

### Narrow band imaging and serology in the assessment of premalignant gastric pathology

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	Biomedical Research Centre in Gastrointestinal and Liver Diseases
Keyword:	Endoscopy-general, Helicobacter-pylori, Gastritis



**Title Page****Narrow band imaging and serology in the assessment of premalignant gastric pathology**

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1  
2  
3 No authors conflict of interest  
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## 10 11 **Keywords**

12  
13 Endoscopy, narrow band imaging, white light endoscopy, serology, *H. pylori* gastritis, gastric  
14 atrophy, intestinal metaplasia  
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## 20 **Abstract**

### 21 22 23 ***Background***

24  
25 Patient outcomes in gastric adenocarcinoma are poor due to late diagnosis. Detecting and treating  
26 at the premalignant stage has the potential to improve this. *H. pylori* is also a strong risk factor  
27 for this disease.  
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### 30 31 ***Aims***

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33 Primary aims were to assess the diagnostic accuracy of magnified narrow band imaging (NBI-Z)  
34 endoscopy and serology in detecting normal mucosa, *H. pylori* gastritis and gastric atrophy.  
35 Secondary aims were to compare the diagnostic accuracies of two classification systems using  
36 both NBI-Z and white light endoscopy with magnification (WLE-Z) and evaluate the inter-  
37 observer agreement.  
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### 43 ***Methods***

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45 Patients were prospectively recruited. Images of gastric mucosa were stored with histology and  
46 serum for IgG *H. pylori* and Pepsinogen (PG) I/II ELISAs. Blinded expert endoscopists agreed  
47 on mucosal pattern. Mucosal images and serological markers were compared with histology.  
48 Kappa statistics determined inter-observer variability for randomly allocated images among four  
49 experts and four non-experts.  
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### 53 ***Results***

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3 116 patients were prospectively recruited. Diagnostic accuracy of NBI-Z for determining normal  
4 gastric mucosa was 0.87(95%CI 0.82-0.92), *H. pylori* gastritis 0.65(95%CI 0.55-0.75) and  
5 gastric atrophy 0.88(95%CI 0.81-0.94). NBI-Z was superior to serology at detecting gastric  
6 atrophy: NBI-Z gastric atrophy 0.88(95%CI 0.81-0.94) vs PGI/II ratio<3 0.74(95%CI 0.62-0.85)  
7  
8 p<0.0001. Overall NBI-Z was superior to WLE-Z in detecting disease using two validated  
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10 classifications. Inter-observer agreement was 0.63(95%CI 0.51-0.73).  
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### 14 **Conclusions**

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17 NBI-Z accurately detects changes in the GI mucosa which currently depend on histology. NBI-Z  
18 is useful in the detection of precancerous lesions, potentially improving patient outcomes with  
19 early intervention to prevent gastric cancer.  
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### 23 **Introduction**

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26 *Helicobacter pylori* (*H. pylori*) colonizes the gastric mucosa of approximately 50% of the  
27 world's population, although the prevalence varies between countries the infection rates are  
28 higher in developing countries (1, 2). *H. pylori* infects individuals during childhood and typically  
29 persists lifelong in the absence of effective eradication therapy (3). In 15% of individuals  
30 infection leads to serious complications such as peptic ulcer disease, distal gastric  
31 adenocarcinoma or primary gastric mucosa associated lymphoid tissue (MALT) lymphoma (4).  
32 Other conditions associated with *H. pylori* include iron deficiency anemia, gastric atrophy and  
33 idiopathic thrombocytopenia purpura (5, 6). *H. pylori* infection has also been suggested to be a  
34 significant contributor to the hygiene hypothesis and the development of a healthy immune  
35 system (4, 7).  
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44 Gastric atrophy occurs as a result of a chronic gastric mucosal inflammation, usually due to *H.*  
45 *pylori* infection, leading to loss of specialized glandular cells and replacement with an intestinal  
46 type surface and fibrous tissue (8). This may then progress to intestinal metaplasia then dysplasia  
47 and finally intestinal type gastric cancer. The development from normal mucosa to gastric cancer  
48 is gradual and in a stepwise manner (9). The annual incidence of progression from intestinal  
49 metaplasia to gastric cancer varies from 0.1% to 0.9% (10). The annual incidence increases to  
50 6% in dysplasia (11, 12). Gastric atrophy is, therefore, considered a pre-cancerous condition and  
51 current European guidelines recommend endoscopic surveillance of these high risk patients with  
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3 severe atrophy (13). Unfortunately, at present these premalignant mucosal changes are often  
4 disregarded in routine clinical practice or result in variable surveillance frequency (14). Gastric  
5 cancer is ranked the fifth most common malignancy worldwide (15) and is the third most  
6 common cause of cancer related death (16). In order to reduce this associated mortality, one  
7 possibility is to detect premalignant disease using advanced endoscopy techniques. However,  
8 due to variety in endoscopic techniques and mucosal classifications the diagnosis is often  
9 dependent on histology.  
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12 High definition magnified white light endoscopy (WLE-Z) allows for detailed assessment of  
13 mucosal pit and vascular pattern, magnifying images by factors greater than 100 with resolutions  
14 smaller than 7.9 $\mu$ m (17-19). Narrow band imaging (NBI) relies on specific wavelengths of light  
15 to produce a sharper contrast between mucosal and vascular structures enhancing detail (20, 21).  
16 NBI endoscopes enable the endoscopist to easily switch from WLE to NBI to optimize  
17 visualization and sampling.  
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20 Standard WLE mucosal appearances often correlate poorly with histology and there is no widely  
21 accepted consensus on the macroscopic appearance, therefore, clinicians are reliant on histology  
22 which is dependent on multiple factors such as biopsy area, biopsy numbers and experience of  
23 the histopathologist (22, 23). Anagnostopoulos *et al* proposed a classification using WLE-Z  
24 which was highly accurate for detecting normal, *H. pylori* gastritis and gastric atrophy with  
25 sensitivity and specificity of 90-100%. Using this classification a normal gastric corpus  
26 microvasculature consists of a honeycomb type sub epithelial capillary network (SECN) with a  
27 regular arrangement of collecting venules and round pits. In the inflamed corpus, the normal  
28 SECN pattern and collecting venules are lost with enlarged white pits surrounded by erythema.  
29 Gastric atrophy is characterized by loss of the normal SECN and round pits, with an irregular  
30 distribution of collecting venules (18). Pimentel *et al* described a more detailed NBI  
31 classification that also included intestinal metaplasia and dysplasia with accuracy of 84% and  
32 95% respectively (24). The light blue crest (blue-whitish patchy reflections sited on the epithelial  
33 margins) appearance in magnified NBI (NBI-Z) of gastric mucosa was first described by Uedo  
34 *et al* and correlated well to intestinal metaplasia with an accuracy of 91% (25). White Opaque  
35 Substance (WOS) is also sometimes associated with epithelial tumors and intestinal metaplasia  
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3 (26). The use of NBI in the detection of these conditions was also accurate in other studies but  
4 due to study limitations reported results vary (27-30).

