The significance of *cagA*+ *Helicobacter pylori* in reflux oesophagitis

V J Warburton-Timms, A Charlett, R M Valori, J S Uff, N A Shepherd, H Barr, C A M McNulty

Abstract

***Background*—*Helicobacter pylori* is a gastroduodenal pathogen associated with ulceration, dyspepsia, and adenocarcinoma. Recent preliminary studies have suggested that *H pylori* may be protective for oesophageal adenocarcinoma. In addition, strains of *H pylori* identified by the presence of the cytotoxin associated gene A (*cagA*) are shown to have a significant inverse association with oesophageal adenocarcinoma. Given that *cagA*+ *H pylori* may protect against oesophageal carcinoma, these strains may be protective for oesophagitis, a precursor of oesophageal carcinoma.**

***Aims*—The aim of this study was to investigate the association between *cagA*+ *H pylori* and endoscopically proved oesophagitis.**

***Patients*—The study group included 1486 patients attending for routine upper gastrointestinal tract endoscopy.**

***Methods*—At endoscopy the oesophagus was assessed for evidence of reflux disease and graded according to standard protocols. Culture and histology of gastric biopsy specimens determined *H pylori* status. The prevalence of *cagA* was identified by an antibody specific ELISA (Viva Diagnostika, Germany).**

***Results*—*H pylori* was present in 663/1485 (45%) patients and in 120/312 (38%) patients with oesophagitis. Anti-CagA antibody was found in 499/640 (78%) *H pylori* positive patients. Similarly, anti-CagA antibody was found in 422/521 (81%) patients with a normal oesophagus and in 42/60 (70%) with mild, 24/35 (69%) with moderate, and 11/24 (46%) with severe oesophagitis. The risk of severe oesophagitis was significantly decreased for patients infected with *cagA*+ *H pylori* after correction for confounding variables (odds ratio 0.57, 95% confidence interval 0.41–0.80; p=0.001).**

***Conclusions*—These results suggest that infection by *cagA*+ *H pylori* may be protective for oesophageal disease.**

(*Gut* 2001;**49**:341–346)

Keywords: *Helicobacter pylori*; *cagA*+; gastro-oesophageal reflux disease; oesophagitis; oesophageal adenocarcinoma; hiatus hernia

Public Health Laboratory, Gloucestershire Royal Hospital, Gloucester, UK
V J Warburton-Timms
C A M McNulty

Gloucester Gastroenterology Group, Gloucestershire Royal Hospital, Gloucester, UK
R M Valori
H Barr

Department of Histopathology, Gloucestershire Royal Hospital, Gloucester, UK
J S Uff
N A Shepherd

PHLS Statistics Unit, 61 Colindale Avenue, London, UK
A Charlett

Correspondence to: Dr C A M McNulty, Public Health Laboratory, Gloucestershire Royal Hospital, Great Western Road, Gloucester GL1 3NN, UK. jwhiting@phls.nhs.uk

Accepted for publication 5 December 2000

Helicobacter pylori is an important and prevalent gastroduodenal pathogen associated with ulceration, dyspepsia, and adenocarcinoma.[1 2] Circumstances that promote the development of *H pylori* associated diseases include host and environmental influences and features of the infecting strain.[3]

Significant gastroduodenal disease is particularly associated with infection by evidently virulent *H pylori* strains that possess the cytotoxin associated gene (cag) pathogenicity island (PAI).[4] The cag PAI is a segment of DNA with a distinct nucleotide composition compared with the rest of the chromosome, containing genes thought to have an association with pathogenesis. With *H pylori* the guanosine and cytosine content is 38–45% for other chromosomal sequences and 35% for the cag PAI.[5] The cag PAI contains, among others, the cytotoxin associated gene A (*cagA*).[6]

cagA is present in about 70% of UK strains.[7] Patients infected by *cagA*+ *H pylori* have a greater risk of developing duodenal ulcer disease and gastric adenocarcinoma.[8] *H pylori* expressing *cagA* are also known to contribute to significant gastric inflammation and cytokine production.[9] Anti-CagA antibodies predict infection by a *cagA*+ strain. The CagA protein is possibly a surface expression protein or part of the export machinery necessary for stimulating the enhanced local inflammatory response seen with *cagA*+ infections.[5]

