CLINICAL IMAGING/TECHNIQUE

Narrow-Band Imaging Endoscopy for Diagnosis of Malignant and Premalignant Gastrointestinal Lesions

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Abstract

Narrow-band imaging (NBI) is a novel endoscopic technique that may enhance the accuracy of diagnosis by using narrow-bandwidth filters in a red-green-blue (R/G/B) sequential illumination system. Magnifying endoscopy by using NBI has two distinct applications: the analysis of the surface architecture of the epithelium (pit pattern) and the analysis of the vascular network. This new technique allows a better characterization of distinct types of gastrointestinal epithelia (e.g. intestinal metaplasia in Barret's esophagus), as well as the disorganization of the vascular pattern in inflammatory disorders and the irregular pit pattern in early neoplastic lesions of the esophagus, stomach and large bowel.

Key words

Narrow-band imaging (NBI) - endoscopy with magnification - malignant/premalignant lesions

Rezumat

Tehnica endoscopiei în bandă ingustă (NBI) este o nouă metodă de examinare destinată creşterii acurateţei diagnosticului prin utilizarea unor filtre pentru lungimile de undă corespunzătoare culorilor albastru/verde/roşu. Endoscopia cu magnificaţie asociată cu NBI are două aplicaţii distincte: studiul arhitecturii epiteliului de suprafaţă (dispoziţia foveolară) şi studiul vascularizaţiei superficiale. În practică, această tehnică permite o mai bună caracterizare a modificărilor epiteliale (de exemplu, metaplazia intestinală, displazia), dezorganizării vasculare în afecţiuni inflamatorii gastrointestinale si a dezorganizării pattern-ului foveolar în leziunile neoplazice esofagiene, gastrice si colonice.

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Introduction

In endoscopic examination, lesions are identified by changes in colour and irregularity of surface mucosa. Narrow-band imaging (NBI) is a novel endoscopic technique that may enhance the accuracy of diagnosis by using narrow-bandwidth filters in a red-green-blue (R/G/B) sequential illumination system (1). This results in different images at distinct levels of the mucosa and increases the contrast between the epithelial surface and the subjacent vascular pattern. It has been postulated that NBI may lead to the same contrast enhancement capabilities as chromoendoscopy, but without the toil of using dye agents (2).

The depth of penetration into the mucosa depends on the wavelength used – superficial for the blue band, deep for the red band and intermediate for the green band; the blue filter is designed to correspond to the peak absorption spectrum of hemoglobin to emphasize the image of capillary vessels on surface mucosa (3).

Magnifing endoscopy by using NBI has two distinct applications: the analysis of the surface architecture of the epithelium (pit pattern) and the analysis of the vascular network (4). NBI may demonstrate the disorganization of the pit pattern and vascular pattern of the gastrointestinal mucosa in inflammatory and neoplastic (premalignant and malignant) lesions of the esophagus, stomach and large bowel.

Interpretation of the surface pit pattern with magnification is easier in the large bowel than in the stomach because of gastric inflammation associated with the high prevalence of Helicobacter pylori (5). In the large bowel mucosa, distinct types of pit patterns have been described for normal mucosa and for non-neoplastic and neoplastic lesions (6). In the esophagus, endoscopy with magnification and NBI shows the microarchitecture of the columnar epithelium with depressions called pits or grooves, and

elevations called crests or ridges. The main usefulness of this technique is to identify and target biopsies to areas of intestinal metaplasia, dysplasia and carcinoma (7,8).

Technical background

Endoscopic examination with NBI is carried out in the usual way; there are no special requirements for preparation and sedation of the patient, but additional information is obtained by analysing the mucosal surface, including vascular pattern in greater detail (9). After endoscopic detection of a lesion, magnification imaging and then NBI are used. The normal image is colored pink and the NBI image is colored in brownish-gray but it provides better contrast – for example, in the esophagogastric junction (Fig.1).

Classic electronic video endoscopes use white light from a xenon source for illumination. The reflected light is captured by a charge-coupled device (CCD) chip at the tip of the instrument in order to reconstruct the images. Two different systems are used to reconstruct images from the reflected light. The first is a "color" CCD (nonsequential), and the second is a "monocrome" CCD (sequential). In the sequential NBI system, the spectral characteristics of the incident light are different; a rotating interference narrow-band R/G/B filter is interposed after the xenon light source. There are gaps between the three narrow bands; they do not cover the full range of the visible spectrum, and the depth of penetration therefore differs. As a consequence, the morphological images reconstructed from the reflected photons are slightly different for each of the three channels (R, G, and B). They correspond with the surface (small capillaries), middle, and deep layers (large collecting vessels) of the mucosa, respectively. The single image displayed on the monitor combines the morphology of the three narrow-band images.