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7 IgG ELISA serology detects *H. pylori* antibodies and is relatively cheap and non-invasive but a  
8 positive test cannot distinguish between current and previously treated infection. Accuracy is  
9 variable but some commercial kits report accuracy of greater than 90% (31) with the benefit that  
10 results are not affected by proton pump inhibitor (PPI) treatment.  
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15 Serum pepsinogen can be used to predict the extent of gastric atrophy. Pepsinogen I (PGI) and  
16 Pepsinogen II (PGII) are usually released from secretory cells found in the gastric mucosa. With  
17 the progression to atrophy this causes the loss of these secreting cells and reduces pepsinogen  
18 levels. PGI is more affected by this and thus the ratio is decreased further. Low pepsinogen I or  
19 pepsinogen I/II ratio less than 3 can signify moderate to severe corpus atrophy (13). For  
20 estimating gastric atrophy extent studies have described a huge variation in results with  
21 sensitivity and specificity from 9.4% to 92.3% and 9.9% to 100% respectively (13, 32-34).  
22 Serological markers of gastric atrophy are not routinely used in Western countries.  
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30 No study has yet evaluated the utility of both magnified narrow band imaging and serology in the  
31 detection of premalignant gastric pathology. Patients referred for endoscopic investigation for  
32 iron deficiency anemia were selected for this study due to the association with both *H. pylori* and  
33 gastric atrophy (6, 35, 36). The Anagnostopoulos *et al* classification was adapted to use NBI-Z  
34 rather than WLE-Z in this study and termed the Nottingham classification.  
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39 The primary aim of this pilot study was to assess the diagnostic accuracy of magnified NBI  
40 endoscopy and serology in diagnosing normal mucosa, *H. pylori* gastritis and gastric atrophy  
41 using the Nottingham classification. Secondary aims were to compare the diagnostic accuracies  
42 of two validated classification systems using both NBI-Z and WLE-Z and evaluate the inter-  
43 observer agreement.  
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## 49 **Material and Methods**

### 50 ***Participants and clinical samples***

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52 150 adult patients (18-85yrs) attending Nottingham University Hospitals (NUH) NHS Trust for a  
53 diagnostic gastroscopy as part of their investigation into iron deficiency anemia were  
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3 prospectively recruited between August 2010 and December 2014. Derbyshire Research Ethical  
4 Committee (REC Ref: 10/H0401/33) approved the protocol and written informed consent was  
5 gained. Patients with low hemoglobin (<130g/l men & <120g/l women) and either a low MCV  
6 (<84fl) or low ferritin (<25mcg/l men & <13 mcg/l women) were recruited. Patients taking  
7 anticoagulants and proton pump inhibitors or individuals for whom biopsy sampling was  
8 contraindicated were not recruited. Patients who had an overt cause for iron deficiency anemia  
9 after both upper and lower GI investigations (e.g. malignancy (n=22), coeliac disease (n=9), poor  
10 quality digital images (n=2) or patients without biopsies (n=1)) were excluded. 116 patients were  
11 included in the final analysis.  
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### 19 ***Laboratory Investigations***

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22 Fasting blood samples were collected and analyzed for full blood count, B12, folate, serum  
23 ferritin, transferrin saturation, transferrin, serum iron and iron binding capacity. Plasma was also  
24 stored at -80°C until processed for *H. pylori* IgG (Biohit), PG I (Biohit) and PG II (Biohit) with  
25 ELISA kits according to manufacturer's instructions.  
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### 30 ***Endoscopy procedures***

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32 Procedures were performed by expert endoscopists using pharyngeal local anaesthetic spray  
33 Xylocaine (AstraZeneca, Luton, UK) or conscious sedation (midazolam/pethidine) according to  
34 patient preference. A black soft rubber hood (MB46, MAJ-1990, Olympus) was attached to the  
35 endoscope tip to allow a fixed 2mm distance between gastric mucosa and gastroscop. All  
36 procedures were done with high definition and magnification Gastroscopes (GIF-FQ260Z;  
37 Olympus Optical, Tokyo, Japan) and Lucera Elite CV290 video processor. The video images  
38 were viewed on a high definition video monitor (OEV-191H, Olympus). During the procedure  
39 the mucosa was washed with a mixture containing 100ml of water mixed with 2ml of  
40 acetylcysteine (200mg/ml, Parvolex, Celltech, UK) and 0.5ml (40mg/ml) dimethicone (Infacol,  
41 Forrest Laboratories, UK). Detailed examination of the gastric mucosa was then carried out, in  
42 WLE and then NBI using both low magnification and magnified views. Still digital images were  
43 recorded in both WLE and NBI, with biopsies taken from the areas where the digital images  
44 were recorded. A minimum of 8 images were recorded for each patient. All still images were  
45 transferred to an external hard drive.  
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### ***Post endoscopy image production***

Images were stored as JPEG files (200-300 kilobytes, 1093x948 pixels, 32-bit color), edited, anonymized and given random numbers generated in Excel Office 2010 (Microsoft Corporation, Redmond, Washington, USA) before transfer into an evaluation set of folders according to area and classification system. Two principal endoscopists (Ragunath/Sami), experts in advanced endoscopy, agreed on the magnified appearance of each selected images of the gastric mucosa in WLE-Z and NBI-Z according to specific criteria. Both were blinded to clinical, histological and serological findings. Images were reviewed and graded according to mucosal morphology using the classifications described below. These scores were used to assess magnification endoscopy performance in terms of sensitivity, specificity, accuracy, positive and negative likelihood ratios.

### ***Image classification***

Two validated classification systems were used for the gastric corpus: the Nottingham classification (Figure 1) (18) and a modified Pimentel-Nunes *et al* classification (24) to include gastric atrophy (Db) termed the modified Porto classification (Table 1, Figure 2).

### ***Inter-observer variability study***

Eight blinded endoscopists assessed the digital still images: four experienced, fully accredited endoscopists (experts) and four trainee endoscopists (non-experts). Prior to grading the images all endoscopists underwent a comprehensive, self-directed training package which covered all the gastric mucosa classifications. Each endoscopist viewed folders containing WLE-Z and NBI-Z images of the corpus for both classifications. Approximately 464 anonymized randomized images were reviewed over an unrestricted length of time. Data on image classification from a drop down menu of pre-defined options and image quality according to a 10 point Visual Analogue Scale (VAS) (37) were recorded onto an Excel spreadsheet.

### ***Histopathology analysis***

Two gastric antrum, two gastric corpus and four duodenal samples were fixed in formalin, then embedded in paraffin and cut into approximately 4µm sections. Sections were stained with

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3 haematoxylin and eosin (H&E) to allow histological scores to be carried out according to the  
4 updated Sydney scoring system (38). All specimens were classified as none (0), mild (1),  
5 moderate (2) or severe (3) for the following histological features activity (polymorphonuclear  
6 cell infiltration), inflammation (mononuclear cell infiltration), atrophy (loss of specialized  
7 glands) and intestinal metaplasia (replacement gastric mucosa by metaplastic columnar  
8 absorptive cells and goblet cells with intestinal morphologic features). Toluidine blue staining  
9 was also carried out for *H. pylori* density grading. A single blinded expert GI histopathologist  
10 carried out the histological grading. One biopsy from the antrum was placed in urease medium  
11 for rapid urease detection, and another sample in iso-sensitest broth (Oxoid, Cambridge,  
12 UK)/10% glycerol for *H. pylori* isolation and culture.  
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### 21 ***Statistical methods***

