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Interpretation of Benign Gastric Mucosal Lesions Using Narrow-Band Imaging

Sameer Paghadhar[1] Mayank Jain[2] B. Mahadevan[1] Jayanthi Venkataraman[3]

[1]Department of Gastroenterology, Gleneagles Global Health City, Chennai, Tamil Nadu, India
[2]Department of Gastroenterology, Arihant Hospital and Research Centre, Indore, Madhya Pradesh, India
[3]Department of Gastroenterology, Sri Ramachandra Medical College, Porur, Chennai, Tamil Nadu, India

Address for correspondence Mayank Jain, MD, DNB, Department of Gastroenterology, Arihant Hospital and Research Centre 283-A Gumasta Nagar, Indore 452009, Madhya Pradesh, India (e-mail: mayank4670@rediffmail.com).

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Abstract

The major drawback of conventional white light endoscopy (WLE) is that it lacks accuracy in diagnosis and differentiation of various benign and premalignant mucosal gastrointestinal lesions. To overcome this, image-enhanced endoscopy techniques, which provide high-definition images with good resolution and contrast enhancement, have been developed. One such technique is narrow-band imaging (NBI). NBI functions by filtering the illumination light. The red component of the standard red, green, and blue filters is rejected and the selected bandwidth of the blue and green light is transmitted. The present review highlights the role of NBI in diagnosis of benign gastric lesions like atrophic gastritis, *Helicobacter pylori*–related gastritis, intestinal metaplasia, and other rarer conditions. NBI is a simple procedure which does not require any additional equipment and does not have a long learning curve. Use of NBI in daily practice is likely to improve detection of mucosal abnormalities.

Keywords
- endoscopy
- gastric
- imaging
- mucosa

Introduction

Since the invention of flexible fiber-optic endoscope in 1957, several modifications and improved techniques have been developed to enhance the diagnostic yield of the endoscopy procedure. The major drawback of conventional white light endoscopy (WLE) is that it lacks accuracy in diagnosis and differentiation of various benign and premalignant mucosal gastrointestinal lesions.[1] To overcome this, image-enhanced endoscopy techniques providing high-definition images with good resolution and contrast enhancement have been developed. One such technique is narrow-band imaging (NBI).[2]

NBI functions by filtering the illumination light. The red component of the standard red, green, and blue filters is rejected and the selected bandwidth of the blue and green lights is transmitted (►**Fig. 1**). The mucosa is illuminated selectively with narrow-band wavelengths of blue (415 ± 15 nm) and green (540 ± 15 nm).[3] The hemoglobin absorbs light at both these wavelengths and mucosa reflects it. The blood vessels thereby appear dark brown against a light background providing the necessary contrast between blood vessels and mucosa. While doing endoscopy procedure, real-time change from white light to NBI is possible by using a "switch" whereby wavelength of specific bandwidths 415 ± 15 nm and 540 ± 15 nm is only transmitted by a filter that exists at the distal tip of the endoscope. This narrow band light illuminated mucosa is reflected and the light reaches the couple charged device (CCD) which produces electronic signals based on amount and wavelengths reflected. The signal from the CCD gets processed by the video processor which resynthesizes the final output image. Colors in final image are allocated by processor according to the human visual perception.

Normal Appearance of Stomach on NBI

On NBI, the normal gastric mucosa reflects different morphological architecture of surface (S) and microvascular pattern (V) in the corpus and antrum referred to as SV pattern.[4] Yao described the surface and vascularpattern of gastric mucosa using microanatomical components of mucosa.[5] The major