In the NBI magnification system, normal inspection can be switched to NBI using the broadband R/G/B interference filter (wavelengths centered on 415, 540, and 600 nm), only by pressing a button. Photons with a short wavelength in the blue part of the spectrum (415 nm) reproduce a morphological image of the mucosal surface and the superficial network of capillaries. They scatter with a minimal depth of penetration and are selectively absorbed by hemoglobin, providing good contrast for small vessels (10). The photons in the red part of the spectrum (600 nm), which are less scattered, penetrate more deeply; their longer wavelength is outside the hemoglobin absorption band, and good contrast with the adjacent tissue is obtained only for large vessels. The red photons reproduce a morphol-ogical image of large, deep collecting vessels. Photons with an intermediate wavelength in the green part of the spectrum produce a transitional image.

NBI is capable of enhancing the diagnostic ability of endoscopes in charactering tissues by using narrow-bandwidth filters in a R/G/B sequential illumination system.

Clinical applications

Tumors in the esophagus, stomach, and large bowel represent a substantial proportion of the burden of cancer mortality. Secondary prevention of cancer requires early detection at the stage when the lesion is still curable. Magnifying endoscopy by using NBI provides the most effective method of detecting premalignant and malignant precursors of advanced cancer in which the tumor process is restricted to the superficial layers of the gastrointestinal wall. Discrete epithelial premalignant lesions in mucosa of the digestive tract are the first step in the progression to superficial malignancy and then to advanced cancer. Premalignant lesions often develop against a background of inflammation and diffuse alterations in the mucosa; these are considered to be risk factors for cancer and are called "premalignant conditions". Premalignant conditions of the gastrointestinal tract include intestinal metaplasia of the esophagus and stomach, chronic gastritis associated with H. pylori infection, chronic inflammation in ulcerative colitis, and gastrointestinal adenomas (11).

Barrett esophagus

The diagnosis of Barrett's esophagus is dependent on random biopsies for the detection of intestinal metaplasia. By using NBI, areas of intestinal metaplasia can be identified, then specific areas can be targeted for biopsy. This would reduce the time and cost required compared to the present practice of obtaining multiple specimens in random biopsies. Barrett esophagus presents two diagnostic challenges: detecting the short form of the condition and identifying areas of dysplasia once Barrett's esophagus has been diagnosed. In cases of severe dysplasia or superficial carcinoma, the architecture of pit pattern is distorted or disrupted (2). By observing the pit pattern in NBI system is possible to categorize Barrett's esophagus. Figs.1 and 2 show images of Barrett's esophagus.

Carcinoma of the esophagus and cardia

Adding the NBI to magnification imaging increases our ability to detect early squamous cell carcinoma and adenocarcinoma of the esophagus and cardia. The main advantages of this technique are the improved visualization of the intrapapillary capillary loops – a key feature for the diagnosis and staging of early squamous cell esophageal cancer (12). In malignant lesions, the intrapapillary capillary loops undergo changes such as dilatation, weaving, and changes in caliber and shape (Fig.3). Meticulous endoscopic inspection using magnification with NBI followed by targeted biopsy sampling is the most important factor that may lead to the detection of abnormalities in the majority of patients with Barrett's esophagus and early adeno-carcinoma.

Malignant and premalignant lesions of the stomach

The surface architecture of the gastric mucosa has been evaluated with the help of magnifying endoscopy with NBI and distinct patterns in the fundus (regular small pit openings) and in the antrum (epithelial crests separated by

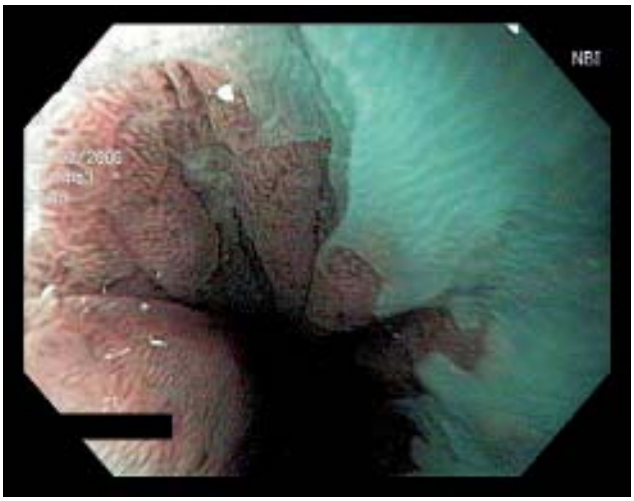


Fig.1 Z-line visualized by NBI technique.