The role of *H pylori* in gastro-oesophageal reflux disease (GORD) has only recently received attention largely because the prevalence of *H pylori* in patients suffering from GORD is similar to the normal population.[10] However, eradication of *H pylori* from those suffering from duodenal ulcer may promote reflux oesophagitis with a consequent increased risk of oesophageal/gastric cardia adenocarcinoma.[11] *H pylori* with the *cagA* gene are significantly less prevalent in subjects with oesophageal adenocarcinoma.[12] Diminution of peptic ulcer disease and adenocarcinoma of the distal stomach have paralleled the decreasing prevalence of *H pylori* infections in the developed world.[13] At the same time, there has been an increase in GORD, Barrett's oesophagus, and adenocarcinoma of the distal oesophagus and proximal stomach of epidemic proportions,[14] suggesting that *H pylori* may protect against these oesophageal diseases, including those that predispose to carcinoma, such as Barrett's oesophagus. Indeed, in a

Abbreviations used in this paper: cag, cytotoxin associated gene; *cagA,* cytotoxin associated gene A; PAI, pathogenicity island; GORD, gastro-oesophageal reflux disease; NSAID, non-steroidal anti-inflammatory drug; PPI, proton pump inhibitor; LOS, lower oesophageal sphincter.

nested case control study, Barrett's oesophagus and oesophageal adenocarcinoma were less common in *H pylori* infected patients.[15]

Our study was specifically aimed at assessing the association between *cagA*⁺ *H pylori* and endoscopically proved oesophagitis in a large cohort of unselected patients being investigated for upper gastrointestinal symptoms. The information was collected before the widespread use of proton pump inhibitors (PPIs).

Methods

PATIENTS

Gloucestershire Royal Hospital has had an open access endoscopy service for 20 years. In 1986 a study of the role of *H pylori* in upper gastrointestinal tract disease in an unselected cohort of 1486 upper gastrointestinal endoscopy patients was undertaken and therefore forms an ideal cohort to examine the role of *H pylori* in GORD. Endoscopies were performed by consultant gastroenterologists, surgeons, trainee gastroenterologists, GP gastroenterology hospital practitioners, and clinical assistants. A detailed endoscopy report form was completed by all endoscopists immediately after the examination. This had been in routine use in the department for some years and all endoscopists were trained and familiar with the grading. The endoscopist recorded the oesophageal appearance on a proforma as normal, mild oesophagitis (definite mild erythematous inflammation on the ridges of the oesophagus), severe oesophagitis (confluent inflammation with superficial ulceration), or moderate oesophagitis (moderate or confluent inflammation without ulceration). This grading was based on the system described by Blackstone.[16] Hiatus hernia, varices, achalasia, monilia, or a motility problem were graded as normal. Oesophageal ulcer, stricture, and long segment Barrett's oesophagus (2 cm of concentric columnar epithelium above the oesophageal sphincter) were deemed as evidence of severe oesophagitis. The presence of short segment Barrett's, an entity not well recognised in 1986, was not recorded. Gastric biopsy specimens were taken from all patients within 5 cm of the pylorus and the presence of *H pylori* infection was assessed by histology, microaerobic culture, and the biopsy urease test.

HISTOPATHOLOGICAL EXAMINATION

Two gastric biopsy specimens were placed in 10% formol saline and processed for histopathological evaluation. Sections were stained by haematoxylin and eosin, periodic-acid Schiff, and the half Gram method.[17] Biopsy specimens were assessed by a histopathologist without knowledge of the patient's clinical details. Sections were graded for neutrophil (polymorphonuclear) infiltration, mononuclear cells, mucin depletion, *H pylori*, intestinal metaplasia, and lymphoid aggregates on a 0–3 scale with 3 being severe. The severity of chronic active gastritis was graded as mild, moderate, or severe according to standard protocols, or the biopsies were deemed normal.

CULTURE OF *H PYLORI*

Two biopsy specimens for culture were sent in normal saline to the laboratory. The biopsies were smeared across chocolate agar medium and *Campylobacter* selective medium. *H pylori* type strain NCTC11637 was incubated with the isolates to control for changes in atmospheric conditions. Plates were then incubated in a microaerobic atmosphere for 5–7 days. Plates were examined at five and seven days. *H pylori* was confirmed by Gram film and the rapid urease test. *H pylori* infection was considered present when *H pylori* was confirmed by either culture or histology.

CagA SEROLOGY

Venous blood (10 ml) was stored as serum at −70°C in duplicate. Anti-CagA antibody titres were determined without prior knowledge of *H pylori* or oesophagitis status by use of the p120 CagA ELISA kit (Viva Diagnostika, Germany). This is a semiquantitative kit with a calibration calculation for each plate. Plates were read at 450 nm on a Titertek Multiscan (mcc/340 MK11) ELISA plate reader. Results were judged positive or negative according to the manufacturer's instructions and by cut off values validated by a select group of samples assessed blindly by western blot (Helicoblot 2.0; Biorad, UK).