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23 Sensitivity, specificity, positive and negative likelihood ratios along with 95% confidence  
24 intervals (CI) for magnification endoscopy appearances and serological markers were compared  
25 with histology. A receiver operating characteristic (ROC) curve was used to assess the diagnostic  
26 accuracy. Chi-squared tests were used to compare the diagnostic accuracies. Kappa (k) statistics  
27 were calculated to determine inter-rater agreement among experts and non-experts.  
28 Interpretation of k values was as follows: <0= no agreement; 0–0.20= slight agreement; 0.21–  
29 0.40= fair agreement; 0.41–0.60= moderate agreement; 0.61–0.80= substantial agreement; and  
30 0.81–1= almost perfect agreement (39). Differences in image quality were assessed using the  
31 Mann-Whitney U test. P values <0.05 were considered statistically significant. Stata version 14  
32 (Stata Corporation, College Station, Texas) was used for the statistical analysis.  
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### 42 **Results**

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44 Patient characteristics are described in Table 2. 24% of patients had histological evidence of *H.*  
45 *pylori* infection, 35% had gastric atrophy and 14.7% had intestinal metaplasia.  
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### 49 ***Diagnostic accuracy of NBI-Z and serology***

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51 NBI-Z diagnostic accuracy for determining normal corpus (Type I) was 0.87 (95% CI 0.82-  
52 0.92), *H. pylori* gastritis (Type II/III) 0.65 (95% CI 0.55-0.75) and gastric atrophy (Type IV)  
53 0.88 (95% CI 0.81-0.94) respectively.  
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When NBI-Z was compared with serology, NBI-Z was superior for detecting gastric atrophy: NBI-Z Type IV 0.88 (95% CI 0.81-0.94) vs PG I/II ratio <3 0.74 (95% CI 0.62-0.85),  $p < 0.0001$  and NBI-Z 0.88 (95% CI 0.81-0.94) vs PG <30 $\mu$ g/l 0.75 (95% CI 0.64-0.87),  $p < 0.0001$ . Although *H. pylori* IgG had a numerically higher accuracy this did not achieve statistical significance, NBI-Z Type II/III 0.65 (95% CI 0.55-0.75) vs *H. pylori* IgG 0.82 (0.73-0.9),  $p = 0.078$ .

### ***Diagnostic accuracy of NBI-Z and WLE-Z***

Using the Nottingham classification, NBI-Z performed better than WLE-Z for detecting normal corpus and gastric atrophy. Normal corpus (Type I): NBI-Z 0.87 (95% CI 0.82-0.92) vs WLE-Z 0.82 (95% CI 0.76-0.87),  $p < 0.0001$ . Atrophy (Type IV): NBI-Z 0.88 (95% CI 0.81-0.94) vs WLE-Z 0.81 (95% CI 0.73-0.89),  $p < 0.0001$ . However, WLE-Z performed better than NBI-Z for detecting *H. pylori* gastritis: NBI-Z 0.65 (CI 0.55-0.75) vs 0.69 (95% CI 0.6-0.79),  $p < 0.0001$ . (Table 3).

### ***Diagnostic accuracy of the Modified Porto classification***

NBI was more accurate than WLE for detecting normal mucosa, *H. pylori* gastritis and atrophy in the corpus. Normal corpus (Ab): NBI-Z 0.81 (95% CI 0.74-0.87) vs WLE-Z 0.79 (95% CI 0.72-0.87),  $p < 0.0001$ . *H. pylori* gastritis (Ab+): NBI-Z 0.77 (95% CI 0.67-0.87) vs WLE-Z 0.62 (95% CI 0.51-0.74),  $p = 0.01$ . Gastric atrophy (Db): NBI-Z 0.71 (95% CI 0.62-0.79) vs WLE-Z 0.65 (95% CI 0.56-0.73),  $p < 0.0001$ . For detecting intestinal metaplasia, there was no statistical difference in accuracy. Intestinal metaplasia (Bb): NBI-Z 0.66 (95% CI 0.53-0.79) vs WLE-Z 0.59 (95% CI 0.45-0.73),  $p = 0.28$ . (Table 4).

### ***Inter-observer agreement***

The mean kappa values for inter-observer agreement for NBI endoscopy images were higher among expert than non-experts endoscopists. For describing the corpus using the Nottingham classification the agreement was 0.63(95% CI 0.51-0.73) vs 0.5 (95% CI 0.39-0.62). When describing atrophy the agreement was 0.65 (95% CI 0.53-0.75) vs 0.47 (95% CI 0.2-0.68). Using the modified Porto classification when describing the corpus was 0.33 (95% CI 0.21-0.43) vs 0.2 (95% CI 0.12-0.28). When describing intestinal metaplasia the agreement was 0.36 (95% CI

0.24-0.47) vs 0.21 (95% CI 0.1-0.34). Both expert and non-expert endoscopists rated the overall image quality VAS higher for NBI than WLE (7 vs 6  $p < 0.0001$ ).

## Discussion

Standard WLE is limited in its ability to accurately diagnose gastric lesions, which has led to the development of a variety of techniques such as chromoendoscopy, NBI, flexible spectral imaging color enhancement (FICE), autofluorescence (AFI) and confocal laser endomicroscopy (19) in addition to gold standard histology. NBI has been extensively studied for its use in detecting dysplasia in the esophagus, bronchus and in colonic polyps (19, 40-42).

We conducted this pilot study to assess the role of NBI and serology in predicting the histological diagnosis of gastric mucosa. We demonstrated good correlation with normal and gastric atrophy using magnification endoscopy. However, for detecting *H. pylori* gastritis our results were limited with an accuracy of 0.65 using the Nottingham classification. Endoscopic diagnosis of *H. pylori* infection requires a subjective assessment of vascular density of subepithelial capillary network (SECN). A more objective and accurate measurement may be needed to increase accuracy. Overall, NBI-Z performed better than both WLE-Z and serological markers for predicting disease. This was the first study to compare NBI-Z and serological markers with gastric pathology.

The main factor influencing NBI appearance is light absorption by hemoglobin within blood vessels which in turn leads to variation in the vascular pattern of the gastric mucosa. The differences seen in gastric mucosa using NBI are a true reflection of the structural differences seen *in vitro* histologically. This in turn allows NBI to predict histological diagnosis (43). The endoscopic appearance of gastric atrophy has been established since the 1970's (44). The normal gastric body consists of a regular pattern of honeycomb type SECN and collecting venules but in *H. pylori* gastritis this is irregular and accompanied by surrounding edema (18, 45).

Very few studies have investigated the endoscopic appearance of *H. pylori* gastritis, with nodular mucosal and gastric fold hypertrophy the most consistent features despite low sensitivities when compared to histology (46, 47). Thus the exact features that describe *H. pylori* gastritis are not entirely known which makes description and interpretation difficult. The findings using the Nottingham classification were lower than when initially described using WLE (18). Potential