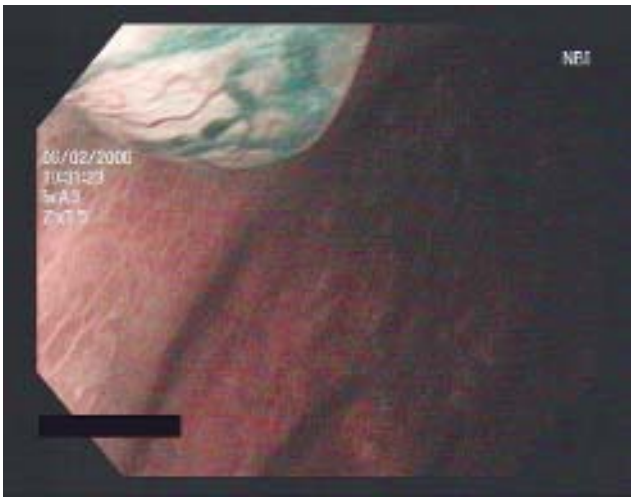
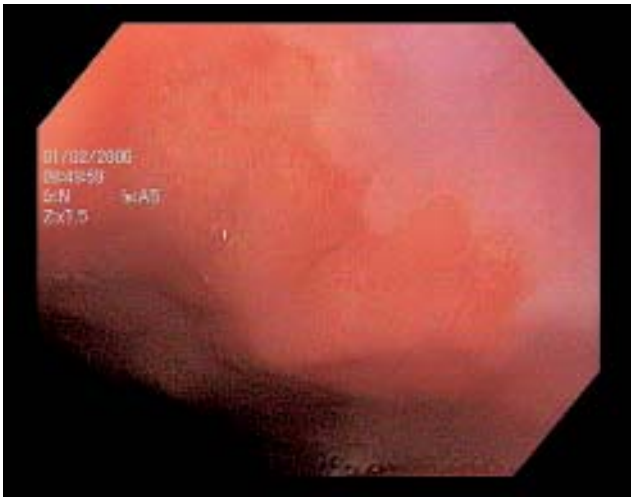


Fig.3 NBI image showing tortuosity and large caliber of intrapapillary capillary loop in cardial cancer.



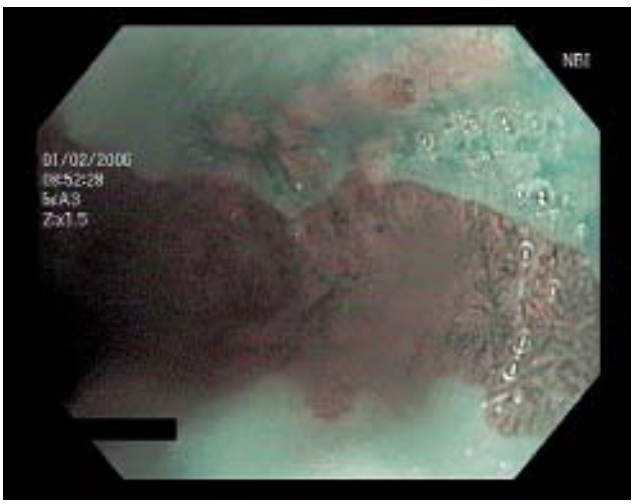


Fig.2 A,B White light (2A) and NBI light (2B) clearly showing an island of columnar mucosa in the esophageal squamous epithelium and intestinal metaplasia.

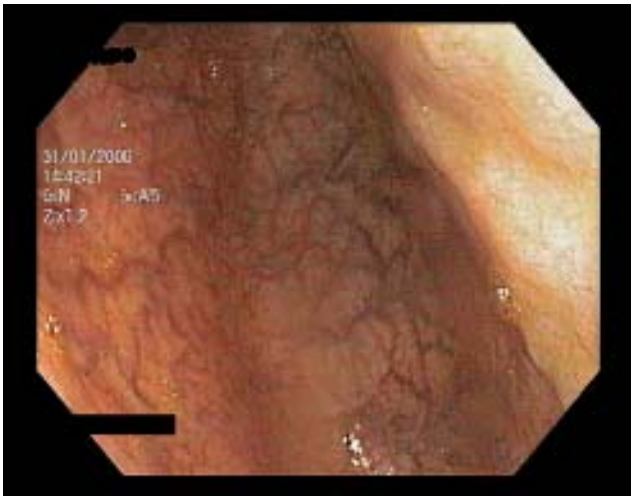


Fig.4A, B White light (2A) and NBI light (2B) image of atrophic gastritis.