DATA COLLECTION

Patient consent for the study and data on age, sex, past medical history, drug history, tobacco use, alcohol consumption (none, mild <15 units/week, moderate 15–30 units/week, severe >30 units/week), and family history of upper gastrointestinal disease (peptic ulcer, malignancy, hiatus hernia, dyspepsia in spouse, parent, sibling, or child) were obtained by standard questionnaire administered by nurses before the endoscopy. Full details of the questionnaire can be obtained from the authors. Ethics approval was obtained from the Gloucestershire Royal Hospital ethics committee and patients gave informed signed consent for biopsy specimens to be taken.

STATISTICS

Initially the association between oesophagitis and *H pylori* and *cagA* status was assessed using χ^2 tests of associations and trend. The association between oesophagitis and other factors was also assessed. Any factor having some evidence of association ($p<0.2$) was used in a multivariable logistic regression analysis.

The dependent variable in this analysis was whether or not the patient had endoscopically confirmed oesophagitis. The candidate predictor variables came from several areas. Demographic factors were: age group (<40, 40–49, 50–59, 60–69, ⩾70), sex (male or female), smoking (none, ex, or current), alcohol consumption (none, mild, moderate, or heavy), and past medical history of, or current, hiatus hernia. Family history factors were: other gastrointestinal disease and parent with a gastrointestinal disease. Drug history factors were: antacids more than twice a week, non-steroidal anti-inflammatory drug (NSAID), aspirin, and

Table 1 Prevalence of Helicobacter pylori infection in subjects with and without oesophagitis

	Oesophagitis				
	None	Mild	Moderate	Severe	Total
H pylori positive	543 (46%)	61 (38%)	35 (41%)	24 (37%)	663
H pylori negative	629 (54%)	101 (62%)	50 (59%)	41 (63%)	821
Total	1172[a]	162	85	65	1484[b]

[a]*H pylori* status for one patient unknown.
[b]Oesophageal grading for one patient unknown.

Table 2 Proportion of patients cagA positive by category of oesophagitis

	Oesophagitis				
	None[a]	Mild[b]	Moderate	Severe	Total
cagA positive	422 (81%)	42 (70%)	24 (69%)	11 (46%)	499
cagA negative	99 (19%)	18 (30%)	11 (31%)	13 (54%)	141
Total	521	60	35	24	640

[a]*CagA* serology could not be done for 20 patients. Two patients gave consistently borderline results.
[b]One patient gave borderline results consistently.

Table 3 Multivariable logistic regression analysis

Predictor		Estimated odds ratio	95% CI	p Value
Age group (y)	<40	Reference		
	40–49	1.01	0.61–1.68	
	50–59	1.55	0.98–2.45	
	60–69	1.71	1.09–2.69	
	⩾70	1.72	1.06–2.78	0.04
Sex	Male	Reference		
	Female	0.61	0.44–0.83	0.002
Smoking	Non	Reference		
	Ex	1.13	0.62–1.34	
	Current	0.91	0.75–1.45	0.51
Alcohol consumption	None	Reference		
	Mild	1.04	0.75–1.45	
	Moderate	1.45	0.91–2.32	
	Severe	1.82	0.77–4.31	0.25
H pylori −ve		Reference		
H pylori +ve	*cagA*⁻	1.05	0.67–1.66	
H pylori +ve	*cagA*⁺	0.57	0.41–0.80	0.003
Drug history, NSAID	None	Reference		
	Yes	1.54	0.76–3.15	0.24
Drug history, antacids >2× week	No	Reference		
	Yes	1.58	1.19 to 2.11	0.002
Intestinal metaplasia	0	Reference		
	1–100	0.83	0.57–1.21	0.33
Hiatus hernia	No	Reference		
	Yes	4.86	3.59–6.57	<0.0001

H_2 blocker as either treatment or maintenance. Histological factors were: intestinal metaplasia (absent, present), mucosal type, and mononuclear and polymorphonuclear infiltration. The final factor was the status of the endoscopist. The variable giving *H pylori* status was classified as *H pylori* negative, *H pylori* positive, and *cagA*⁻, or *H pylori* positive and *cagA*⁺.

Logistic regression analysis results in some loss of information as the ordinal classification of oesophagitis was dichotomised into present or absent. The likelihood ratio test was used to assess the significance of the predictor variables.

Results

Oesophageal grading was available for 1485/1486 (787 male, 53%) non-duplicate patients. In the multivariable analysis, no specific grade of endoscopist was more or less likely to report oesophagitis. *H pylori* infection was detected in 663/1484 (45%) patients and in 120/312 (38%) patients with oesophagitis (table 1).