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3 reasons for this include the fact that the principal endoscopists scoring the images did not  
4 perform the procedures and, therefore, were blinded to potential clinical information that could  
5 influence decision making. Although the modified Porto classification required more time to  
6 examine the images it also offered more details in terms of the presence of intestinal metaplasia  
7 and dysplasia. The specificity was high for normal mucosa, gastric atrophy and intestinal  
8 metaplasia. Potentially this could enable endoscopists to confidently avoid taking biopsies in the  
9 corpus. The evidence for the use magnified endoscopy in detecting other disease shows the  
10 majority have good correlation with histology (18, 28, 48-50). Currently, the gold standard for  
11 the diagnosis of intestinal metaplasia and dysplasia remains histology despite promising results  
12 with NBI.  
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21 When compared with serological markers, NBI-Z overall performed better. Previous studies  
22 have also shown that NBI is accurate in detecting premalignant lesions (29, 30, 51). The  
23 serological data presented in this study was similar to previous studies in terms of sensitivity and  
24 specificity (13, 31, 52, 53). *H. pylori* serology is commonly used in clinical practice in the UK  
25 but markers of atrophy are not. These results suggest the PG I/II ratio or PG I alone cannot  
26 replace endoscopy surveillance or detection of gastric atrophy. However, using this in clinical  
27 practice could reduce the need to obtain histology if serology is negative and NBI-Z does not  
28 suggest disease, therefore, reducing associated costs and time.  
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36 Inter-observer agreement was unsurprisingly higher among expert endoscopists when compared  
37 with non-experts. Endoscopy assessment is dependent on experience and training, so these  
38 techniques are likely to perform better in the hands of experts (54, 55). The training of western  
39 endoscopists is also likely to be different compared to Asian countries where the incidence of  
40 gastric cancer is higher. The observers VAS median scores were higher for NBI-Z than WLE-Z  
41 suggesting NBI provided more clarity to enable a diagnosis.  
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47 Our results are more applicable to specialist centers that routinely use NBI endoscopy as it  
48 requires a certain skill level and so may not always be practical to use in routine clinical practice.  
49 In the same way, the captured images in this study were captured by endoscopists with advanced  
50 diagnostic imaging experience and this is unlikely to happen routinely. As shown by the lower  
51 agreement amongst non-experts, NBI requires training in mucosal pattern recognition. The main  
52 comparison was done with experts so if this was used in a real world setting the results may be  
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3 poorer. Also the time duration each endoscopist spent reviewing the still images for the inter-  
4 observer study was not specified and unlike time constraints seen in clinical practice, possibly  
5 influencing the decision making process. In terms of training, this study did not measure inter-  
6 observer agreement before and after the training session which would have given some insight  
7 into the learning required for NBI use in a routine clinical setting.  
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12 Study strengths include the use of two endoscopy classification criteria to describe the magnified  
13 gastric mucosa in addition to serological markers in a large cohort of prospectively recruited  
14 patients. Post endoscopy image assessment controlled for clinician influence on pre-test  
15 probability. Bias was also reduced by blinding both the endoscopists and histopathologist to  
16 clinical data. Also the consistent use of the same gastroscope reduced image quality variability.  
17 Patients on proton pump inhibitors were also excluded to lower the number of false negatives in  
18 terms of *H. pylori* infection and to avoid missing early gastric neoplasia (56). This work has  
19 provided further evidence to support routinely investigating the presence of gastric atrophy and  
20 *H. pylori* gastritis in iron deficiency anemia patients (31, 36).  
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29 With regards to study limitations, by including only iron deficiency anemia patients this makes  
30 the study prone to selection bias and thus may not be representative at a population scale.  
31 However, as the annual incidence of gastric atrophy is low (0-10.9%) (57) we needed a larger  
32 cohort to enable estimates of sensitivity and specificity to be made to guide sample size  
33 calculations in future larger studies. Extent of disease also influenced the results. For example,  
34 atrophy serology tests only detect moderate to severe atrophy so endoscopy is more likely to  
35 perform better as these classifications only detect the presence of atrophy and not the degree.  
36 Inter-observer agreement for the modified Porto classification may also be lower due to the  
37 examiners been more familiar with the Nottingham classification at this specialist center. Finally,  
38 although the addition of atrophy to the modified Porto classification provided a more detailed  
39 description which more accurately resembled histology it also made the classification more  
40 complex and time consuming. The diagnosis of intestinal metaplasia is more reliable in terms of  
41 both histological grading and disease progression.  
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52 In conclusion, NBI-Z can detect changes in the GI mucosa which are usually dependent on  
53 histology. Although serology performs well, NBI endoscopy performs better in terms of disease  
54 detection with a high specificity and moderate to substantial observer agreement. A detailed  
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3 examination with NBI-Z could potentially help identify early precancerous lesions, which could  
4 enable patients to be promptly enrolled in appropriate endoscopic surveillance with improved  
5 disease outcomes. Also NBI-Z use may allow stratification of the need for histology and thus  
6 minimize associated costs, time and sampling error. These study findings will help to design  
7 future trials to evaluate NBI techniques in the gastric mucosa.  
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### 26 **Disclosure statement**

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33 The authors report no conflict of interest.  
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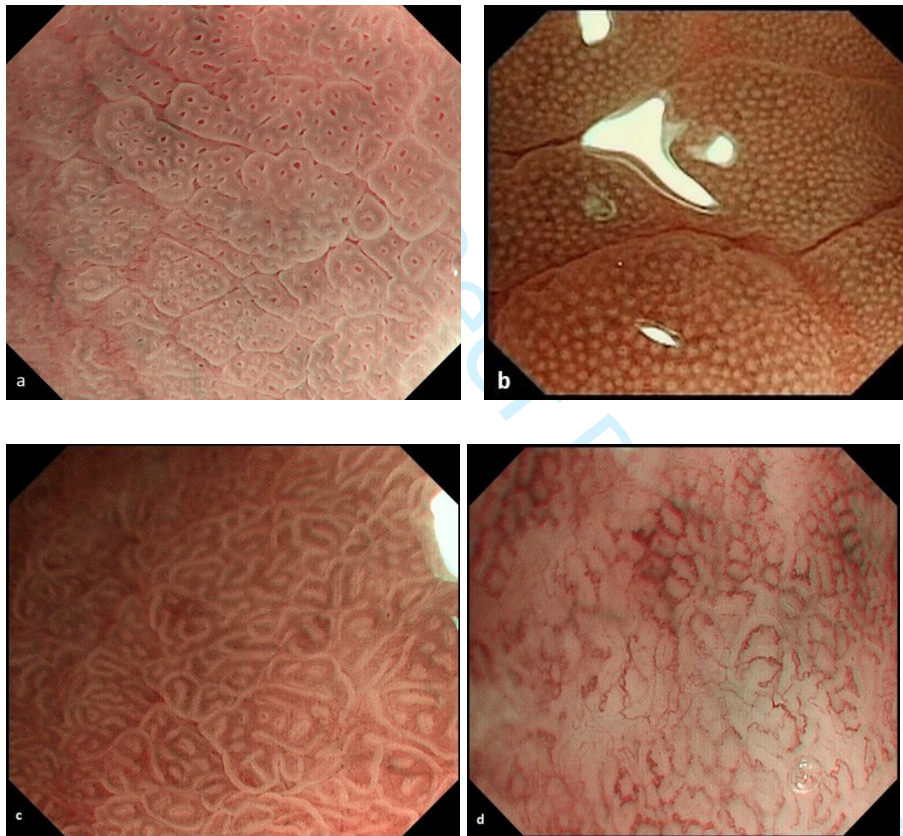


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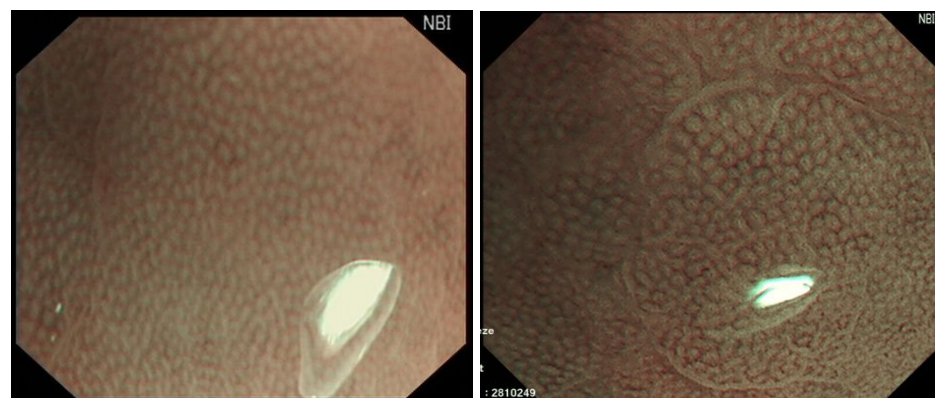
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41 Figure 1 The Nottingham classification in gastric corpus

