 5-2-4-3), with no significant histologically detectable difference in the colonization of the gastric epithelium by the organism. In this case, PCR has always failed to show a clonal population. Remission preceeding a complete eradication of H pylori.

Indeterminate/discordant cases. The clinical, histologic, and molecular data are summarized in Table 3. In 1 case, the original biopsies showed severe crush artefact. Although crushing of cells and nuclear smearing has been suggested to be a feature suggestive of a neoplastic infiltrate, the histologic features of the preserved areas in this biopsy were not thought to be sufficient for a diagnosis of lymphoma. Endoscopy showed a single healed scar but no obvious tumor mass. PCR analysis of this biopsy showed monoclonality. A second biopsy 2 months after the completion of anti-H pylori therapy showed no histologic evidence of lymphoma, and PCR of this biopsy showed disappearance of the original clone. This case remains disease and infection free 25 months after eradication.

One case showed histologic features of a reactive lymphoid infiltrate (score 2) but a PCR-detectable monoclonal population. Endoscopy of this case showed gastritis but no ulcer or mass. Follow-up biopsies showed continued absence of histologic features of lymphoma and molecular regression 23 months after eradication.

A third case initially showed histologic features of chronic follicular gastritis (score 2), with no evidence of a clonal population by PCR. A repeat biopsy 29 months later showed a more intense lymphoid infiltrate (score 3) but no overt histologic evidence of lymphoma; H pylori infection persisted. PCR of this material produced a clonal pattern.

DISCUSSION

The clinical presentation of the cases of low-grade MALT lymphoma in this study reinforces the nonspecific nature of the digestive symptoms in patients subsequently found to have lymphoma. In addition, the endoscopic findings suggest that an appearance of gastritis or a normal gastric mucosa can harbor low-grade MALT lymphoma. Biopsy of all patients undergoing gastroscopy for upper gastrointestinal symptoms is advised to exclude a possible underlying malig-
Fig 1. (A and B) Empty lamina propria. Characteristic histologic aspect of gastric low-grade MALT lymphoma regression after the eradication of H pylori: loose connective tissue with scattered plasmacells with loss of gastric glands. (H&E; original magnification x 100 and x 200, respectively.)

nancy. The finding of early, stage IE disease in all the patients in this study contrasts with a recent report of frequent extragastric extension of low-grade MALT lymphoma.\textsuperscript{12} Both this and the minimal gastroscopic abnormalities in these cases may be explained by a high endoscopy rate in this institution.

The histologic distinction between a florid reactive lymphoid infiltrate and low-grade lymphoma of MALT type can be difficult. Several investigators have identified features that are helpful in the diagnosis of gastric MALT lymphoma, including the presence of lymphoepithelial lesions, Dutcher bodies, and marked to moderate cytologic atypia.\textsuperscript{4-8} Extension of centrocyte-like cells into the lamina propria, mild cytologic atypia, and crushing/smearing of lymphocytes are features considered to suggest a lymphoma diagnosis. Many biopsy specimens do not show all these features, which results in histologic suspicion without diagnostic certainty. Immunocytochemical staining of the small routinely fixed and paraffin-embedded gastric biopsies can be problematic, and assessment of stains for Ig light chain restriction in this material can be difficult to interpret. PCR from routinely processed paraffin-embedded material provides a powerful tool for the identification of neoplastic lymphoid populations by the examination of the Ig heavy chain and T-cell receptor genes.\textsuperscript{9,14,15} Application of PCR to small biopsies could potentially be used to distinguish between benign and neoplastic infiltrates. Our finding of PCR-detectable clone in 69% of cases with histologic features suggestive or diagnostic of low-grade MALT lymphoma is in accordance with previously published studies comparing Southern blot and PCR-detectable monoclonality and the detection of clonal populations in frozen and paraffin-embedded material.\textsuperscript{10} The high false-negative rate (30%) means that histologic examination of gastric endoscopic biopsies remains the method of choice for the diagnosis of low-grade MALT lymphoma. When a
positive result is obtained, PCR provides a useful confirmation of the histologic impression of lymphoma, but can only be interpreted in the context of the histology.