Anti-CagA antibody was detected in 499/640 (78%) *H pylori* positive patients. The *cagA* status of the 663 *H pylori* positive patients and its association with oesophagitis is presented in table 2. *cagA*⁺ *H pylori* were found in 422/521 (81%) patients with a normal oesophagus, in 42/60 (70%) with mild oesophagitis, in 24/35 (69%) with moderate oesophagitis, and in 11/24 (46%) with severe oesophagitis. The inverse association with a *cagA* strain remained, even after correction for other confounding factors in a multivariable logistic regression analysis (table 3). For those patients who were *H pylori* positive with a *cagA*⁺ strain the estimated odds of oesophagitis were nearly half those in the *H pylori* negative group (odds ratio 0.57, 95% confidence interval (CI) 0.41–0.80; p=0.0001). Those patients that were *H pylori* positive but with a *cagA*⁻ strain were at a slightly increased odds of oesophagitis (odds ratio 1.05, 95% CI 0.67–1.66); however, this was not statistically significant.

The results of the multivariable logistic regression model are presented in table 3. Considering age as a risk factor, the odds of oesophagitis was not significantly higher in the 40–49 year category compared with the <40 year old category. For the other three age groups, the odds of oesophagitis compared with those <40 years increased by over 50% (odds ratios 1.55, 1.71, and 1.72 in the 50–59 years, 60–69 years, and 70 years or over age categories, respectively). The pattern of the odds ratios indicates that there was not a steadily increasing frequency of oesophagitis with age but rather a large step up in the frequency around the age of 50 years.

The risk of oesophagitis was significantly lower in females, with an odds ratio of approximately two thirds that for males. There was no association between smoking status and oesophagitis. The estimated odds of oesophagitis increased with increasing alcohol consumption. A test of linear trend (p=0.11) indicated weak evidence. The precision with which the odds ratios were estimated could indicate that the increase observed was due entirely to chance.

Those patients taking NSAIDs were associated with an increased odds of oesophagitis (odds ratio 1.54, 95% CI 0.76–3.15). However, this increase failed to reach statistical significance possibly because of the small numbers; only 46 patients had taken NSAIDs. Those patients taking antacids more than twice a week were associated with an increased odds of oesophagitis (estimated odds ratios of 1.58, 95% CI 1.19–2.11). There was no association with aspirin or H_2 blockers (p=0.89 and 0.92, respectively).

Several histology variables exhibited a weak association with oesophagitis grade. However, polymorphonuclear infiltration and intestinal metaplasia were the only variables significantly associated with oesophagitis. After allowing for other variables, there remained a weak association between intestinal metaplasia and oesophagitis; those patients with intestinal metaplasia had a reduced odds of oesophagitis (odds ratio 0.83, 95% CI 0.57–1.21).

Those patients with either a past history of hiatus hernia or who currently have this condition were associated with a significantly increased risk of oesophagitis (estimated odds ratio 4.86, 95% CI 3.59–6.57; p<0.0001).

Discussion

The aim of this study was to investigate the relationship between *cagA*$^+$ *H pylori* and endoscopically proved oesophagitis. Our study was performed prospectively on 1486 unselected consecutive patients attending open access endoscopy for investigation of dyspepsia. The study was carried out before the widespread use of PPIs and therefore our results were not influenced by the effects of hypochlorhydria. Other preliminary studies have found similar results but were multicentre investigations, lacked serology in many cases,[18] or were performed on fewer patients.[19] Several studies have examined the relationship with *H pylori* but have not determined CagA status.[20 21]

We found that patients infected by *cagA*$^+$ *H pylori* had half the likelihood of developing oesophagitis compared with those infected by *cagA*$^-$ *H pylori* and those not infected. Over 80% of *H pylori* isolated from patients with an endoscopically normal oesophagus were *cagA*$^+$, this proportion decreasing to 70%, 69%, and 46% in mild, moderate, and severe oesophagitis, respectively. When other factors associated with the development of oesophagitis were taken into account in a multivariable logistic regression analysis, this association between *cagA*$^+$ *H pylori* was still evident. The risk of oesophagitis in the *cagA*$^-$ *H pylori* positive patients was no different to that in the *H pylori* negative patients.