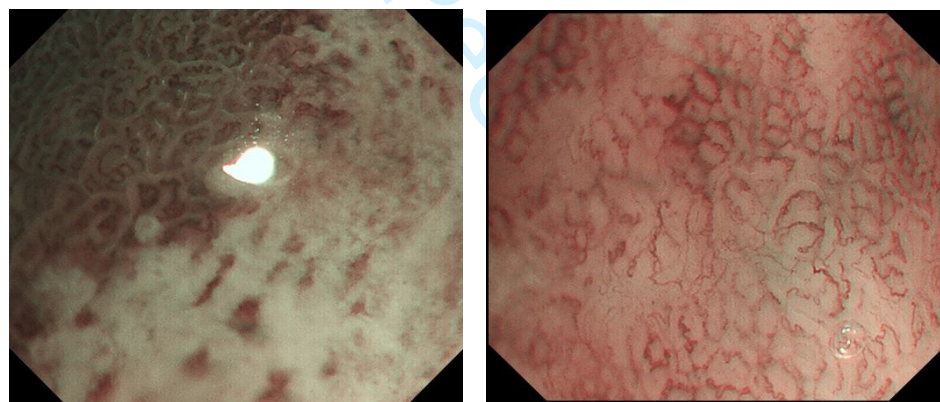
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43 Type I (a) normal gastric body microvasculature = a honeycomb type subepithelial capillary network  
44 (SECN) and collecting venules in a regular arrangement. Type II (b) = honeycomb-type SECN with  
45 regular round pits, either with or without sulci, but with loss of collecting venules. Type III (c) = loss of  
46 the normal SECN and collecting venules, with enlarged white pits surrounded by erythema. Type IV (d) =  
47 loss of the normal SECN and round pits, with irregular arrangement of the collecting venules (18).  
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A

B



C

D

Figure 2 Modified Porto gastric corpus classification

Normal corpus (Ab) in image (A), (B) *H. pylori* gastritis corpus (Ab+), (intestinal metaplasia in corpus with some light blue crest (Bb) in image (C) and atrophy in corpus (Db) in image (D). Magnification 115X.

## Tables

Table 1 Modified Porto classification

	A*	B*	<i>H. pylori</i> +	C*	D*
Mucosal pattern	Regular circular/oval	Regular Ridge/tubulovillous with or without light blue crest	Regular	Irregular/absent with or without white opaque substance	Absent
Vascular pattern (SECN)	Regular mucosa and SECN Vascular pattern central in antrum/peripheral in corpus of gland	Regular	Regular/variable vascular density	Irregular	Absent
Expected outcome	Normal	Intestinal Metaplasia	<i>H. pylori</i> infection	Dysplasia	Atrophic gastritis

The letter (a) for antrum or (b) for corpus is added to the class type to signify the sites. For *H. pylori* positive pattern, the symbol (+) is added to end of the pattern class site. For e.g. *H. pylori* positive pattern in corpus would be classed as Ab+ (24).

Table 2 Patient description and laboratory data

Numbers	116
Male: Female ratio	1:1.1
Age, median (range) years	67 (19-85)
% Pharyngeal local anesthetic: conscious sedation	38%:62%
Midazolam median dose (range)	3mg (1-5)
Pethidine median dose (range)	25mg (25-100)
Hemoglobin males (130- 180g/L) median (range)	110g/L (85 -129)
Hemoglobin females (120- 165g/L) median (range)	101 g/L (42-118)
MCV (84-102fl) median (range)	83fl (56-111)
Ferritin (25-350µg/L) median (range)	12 µg/L (1-474)
Iron (9-31µmol/L) median (range)	11 µmol/L (1-83)
Histological diagnosis:	
% <i>H. pylori</i> infection	24%
% Atrophy corpus	35%
% Intestinal metaplasia	14.7%

Presented as median with full range

Table 3 Sensitivity, specificity and likelihood ratios with 95% CI of NBI-Z and WLE-Z for detecting *H. pylori* gastritis and gastric atrophy using the Nottingham classification and serology

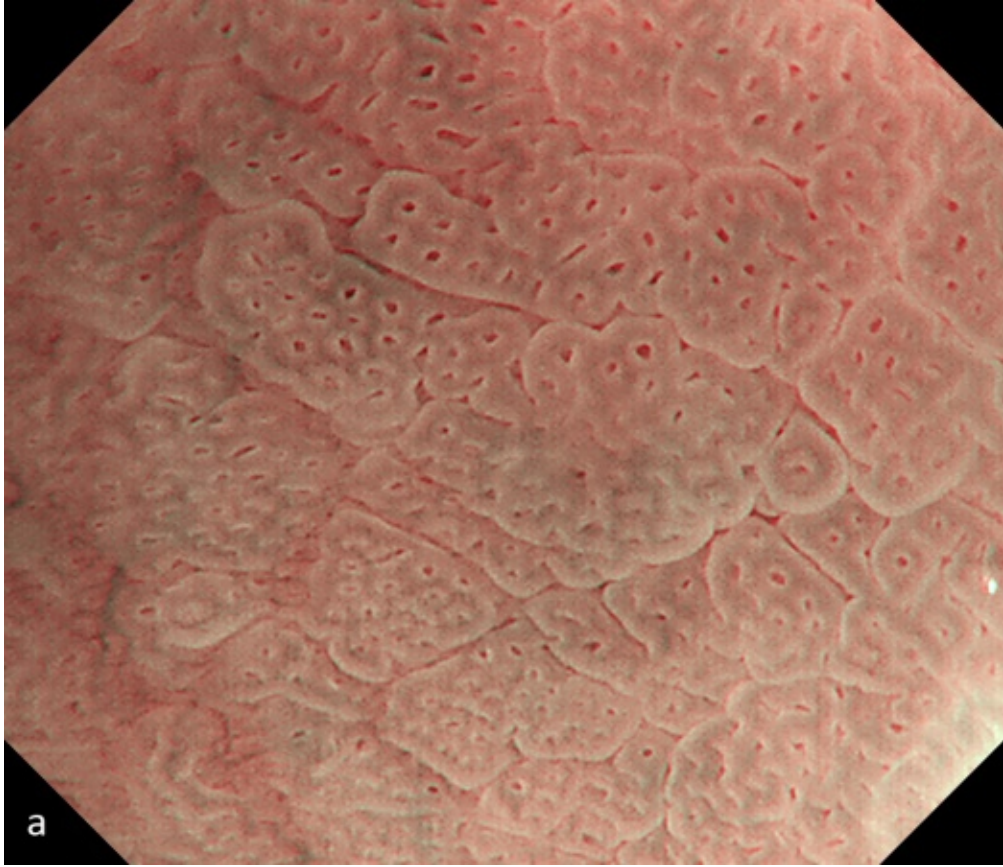
	Sensitivity (95% CI)	Specificity (95% CI)	Positive Likelihood ratio (95% CI)	Negative Likelihood ratio (95% CI)
NBI-Z Type I	75.6% (64.6-84.7)	98.6% (92.2-100)	54.0 (7.4-366.8)	0.25 (0.17-0.37)
WLE-Z Type I	66.2% (54.6-76.6)	96.8% (89-99.6)	20.7 (5.3-82.4)	0.35 (0.25-0.48)
NBI-Z Type II/III	62.1% (42.3-79.3)	68.1% (58.8-76.4)	1.95 (1.32-2.87)	0.56 (0.34-0.9)
WLE-Z Type II/III	74.1% (53.7-88.9)	64.9% (55-73.7)	2.11 (1.5-2.95)	0.40 (0.21-0.77)
NBI-Z Type IV	75.6% (59.7-87.6)	100% (96.6-100)	-	-
WLE-Z Type IV	64.1% (47.2-78.8)	98% (93-99.8)	32.1 (8-130)	0.37 (0.24-0.56)
<i>H. pylori</i> IgG	90% (68.3-98.8)	73.9% (61.9-83.7)	3.45 (2.26-5.27)	0.14 (0.04-0.51)
PG I/II ratio <3	73.7% (48.8-90.9)	73.8% (60.9-84.2)	2.81 (1.71-4.63)	0.36 (0.17-0.77)
PG I <30µg/l	52.6% (28.9-75.6)	98.4% (91.2-100)	32.11 (4.4-235)	0.48 (0.3-0.77)