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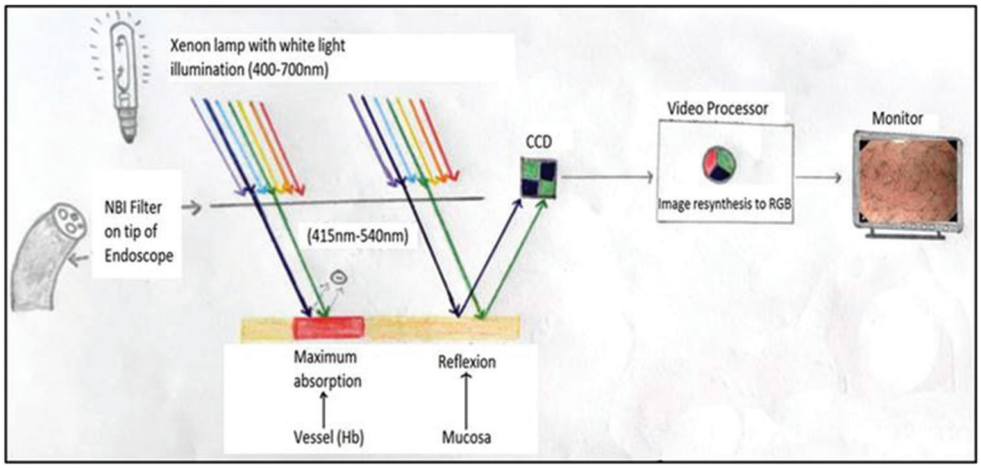

Fig. 1 Overview of NBI system and its principle. NBI, narrow-band imaging.

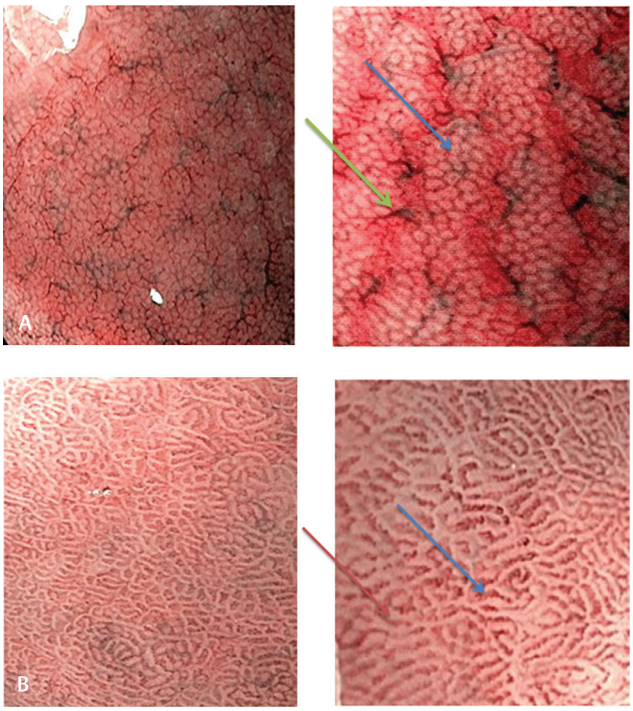

Fig. 2 (**A**) Normal corpus mucosa of stomach: (left) as seen by NBI without magnification, (right) NBI with magnification: regular round to oval pits with honeycomb like SECN pattern (blue arrow) and spider like collecting venules (green arrow). (**B**) Normal antral mucosa of stomach: (left) as seen by NBI without magnification, (right) NBI with magnification: regular polygonal pits (red arrow) with coil or spring like SECN pattern (blue arrow) and absence of collecting venules. NBI, narrow-band imaging; SECN, subepithelial capillary network.

structural or surface components, that is, S pattern refers to the marginal crypt epithelium, the crypt opening or pit, and the intervening portion between crypts. In V, that is, vascular pattern, vessels are described as the subepithelial capillary network and the collecting venule. When there is difficulty in categorizing a vessel as capillary or venule, this is referred to microvessel.

In corpus, the marginal crypt epithelium is seen as whitish circle surrounding the crypt opening.[5-7] The latter is seen as a round to oval brown dot in center of subepithelial capillary network which appears as dark brown anastomosing capillaries giving a honeycomb appearance. The intervening part appears light pink. The capillaries drain into deeper placed collecting venules that are perceived as cyancolored spider-like/starfish-like thick vessels interspersed regularly in mucosa[4-8] (►**Fig. 2A**).