A possible shortcoming of our study is that grading oesophagitis by endoscopic appearance does not necessarily reflect the extent of gastro-oesophageal reflux. Ambulatory 24 hour pH monitoring is the gold standard test of reflux but it is cumbersome and would be difficult to justify in a study such as this.[22] Given the few patients suffering from severe oesophagitis and the highly significant difference in the prevalence of *cagA*, we feel that our results are accurate. One criticism may be that we identified *cagA* positivity by serology. Although the *cagA* gene is a marker of the presence of the PAI, it may not be a completely reliable marker of virulence. Some *cagA*$^+$ strains may have more virulent genes than others, depending on how much of the cag PAI is present. This problem could be overcome with a more reliable marker of a fully intact cag PAI which has not yet been reported. For this study, detection of anti-CagA antibodies was the most suitable method for differentiating *H pylori* strains and it is considered to be the most accurate method for assessing expression of the cag PAI.[23]

Age and sex were strongly associated with patients having oesophagitis. In addition, a weak trend for increasing alcohol consumption appeared to correlate with an increased risk of oesophagitis. The protective effect associated with *cagA*$^+$ *H pylori* infection was significant even after adjusting for age, sex, smoking, alcohol intake, drug history, and histological inflammation. Many studies have shown that age increases the risk of oesophagitis[24] and a uniform lack of age adjusted control populations in most studies means that this is usually overlooked.[25] Our finding of a close association between oesophagitis and hiatus hernia is in keeping with other studies of these two conditions.[26–28] These studies have shown that hiatus hernia is more frequent in patients with reflux oesophagitis.[26] Acid exposure of the oesophagus is higher, and lower oesophageal sphincter (LOS) pressure is lower in the presence of hiatus hernia.[27 28] It seems likely that the relationship of hiatus hernia and reflux oesophagitis is causal, mediated by a reduction in protective mechanisms for oesophagitis in hiatus hernia.

It seems a contradiction that *cagA*$^+$ *H pylori* are positively and negatively associated with two conditions, peptic ulcer and reflux oesophagitis, that both respond to control of acid secretion.[29–31] This is probably explained by the severity and distribution of the gastritis associated with *H pylori* infection in a particular individual. Antral predominant gastritis is probably the most important predictor of duodenal ulcer disease in the presence of *H pylori* infection.[25] Antral predominant gastritis leads to reduced antral D cell density and somatostatin concentrations. This in turn leads to high serum gastrin and, in the presence of a normal corpus, to increased gastric acid, leading to a higher duodenal acid load and duodenal ulceration.[32 33] As acid is produced in the gastric glands of the corpus, the amount of acid secreted in any *H pylori* infected stomach is dependent largely on the severity of corpus gastritis. More severe corpus gastritis is associated with lower acid output, which returns to normal when *H pylori* is eradicated.[34 35]

Compared with *cagA* negative strains, *cagA* positive strains are associated with enhanced development of atrophic gastritis[36] wherever the organism is present in the stomach. Atrophy of the corpus leads to the destruction of gastric glands and, in turn, hypochlorhydria. As this advances, the acid load presented to the duodenum and oesophagus diminishes, so protecting against GORD. This effect is lost when *H pylori* is treated, leading to an increased risk of developing oesophageal reflux.[37–39] The possibility that corpus gastritis plays a crucial protective role is supported by a study showing that patients with reflux symptoms without oesophagitis more often had active corpus gastritis than those with GORD with erosive oesophagitis.[40] Our data showed that patients with antral intestinal metaplasia were less likely to have severe oesophagitis. Corpus biopsies were not taken for histological analysis in 1986 and therefore we are unable to predict the pattern of gastritis. *H pylori* is found in the cardia in almost all patients in whom infection is detected in the gastric antrum and body.[41 42] Thus patients who develop gastrointestinal metaplasia and atrophy may have an increased risk of gastric carcinoma but a decreased risk of GORD.[43–45] Patients without corpus atrophic gastritis (so-called antral predominant gastritis) will have normal acid production and are therefore at increased risk of GORD and possibly oesophageal adenocarcinoma.

Gastro-oesophageal reflux arises from a weak LOS or one that relaxes inappropriately.[46 47] LOS pressure can be affected by smoking[48] and it was interesting to find that the ex-smokers in our study had a higher, although not significantly increased, risk of oesophagitis than current smokers. This may suggest that the effect of smoking on the LOS is not reversible. It is more likely however that the continued risk may be due to persistent airways disease and chronic cough that might promote gastro-oesophageal reflux.

It has been suggested that LOS pressure may be increased by the raised serum gastrin concentrations present in *H pylori* infections.[49] Although initial animal studies demonstrated this association,[50] a recent study showed no association between increasing gastrin concentration and LOS pressure.[51]

One mechanism that affects the pattern of gastritis and the likelihood of GORD is administration of PPIs.[52] Our data were collected before the widespread use of PPIs and general practitioners were asked to stop H_2 antagonists before endoscopy. Those patients taking antacids more than twice a week had an increased risk of oesophagitis but it is difficult to interpret this association as causal as it could simply reflect use to relieve symptoms.