Regression of gastric low-grade MALT lymphoma after the eradication of H pylori has previously been reported.\(^5,7\)

To date, no study has assessed the role of PCR in the diagnosis and follow-up of these patients or documented the timing of histologic and molecular regression of lymphomas responding to antibiotic therapy. In the 4 cases in this study that showed histologic features of lymphoma on retrospective examination of previous biopsies, no histologic change was seen 9 to 52 months before anti-H pylori therapy. This absence of spontaneous remission is further evidence that the lymphoma regression is specifically related to the eradication/suppression of H pylori.

The significance of persistent PCR-detectable monoclonality after histologic regression in some cases is undetermined. The in vitro demonstration of the MALT lymphoma cells’ T-cell-dependent proliferation when exposed to H pylori strains specific for an individual tumor\(^7\) suggests that eradication of the organism removes the T-cell drive to an immunologically competent malignant clonogenic cell. It has also been suggested that MALT lymphoma cells can terminally differentiate into nonproliferative but clonal plasma cells.\(^8\) The lag phase between histologic and molecular regression might therefore be explained by the time interval between the removal of proliferative drive and the terminal differentiation and senescence of the differentiating but nonproliferating lymphoma cells.

In this study, PCR showed monoclonality in the original biopsies in 2 cases lacking histologic features of lymphoma. In 1 case, crush artefact obscured the histology and might have raised a suspicion of lymphoma. A repeat biopsy was suggested, which was performed 2 months after completion of anti-H pylori therapy; at that time, no evidence of lymphoma was found using history or PCR. Whether or not this represents an inappropriate PCR result will never be known.

A definite false-positive molecular result was found in 1 case. The endoscopic features were reported as showing gastritis, and the histology of the biopsy specimens showed follicular gastritis with a mild lymphoplasmacytic infiltrate in the lamina propria but no evidence of lymphoma. Repeat biopsies after eradication of H pylori showed persistence of this monoclonality for 17 months. As far as possible, the presence of artefactual amplification within the PCR reactions has been excluded by repeated extractions on separate occasions and comparison of the products obtained from the original and subsequent biopsy specimens. Each extract from each biopsy resulted in the amplification of an identically sized product, which suggests the presence of a genuine clonal population. The significance of this finding remains undetermined. However, this might represent the presence of a small lymphoma population within the mucosa that may have become evident in the future.

In 1 case initially diagnosed as reactive, a PCR-detectable clonal population evolved in the absence of histologic evidence of lymphoma but with the persistence of H pylori infection. In this case, the histologic features have changed with an increased lymphoid infiltrate in the lamina propria of lymphocytes, some of which show Dutcher bodies, a feature suggestive of but not diagnostic of lymphoma (score 2 increased to 3). This might be another false-positive result or might represent the emergence of a clonal population from within an H pylori-associated gastritis. Further biopsies may elucidate the nature of the PCR-detectable monoclonality in this case.

The presence of a PCR-detectable population in the absence of histologic features of lymphoma might therefore present a stage in tumor regression in those cases with H pylori eradication or tumor progression in new cases at a time when the clonal population is sufficiently large to be detected by PCR (approximately 5% of the infiltrate) but not by conventional histology.

In cases in which regression was achieved in this series, no relapse was detected after 14 to 36 months (mean, 24 months) follow-up. The indolent nature of low-grade MALT lymphoma, the possibility of reinfection and recrudescence of lymphoma, and the possibility of transformation and T-cell-independent proliferation of any residual quiescent neoplastic cells suggests that continuous regular follow-up is required. Large trials with prolonged follow-up are required to assess the long-term survival and efficacy of antibiotic therapy for low-grade gastric MALT lymphoma.

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