In the antrum, there are ridges that are separated by sulci. Each coil or wave-shaped dark brown colored subepithelial capillary network is located at apical part of the ridge and are separated by linear or reticular crypt opening[7-9] (►**Fig. 2B**). The capillary vessels often anastomose to each other and appear as open loops. The collecting venules are not normally seen in antrum as they are anatomically located in the deeper plane compared with those in the corpus.

Body of the stomach is characterized by regular arrangement of connecting venules and mucosa showing regular, small pits with dark areas encircling light areas. On the other hand, antrum has well-defined ridge pattern without connecting venules and regular circular areas in mucosa with light areas surrounding dark areas. These differences are attributable to differences in vascular pattern and presence of connecting venules at deeper level in antrum.[10]

NBI Appearances of Common Benign Gastric Lesions

Atrophic Gastritis/Gastric Atrophy

In atrophic gastritis, secondary to chronic inflammation of the gastric mucosa as with *Helicobacter pylori* infection (85%), the rate of cell loss may exceed the ability of the stem cells to replace lost cells of surface mucosa and glands resulting in thinning of the mucosa. With white light endoscopy, atrophic gastritis is seen as atrophic mucosal folds that are pale with a shiny surface; submucosal vessels are prominent. These appearances are neither sensitive nor specific for atrophic gastritis.[11]

With NBI, there is loss of pits and subepithelial capillary network with irregular arrangement of prominent collecting venules (►**Fig. 3**). The sensitivity and specificity of these findings approaches up to 90 and 96%, respectively.[12,13] Atrophic

gastritis may vary from mild to severe. Complete loss of pits may be seen in severe atrophy. There is not much data on role of NBI in detecting mild atrophy.

Intestinal Metaplasia

White light endoscopy of the gastric mucosa correlates poorly with histological findings.[14-17] Intestinal metaplasia refers to replacement of foveolar and glandular epithelium in oxyntic or antral mucosa by intestinal epithelium and is considered as the "break point" in the gastric carcinogenesis cascade.

On WLE, intestinal metaplasia appears as shallow depressed and reddish area, slightly raised or whitish flat area or flat lesion with color, similar to the background with minimal morphological changes.[18,19] NBI has an additional benefit of differentiating intestinal metaplasia from normal mucosa by outlining the color differences. A meta-analysis of four studies reported sensitivity and specificity of 86 and 77%, respectively, for diagnoses of intestinal metaplasia (IM) by NBI.[20]

Bansal et al observed that the presence of a ridge or villous pattern by NBI (pseudopylorization of oxyntic mucosa) has a high specificity and sensitivity (80 and 100%, respectively) for identifying intestinal metaplasia.[10] Uedo et al described a novel finding of fine blue–white lines at the crest of epithelial surface described as the "light blue crests" on NBI–magnifying endoscopy (ME) with a high sensitivity (89%), specificity (93%), and accuracy (91%) for the diagnosis of IM.[21] In absence of magnification, the light blue crest is seen as white-blue (cyan color) patches on NBI. It is defined as a fine blue–white line on the crest of the epithelial surface/gyri (►**Fig. 4**).

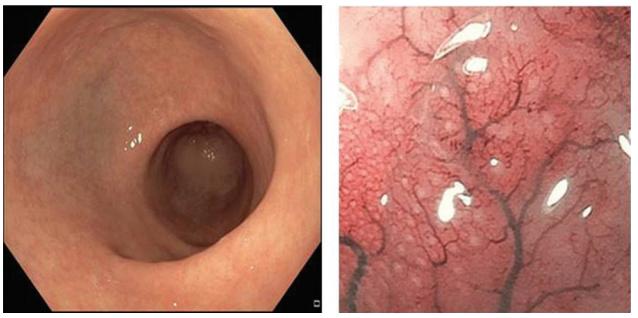

Fig. 3 Chronic atrophic gastritis (CAG): atrophied folds with pale mucosa in CAG. NBI showing obscured surface and vessel pattern with irregular SECN and visible submucosal vessels. NBI, narrow-band imaging; SECN, subepithelial capillary network.