narrow grooves) have been described (13). The vascular pattern has also been assessed showing different features in fundic and antrum mucosa; in the fundus, subepithelial capillaries, surrounding the gastric pits, are organized in a regular honeycomb pattern, while in the antrum they are coiled, elongated, and placed at the centre of the epithelial

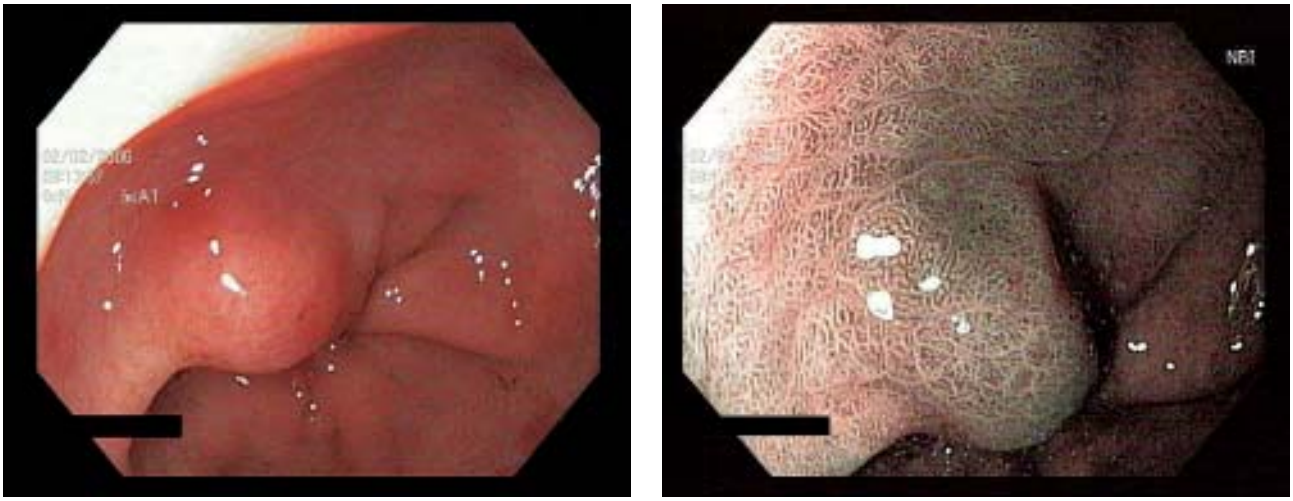


Fig.5A, B Conventional and NBI image showing areas of intestinal metaplasia in papulo-erosive antral gastritis.