H pylori infection per se was not associated with a protective effect against oesophagitis. Some studies have found an inverse relation between *H pylori* and oesophagitis once *H pylori* has been eradicated[11 43] but most studies have found, like ours, that *H pylori* is not associated with oesophageal disease, positively or negatively.[51–55]

The debate on treatment of patients infected with *H pylori* continues. The WHO has classified *H pylori* as a grade 1 pathogen[56] and therefore it would be unwise to stop treating this infection or base management on CagA status alone.[57] However, our study has raised the possibility that eradication of CagA strains of *H pylori* may lead to exacerbation of oesophagitis. If this proves to be the case, eradication may lead to a significant increase in health care costs as treatment of reflux symptoms consumes nearly 1% of the NHS budget.[58] Perhaps more significantly, it may lead to an increase in oesophageal adenocarcinoma.[59] Further well controlled studies are required to resolve the intriguing relationship between *H pylori* and oesophageal disorders and to inform future eradication policies.

Many thanks to all the endoscopy staff involved in this study. The study was funded by the Proctor and Gamble Company, USA. This paper was presented in part at the XIth International Workshop on Gastroduodenal Pathology and *Helicobacter pylori*, Budapest, Hungary, 2–5 September 1998.

1 Marshall BJ, Warren JR. Unidentified curved bacilli in the stomach of patients with gastritis and peptic ulceration. *Lancet* 1984;**i**:1311–15.
2 Forman D, Newell DG, Fullerton F, *et al.* Association between infection with *Helicobacter pylori* and risk of gastric cancer: evidence from a prospective investigation. *BMJ* 1991;**302**:1302–5.
3 Blaser MJ. *Helicobacter pylori* and gastric diseases. *BMJ* 1998;**316**:1507–10.
4 Covacci A, Falkow S, Berg DE, *et al.* Did the inheritance of a pathogenicity island modify the virulence of *Helicobacter pylori*? *Trends Microbiol* 1997;**5**:205–8.
5 Censini S, Lange C, Xiang Z, *et al. cag*, a pathogenicity island of *Helicobacter pylori*, encodes type 1-specific and disease-associated virulence factors. *Proc Natl Acad Sci USA* 1996;**93**:14648–53.
6 Spohn G, Beier D, Rappuoli R, *et al.* Transcriptional analysis of the divergent *cag*AB genes encoded by the pathogenicity island of *Helicobacter pylori*. *Mol Microbiol* 1997;**26**:361–72.
7 Warburton VJ, Everett S, Mapstone NP, *et al*. Clinical and histological associations of *cagA* and *vac*A genotypes in *Helicobacter pylori* gastritis. *J Clin Pathol* 1998;**51**:55–61.
8 Blaser MJ, Crabtree JE. *CagA* and the outcome of *Helicobacter pylori* infection. *Am J Clin Pathol* 1996;**106**: 565–7.
9 Peek RM, Miller GG, Tham KT, *et al.* Heightened inflammatory response and cytokine expression to *cagA⁺ Helicobacter pylori* strains. *Lab Invest* 1995;**73**:760–70.
10 Parsonnet J. The incidence of *Helicobacter pylori* infection. *Aliment Pharmacol Ther* 1995;**9**(suppl 2):45–51.
11 Labenz J, Blum AL, Bayerdorffer E, *et al*. Curing *Helicobacter pylori* infection in patients with duodenal ulcer may provoke reflux oesophagitis. *Gastroenterology* 1997; **112**:1442–7.
12 Chow WH, Blaser MJ, Blot WJ, *et al.* An inverse relation between *cag*A⁺ strains of *Helicobacter pylori* infection and risk of esophageal and gastric cardia adenocarcinoma. *Cancer Res* 1998;**58**:588–90
13 El-Serag HB, Sonnenberg A. Opposing time trends of peptic ulcer and reflux disease. *Gastroenterology* 1997;**112**: A113.