A prospective blinded study showed that WLE with five random biopsies as per the Sydney system was insufficient for detection of gastric intestinal metaplasia. This low yield is likely because metaplastic lesions are often focal and are likely to be missed on random biopsy sampling. Authors therefore recommend NBI-targeted biopsies plus five mapping biopsies as per the updated Sydney system. Mapping biopsies alone without NBI has a poor yield.[22]

Savarino et al reported that NBI detects gastric IM with an accuracy of 93%, a sensitivity of 80%, a specificity of 96%, a positive predictive value of 84%, and a negative predictive value of 95%.[23] A randomized crossover study by Dutta et al[24] showed superiority of NBI over WLE in diagnosing atrophic gastritis, as well as IM. The authors noted that NBI identified additional lesions not detected on WLE.

Pimentel-Nunes et al,[25] in 2012, proposed a simple and reproducible classification system for the diagnosis of IM and dysplasia. The authors noted that regular vessels with circular mucosa was associated with normal histology (accuracy 85%) and tubulovillous mucosa was associated with IM (accuracy = 84%, 95% confidence interval [CI]: 77–91%). Light blue crest had moderate reliability (k = 0.62) and high specificity (87%) for IM.

Apart from light blue crest, other findings have been described in IM. White opaque substance (WOS) was first reported by Yao et al. It is a substance present in the superficial part of gastric neoplasias that obscures the subepithelial microvascular architecture. WOS is an optical phenomenon caused by accumulated lipid droplets.[26-28]

The marginal turbid band (MTB) is another finding noted in IM. It is defined as an enclosing, white turbid band on the epithelial surface/gyri.[21] Recently, another finding, namely, white villiform type mucosa which suggests atrophy and intestinal metaplasia in the gastric antrum has been described[29]

Helicobacter pylori Infection

NBI is a potential tool to diagnose *H. pylori* related gastritis (►**Fig. 5**). In gastric corpus, nonvisualization of normal collecting venules irrespective of central opening and subepithelial capillary changes suggests *H. pylori*–associated

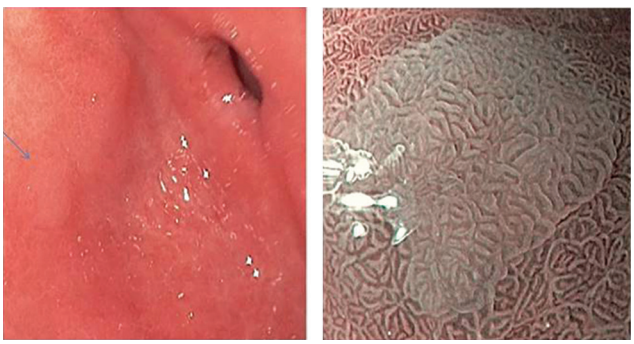

Fig. 4 Intestinal metaplasia (IM): (left) antrum showing slightly raised pale lesion (blue arrow); (right) NBI-ME showing ridge pattern with LBC. ME, magnifying endoscopy; NBI, narrow-band imaging.

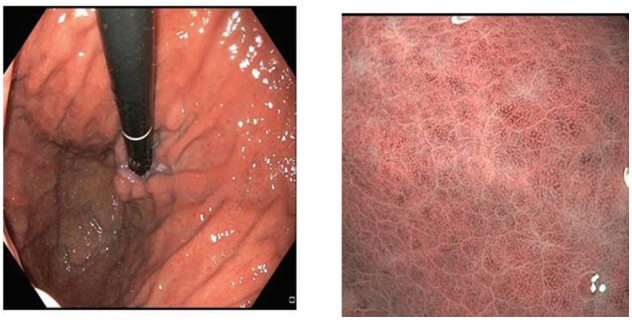

Fig. 5 *H. pylori* related chronic non atrophic gastritis: (left) on WLE, changes are not well appreciated; (right) NBI: showing variable vascular density, pit enlargement, and absence of CV. H, helicobacter; NBI, narrow-band imaging; WLE, white light endoscopy.