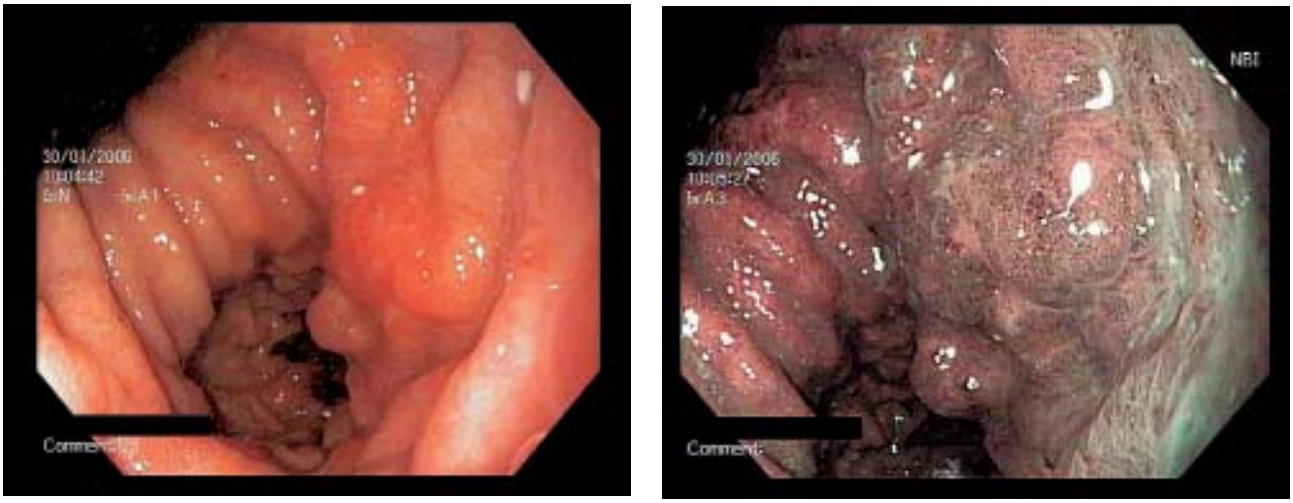


Fig.6A, B Magnifying endoscopy with NBI (6B) improves the vizualization of distorted areas (6A) and allows to target biopsies from irregular pit pattern epithelium.

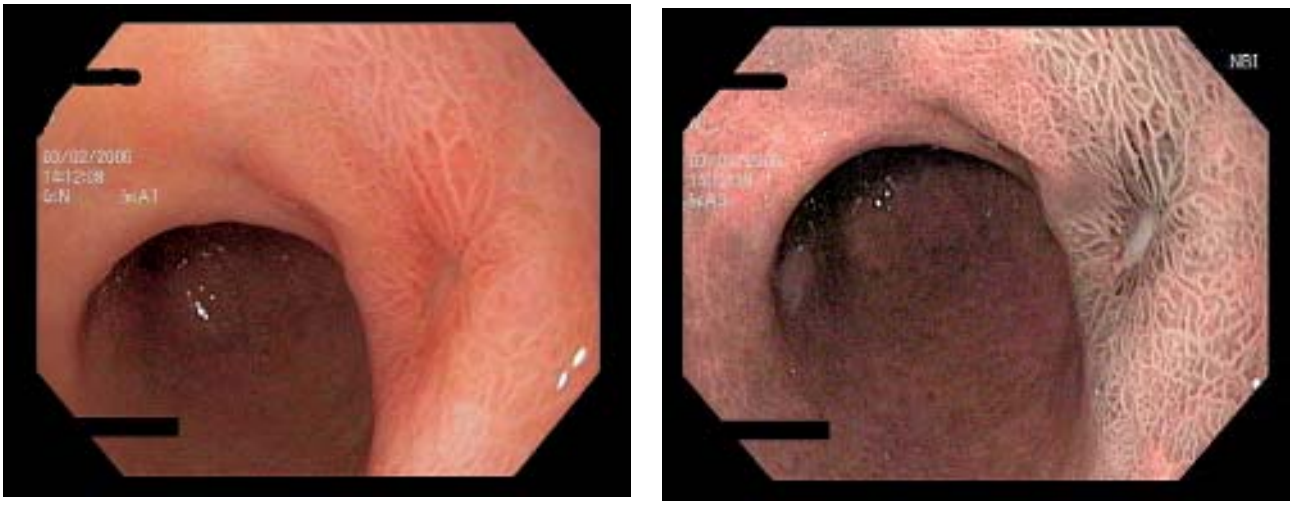


Fig.7 A, B Gastric ulcer (7A) with regular mucosal pit pattern in NBI examination (7B).

crests (14,15). In patients with chronic atrophic gastritis, changes in vascular pattern correlate with the degree of mucosal atrophy (Fig.4). Areas with intestinal metaplasia are suspected when there is a depression with large and long epithelial crests separated by deep sulci (Fig.5). Magnifying endoscopy with NBI improves the vizualization

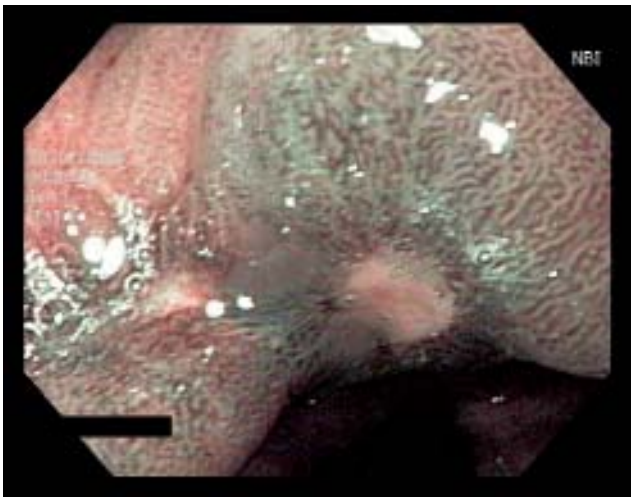


Fig.8 NBI examination showing gastric ulcer with irregular pit pattern.