14 Cameron AJ. Epidemiology of columnar-lined oesophagus and adenocarcinoma. *Gastroenterol Clin North Am* 1997;**26**: 487–93
15 Hansen S, Melby KK, Aase S, *et al. Helicobacter pylori* infection and risk of cardia cancer and non-cardia gastric cancer. A nested case-control study. *Scand J Gastroenterol* 1999;**34**:353–60.
16 Blackstone MO. *Endoscopic interpretation. Normal and pathological appearances of the gastrointestinal tract*. New York: Raven Press, 1984.
17 Trowell JE, Yoong AKN, Saul KJ. Simple half-Gram stain for showing presence of *Campylobacter pyloridis* in sections. *J Clin Pathol* 1987;**40**:702.
18 Chow WH, Blaser MJ, Blot WJ, *et al*. An inverse relation between *cagA⁺* strain of *Helicobacter pylori* infection and risk of esophageal gastric-cardia adenocarcinoma. *Cancer Res* 1998;**58**:588–90.
19 Vicari JJ, Peek RM, Falk GW, *et al*. The seroprevalence of *cagA*-positive *Helicobacter pylori* strains in the spectrum of gastroesophageal reflux disease. *Gastroenterology* 1998;**115**: 50–7.
20 Koike T, Ohara S, Sekine H, *et al. Helicobacter pylori* infection inhibits reflux oesophagitis by inducing atrophic gastritis. *Am J Gastroenterol* 1999;**94**:3468–72.
21 Goldstein NS, Harim R. Gastric cardia inflammation and intestinal metaplasia; associations with reflux oesophagitis and *Helicobacter pylori*. *Mod Pathol* 1999;**12**:1017–24.
22 Riddell RH. The biopsy diagnosis of gastro-oesophageal reflux disease, "carditis" and Barrett's oesophagus and sequelae of therapy. *Am J Surg Pathol* 1996;**20**(suppl 1):S31–50.
23 Atherton JC. CagA, the *cag* pathogenicity islands and *Helicobacter pylori* virulence. *Gut* 1999;**44**:307–8
24 Loof L, Gotell P, Eltberg B. The incidence of reflux oesophagitis. A study of the endoscopy reports from a defined catchment area in Sweden. *Scand J Gastroenterol* 1993;**28**: 113–18.
25 Dooley CP, Cohen H, Fitzgibbons PL, *et al.* Prevalence of *Helicobacter pylori* infection and histologic gastritis in asymptomatic persons. *N Engl J Med* 1989;**321**:1562–6.
26 Wilson LJ, Ma W, Hirschowitz BI. Association of obesity with hiatal hernia and esophagitis. *Am J Gastroenterol* 1999; **94**:2840–4.
27 Kasapidis P, Vassilakis JS, Tzovaras G, *et al.* Effect of hiatal hernia on esophageal manometry and pH-metry in gastroesophageal reflux disease. *Dig Dis Sci* 1995;**40**:2724–30.
28 Sontag SJ, Schnell TG, Miller TQ, *et al.* The importance of hiatal hernia in reflex esophagitis compared with lower esophageal sphincter pressure or smoking. *J Clin Gastroenterol* 1991;**13**:628–43.
29 Dixon MF. *Helicobacter pylori* and peptic-ulceration—histopathological aspects. *Gastroenterol Hepatol* 1991;**6**: 125–30.
30 Lee A, Dixon MF, Danon SJ, *et al.* Local acid production and *Helicobacter pylori:* a unifying hypothesis of gastroduodenal disease. *Eur J Gastroenterol Hepatol* 1995;**7**:461–5.
31 Labenz J, Malfertheiner P. *Helicobacter pylori* in gastro-oesophageal disease: causal agent, independent or protective factor? *Gut* 1997;**41**:277–80.
32 McColl KEL, Fullarton GM, Chittajulla R, *et al.* Plasma gastrin daytime intragastric pH and nocturnal acid output before and at 1 and 7 months after eradication of *Helicobacter pylori* in duodenal ulcer subjects. *Scand J Gastroenterol* 1991;**265**:339–46.
33 Calam J, Beales ILP, Gibbons A, *et al*. Effects of abnormalities of gastrin and somatostatin in *Helicobacter pylori* infection on acid secretions. In: Hunt RH, Tytgat GNJ, eds. *Helicobacter pylori: Basic mechanisms to clinical cure*. London: Kluwer Academic Publishers, 1996:108–21.