Table 4 Sensitivity, specificity and likelihood ratios with 95% confidence intervals of NBI-Z and WLE-Z using the modified Porto classification in the corpus

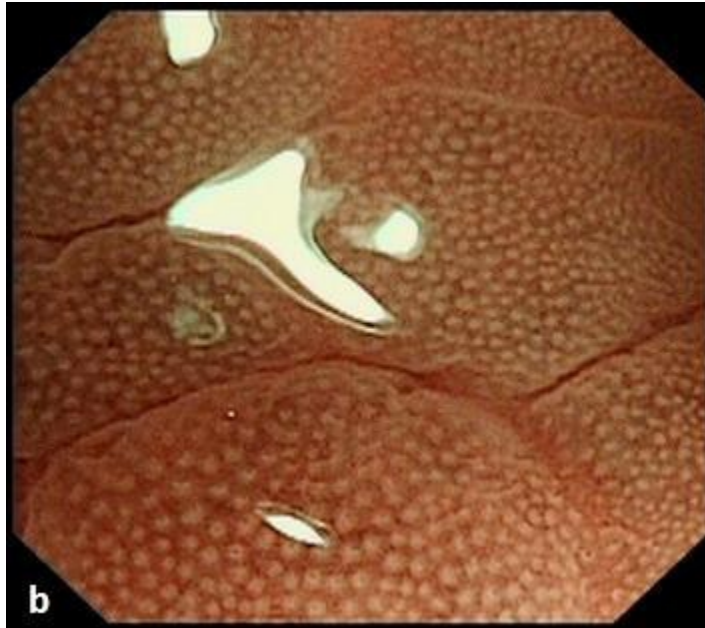
	Sensitivity (95% CI)	Specificity (95% CI)	Positive Likelihood ratio (95% CI)	Negative Likelihood ratio (95% CI)
NBI-Z Ab	70.5% (59.8-79.7)	90.9% (78.3-97.5)	7.75 (3-19.9)	0.32 (0.23-0.45)
WLE-Z Ab	77.8% (66.4-86.7)	81% (65.9-91.4)	4.09 (2.2-7.7)	0.27 (0.17-0.43)
NBI-Z Ab+	75% (53-90.2)	78.7% (69.8-86)	3.52 (2.3-5.4)	0.32 (0.16-0.64)
WLE-Z Ab+	43.5% (23.2-65.5)	81.3% (71.8-88.7)	2.33 (1.24-4.4)	0.69 (0.48-1.01)
NBI-Z Bb	35.7% (12.8-64.9)	95.8% (90.4-98.6)	8.43 (2.78-25.5)	0.67 (0.45-0.99)
WLE-Z Bb	27.3% (6-61)	90.1% (82.5-95.1)	2.75 (0.89-8.53)	0.81 (0.56-1.17)
NBI-Z Db	70% (52-81)	99% (94.5-100)	70.0 (10.74-307)	0.30 (0.23-0.78)
WLE-Z Db	61% (45-76)	100% (95.7-100)	-	0.39 (0.27-0.50)

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Type I (a) normal gastric body microvasculature = a honeycomb type subepithelial capillary network (SECN) and collecting venules in a regular arrangement.

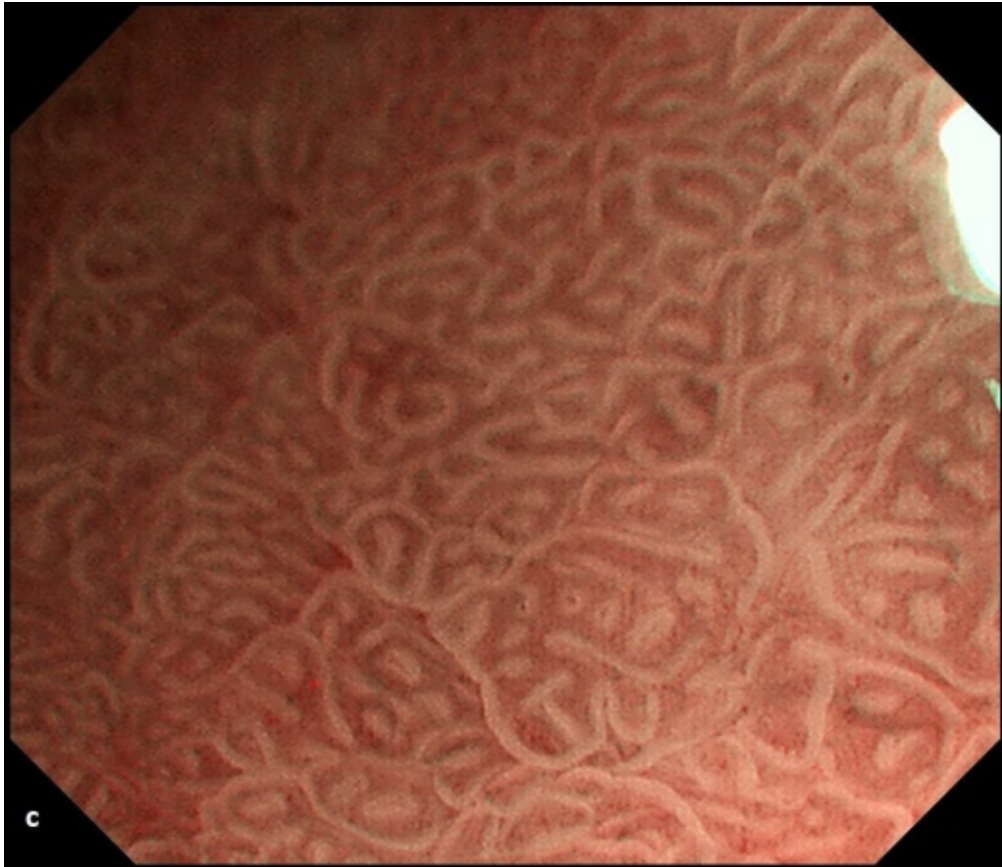
60x52mm (220 x 220 DPI)



Type II (b) = honeycomb-type SECN with regular round pits, either with or without sulci, but with loss of collecting venules.