gastritis (100% sensitivity, 92% specificity, and positive predictive value (PPV) of 100%).[30-32] Tahara et al using NBI of nonneoplastic mucosa of gastric corpus, classified four types to predict *H. pylori* infection and also described histological severity of gastritis and gastric atrophy.[33] Normal pattern was defined by small, round pits surrounded by SECN. Type-1 pattern showed slightly enlarged, round pits with unclear or irregular SECN. Type-2 pattern showed obviously enlarged, oval or prolonged pits with increased density of irregular vessels and type-3 pattern revealed well-demarcated, oval or tubulovillous pits with clearly visible coiled or wavy SECN.[33]

Pimentel-Nunes et al documented that regular vascular and surface pattern with variable vascular density favored the presence of *H. pylori* infection.[24] Bansal et al showed that the sensitivity and specificity of a regular mucosal and vascular pattern for the diagnosis of normal mucosa/mild gastritis were 89 and 78%, while the sensitivity and specificity of an irregular pattern with decreased density of vessels for the diagnosis of *H. pylori* was 75 and 88%.[10] Banerjee et al prospectively compared NBI with WLE in 74 patients and showed that NBI can be a potential tool for real time diagnosis of *H. pylori* infection based on the presence of obscure pit pattern.[34] Yagi et al compared the diagnostic value of conventional endoscopy and magnifying NBI for prediction of *H. pylori* status in patients after endoscopic resection of gastric cancer. The inter observer agreement was moderate (k = 0.56) for conventional endoscopy and substantial (k = 0.77) for magnifying NBI. The sensitivity and specificity were 79 and 52% for conventional endoscopy and 91 and 83% for magnifying NBI endoscopy, respectively.[35]

NBI has been used to investigate the changes of gastric mucosal patterns before and 12 weeks after *H. pylori* eradication. Patients who were successfully treated (confirmed with ^{13}C Urea breath test) showed a change back to small oval or pinhole-like round pits, as well as a reduction in the density of fine irregular vessels. In absence of severe atrophy and intestinal metaplasia, the sensitivity and specificity of NBI for predicting the *H. pylori* eradication was 100%. However, *H. pylori* eradication did not change NBI pattern in those with preexisting severe gastric atrophy and intestinal metaplasia.[36]

Despite the changes associated with *H. pylori* infection being commonly seen, tests for *H. pylori* infection like rapid urease test, and histopathology may still be required for detection of active infection where clinically indicated. More evidence is required on the role of NBI in distinguishing current ongoing infection from past infection especially in the setting of atrophic gastritis and intestinal metaplasia.

NBI Appearance of Other Benign Gastric Lesions

Fundic gland polyps (►**Fig. 6A**) are usually small (1–5 mm) and multiple and are most commonly located in fundus and body of the stomach. On WLE, these polyps are sessile, shiny, and translucent with normal background mucosa and on NBI, as regular round mucosal pit pattern and regular honeycomb or dense vascular pattern on a background normal gastric body mucosa.[37,38]