34 Feldman M, Cryer B, McArthur KE, *et al.* Relationship between severity of *H. pylori* (HP) gastritis and gastric acid-pepsin secretion in man. *Gastroenterology* 1996;**110**:A106.
35 Yasunga Y, Shinimira Y, Kanayama S, *et al.* Improved fold width and increased acid secretion after eradication of the organism in *Helicobacter pylori*-associated enlarged fold gastritis. *Gut* 1994;**35**:1571–4.
36 Blaser MJ, Perez-Perez GJ, Kleanthos H, *et al*. Infection with *Helicobacter pylori*: strains possessing CagA associated with an increased risk of developing adenocarcinoma of the stomach. *Cancer Res* 1995;**55**:2111–15.
37 O'Connor HJ. *Helicobacter pylori* and gastro-oesophageal reflux disease—clinical implications and management. *Aliment Pharmacol Ther* 1999;**13**:117–27.
38 Feldman M, Cryer B, Sammer D, *et al.* Influence of *H. pylori* infection on meat-stimulated gastric acid secretion and gastro-oesophageal acid reflux. *Am J Physiol* 1999;**277**: G1159–64.
39 Labenz J, Blum AL, Bayerdoffer E, *et al.* Curing *Helicobacter pylori* infection in duodenal ulcer may provoke reflux oesophagitis. *Gastroenterology* 1997;**112**:1442–7.
40 De Koster E, Ferhat M, Deprez C, *et al. Helicobacter pylori* gastric histology and gastro-oesophageal reflux disease. *Gut* 1995;(suppl 1):A36.
41 Genta RM, Huberman RM, Graham DY. The gastric cardia in *Helicobacter pylori* infection. *Hum Pathol* 1994;**25**:915–19.
42 Bowery DJ, Clark GWB, Williams GT. Patterns of gastritis in patients with gastro-oesophageal reflux disease. *Gut* 1999;**45**:798–803.
43 Varanasi RV, Fantry GT, Wilson KT. Decreased prevalence of *Helicobacter pylori* infection in gastroesophageal reflux disease. *Helicobacter* 1998;**3**:188–94.
44 Blaser MJ, Chyou PH, Nomura A. Age at establishment of *Helicobacter pylori* infection and gastric carcinoma, gastric ulcer and duodenal ulcer risk. *Cancer Res* 1995;**55**:562–5.
45 Goldblum JR, Vicari JJ, Falk GW, *et al*. Inflammation and intestinal metaplasia of the gastric cardia: the role of gastroesophageal reflux and *H. pylori* infection. *Gastroenterology* 1998;**114**:633–9.
46 Dent J, Holloway RH, Toouli J, *et al*. Mechanisms of lower oesophageal sphincter incompetence in patients with symptomatic gastro-oesophageal reflux. *Gut* 1988;**29**: 1020–8.
47 Mittal RK, Holloway RH, Penagini R, *et al*. Transient lower oesophageal sphincter relaxation. *Gastroenterology* 1995; **109**:601–10.
48 Kahrilas PJ, Gupta RR. Mechanisms of acid reflux associated with cigarette smoking. *Gut* 1990;**31**:4–10.
49 Labenz J, Malfertheiner P. *Helicobacter pylori* in gastro-oesophageal reflux disease; causal agent, independent or protective factor? *Gut* 1997;**41**:277–80.
50 Lipshutz W, Tuck A, Cohen S. A comparison of site of gastrin 1 on lower oesophageal sphincter and antral circular smooth muscle. *Gastroenterology* 1971;**61**:454–60.
51 McCallum R, Walsh JH. Relationship between lower oesophageal sphincter pressure and serum gastrin concentrations in Zollinger-Ellison syndrome and other clinical settings. *Gastroenterology* 1979;**76**:76–81.
52 Lee JM, D'Morain CA. Different management for *Helicobacter pylori* positive and negative patients with gastro-oesophageal reflux disease? *Gut* 1998;**43**(suppl 1):514–20.
53 Newton M, Bryan R, Burnham WR, *et al.* Evaluation of *Helicobacter pylori* in reflux oesophagitis and Barrett's oesophagus. *Gut* 1997;**40**:9–13.
54 Boyd EJS. The prevalence of esophagitis in patients with duodenal ulcer or ulcer-like dyspepsia. *Am J Gastroenterol* 1996;**91**:1539–43.
55 Csendes A, Smok G, Cerda G, *et al.* Prevalence of *Helicobacter pylori* infection in 190 control subjects and in 236 patients with gastroesophageal reflux, erosive esophagitis or Barrett's esophagus. *Dis Esophagus* 1997;**10**: 38–42.
56 International Agency for Research on Cancer. Schistosomes, liver flukes and *Helicobacter pylori*. IARC *Monographs on the Evaluation of Carcinogenic Risks to Humans*. Lyon: IARC, 1994;**61**:177–202.
57 Heikkinen M, Janaturian E, Mayo K, *et al.* Usefulness of anti *Helicobacter pylori* and anti-CagA antibodies in the selection of patients for gastroscopy. *Am J Gastroenterol* 1997;**92**:2225–9.
58 National Institute for Clinical Excellence. *Guidance on the use of proton pump inhibitors in the treatment of dyspepsia*. UK: NICE, Technology Appraisal Guidance No. 7. July 2000 (ISBN 1-84257-018-8).
59 Lagergren J, Bergstrom R, Lindgren A, *et al*. Symptomatic gastro-oesophageal reflux as a risk factor for oesophageal adenocarcinoma. *N Engl J Med* 1999;**340**:825–31.