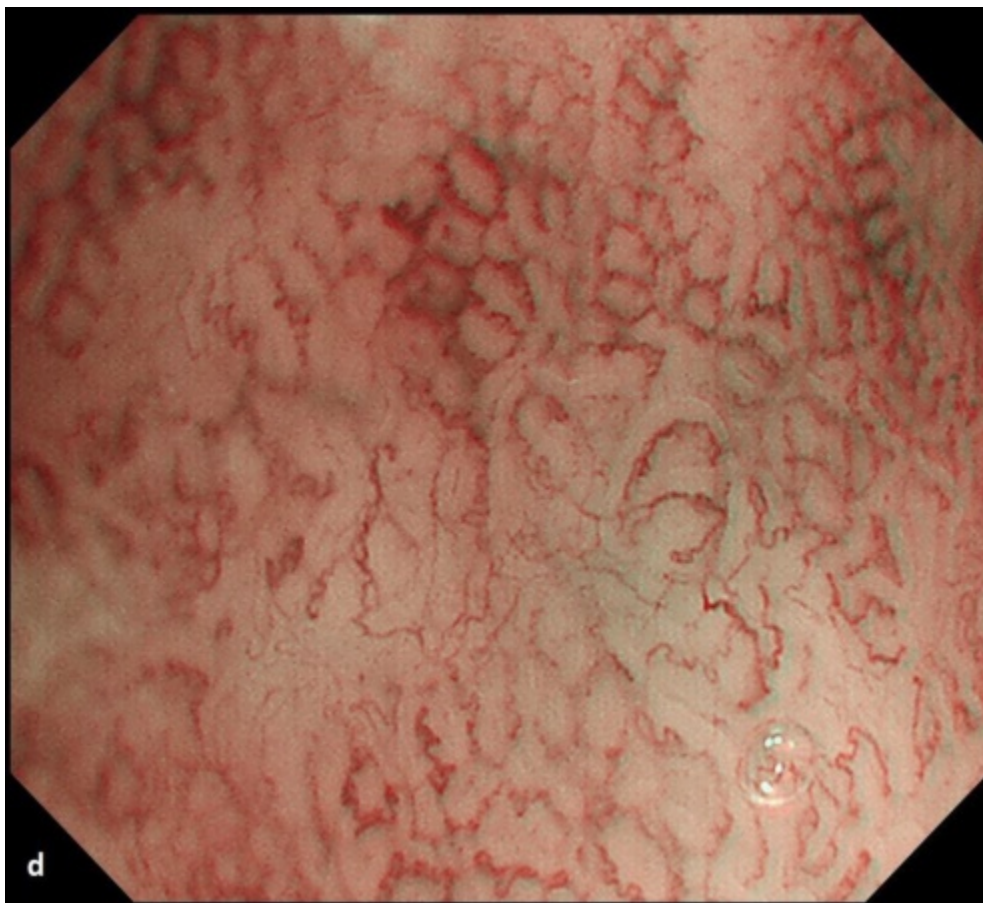
93x83mm (96 x 96 DPI)

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Type III (c) = loss of the normal SECN and collecting venules, with enlarged white pits surrounded by erythema.

59x51mm (220 x 220 DPI)

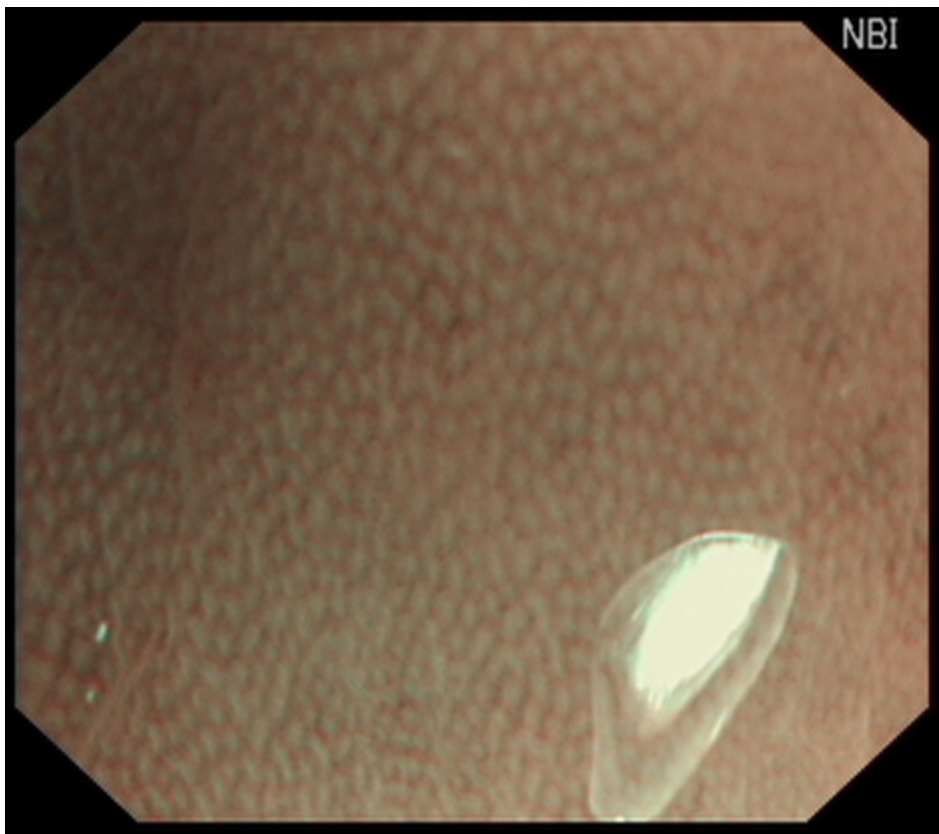


Type IV (d) = loss of the normal SECN and round pits, with irregular arrangement of the collecting venules (18).

57x52mm (220 x 220 DPI)



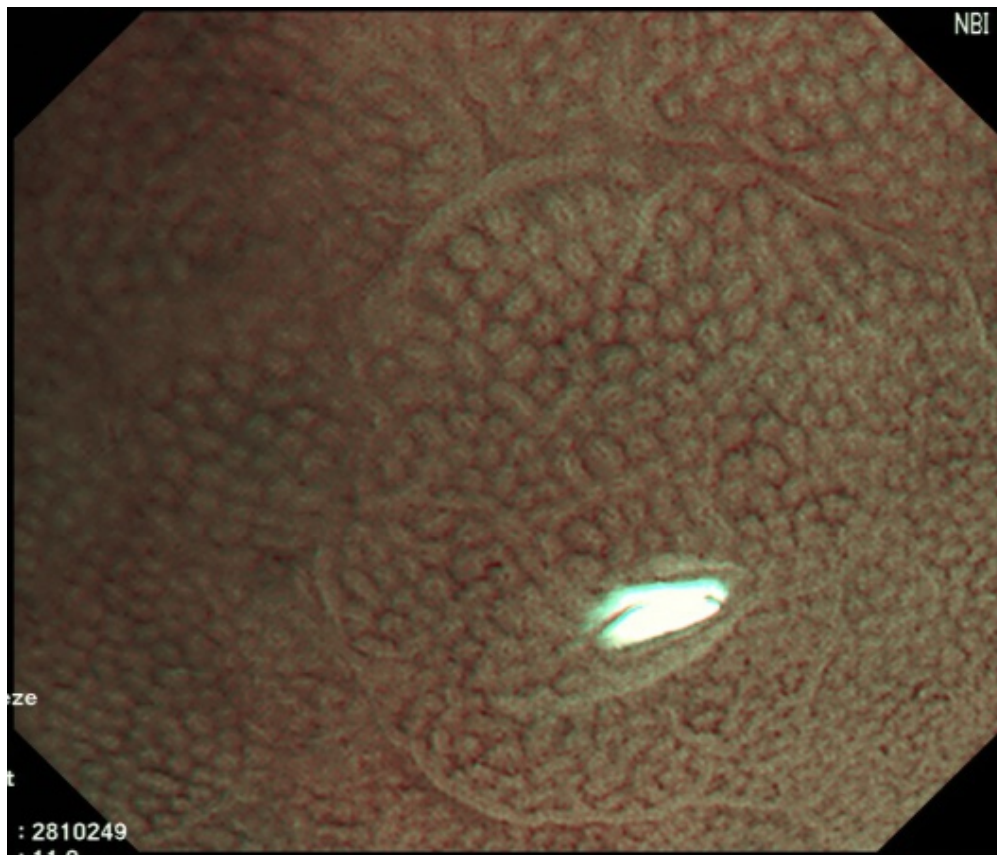
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Normal corpus (Ab) in image (A)