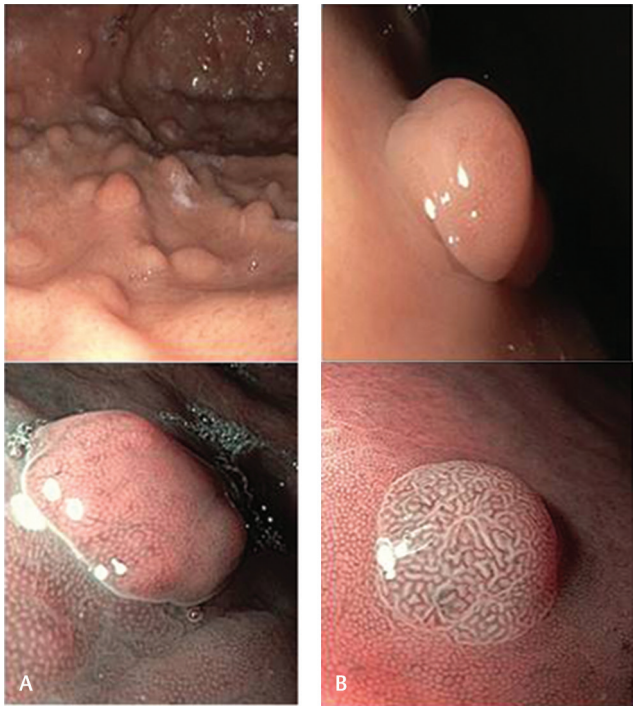

Fig. 6(A) FGP-on WLE and NBI showing round pits with honeycomb SECN and CVs with demarcation line. (**B**) Hyperplastic polyp showing pits were dilated with coil-like enlarged vessels and absent CVs. DL was present. NBI, narrow-band imaging; WLE, white light endoscopy; CV, collecting venule; FGP, fundic gland polyp; LBC, light blue crest; SECN, subepithelial capillary network; DL, demarcation line.

Hyperplastic polyp (►**Fig. 6B**) are usually <2 cm in size, solitary (66%), and commonly located in antrum. They are often associated with chronic *H. pylori* infection against a background of atrophic mucosa. On NBI, these polyps may have tubular mucosal pattern, of several shapes, with thick but regular vessels or dense vascular pattern.[37,38]

Portal hypertensive gastropathy is commonly seen in fundus and body and rarely in antrum of stomach. The changes are usually submucosal; superficial mucosal biopsies are frequently false negative.[39] Characteristics WLE appearance is mosaic or snake skin like pattern or a diffuse, erythematous, and reticular cobblestone pattern of gastric mucosa consisting of small polygonal areas, with superimposed red punctate lesions, >2 mm in diameter and a depressed white border.[40-42] On NBI, red mosaic-like mucosa of portal hypertensive gastropathy is seen as extended and swollen gastric pits with varying degrees of dilated and convoluted capillaries surrounding the gastric pits, collecting venules are obscured.[43]

Gastric antral vascular ectasia (GAVE) is common in elderly (>70 years) women (80%); 30% cases are associated with portal hypertension. On WLE, GAVE appears as tortuous columns of ectatic vessels simulating a "watermelon" or is seen as a diffuse pattern. These areas of erythema are commonly arranged in a linear manner along folds in the antrum and less commonly arranged as diffuse erythema in the ant rum.[40,41,44,45] Hayashi et al described NBI appearance of GAVE as partial and marked dilatation of the capillaries surrounding the gastric pits and capillaries located below the gastric

pits.[43] Chen et al described GAVE on magnifying NBI as ring type of red spots, which has dilated, tortuous telangiectatic capillaries at the intervening part, providing a sensitivity and negative predictive value of 100 and 100%, respectively.[46]

Clinical Applications of NBI in Present Scenario

NBI is useful today to differentiate low-grade adenoma and high-grade adenoma/early cancer[47] to determine chronic gastritis[48] in diagnosis of papillary adenocarcinoma using vessel within an epithelial circle pattern[49] and in diagnosis of histological differentiation.[50,51] Majority of the studies on use of NBI in stomach lesions have been done in Japan. The data from Japan need to be validated in Indian setting and currently histopathology remains the gold standard for diagnosis for majority of these benign lesions. NBI helps in targeted biopsy which definitely improves yield of histopathology testing. Prospective, pan Indian data are required to ascertain the status of NBI in Indian setting.

Conclusion

NBI alone or with magnification endoscopy helps in better characterization of benign gastric lesions. The procedure is safe and can be done during a regular endoscopy, at the "switch of a button." It is ideal for identifying intestinal metaplasia and diagnosing *H. pylori* positivity with high accuracy.

Conflict of Interest

None.

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