165x146mm (72 x 72 DPI)

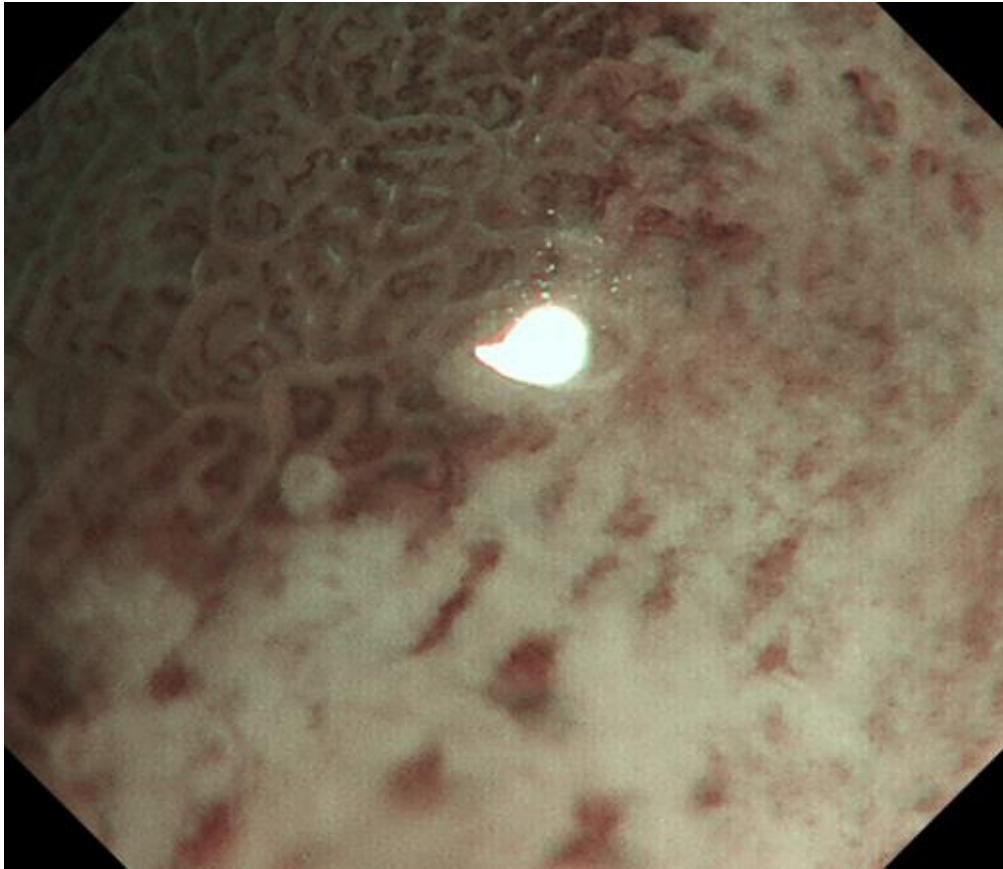
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(B) *H. pylori* gastritis corpus (Ab+)

61x51mm (220 x 220 DPI)

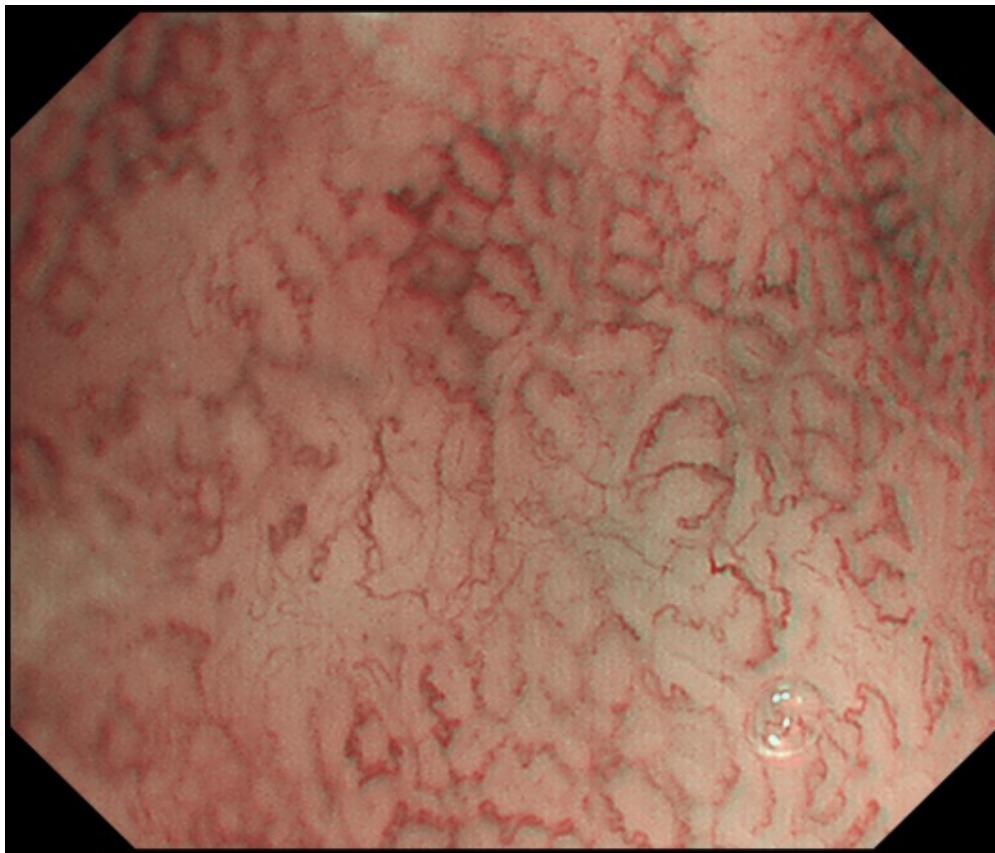
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Intestinal metaplasia in corpus with some light blue crest (Bb) in image (C)  
59x51mm (220 x 220 DPI)



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Atrophy in corpus (Db) in image (D). Magnification 115X.

61x51mm (220 x 220 DPI)