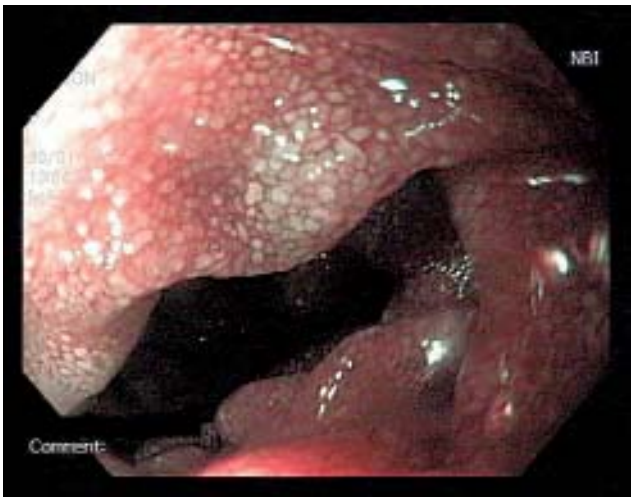
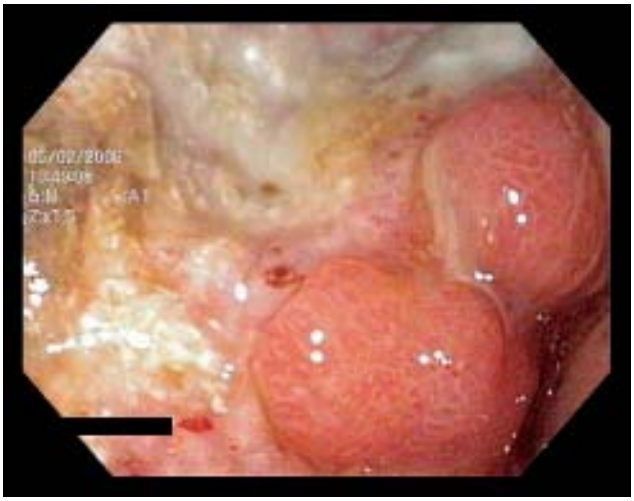


Fig.10 NBI improves the vizualization of duodenum and its villi.



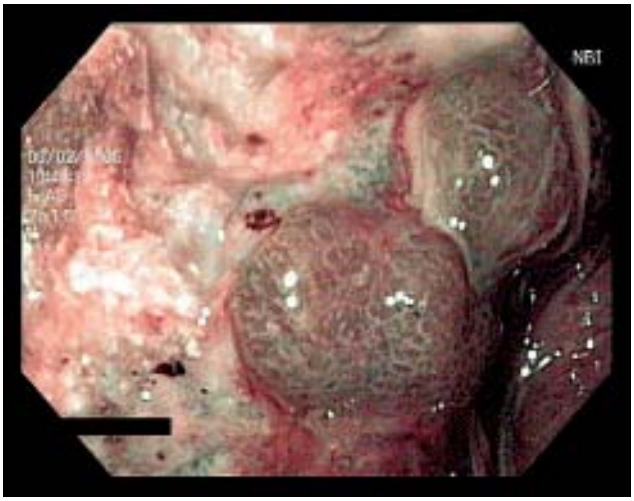


Fig.9A, B Gastric cancer (9A) explored using NBI shows irregular elevation, amorphous pattern and allows targeted biopsies.

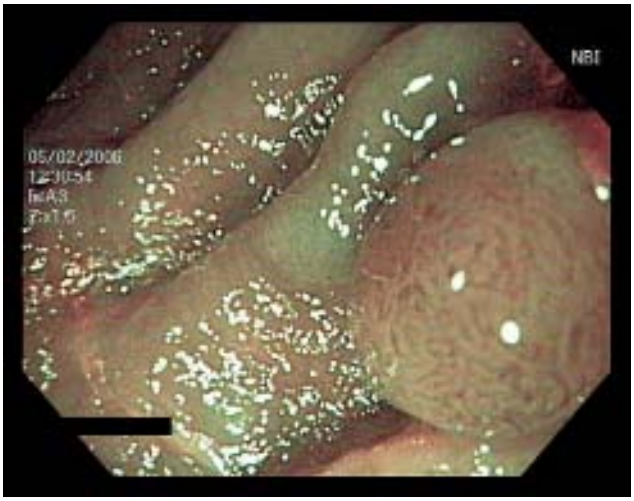


Fig.11 Colonic polyp: the pit pattern of adenoma is clearly visible (NBI technique).

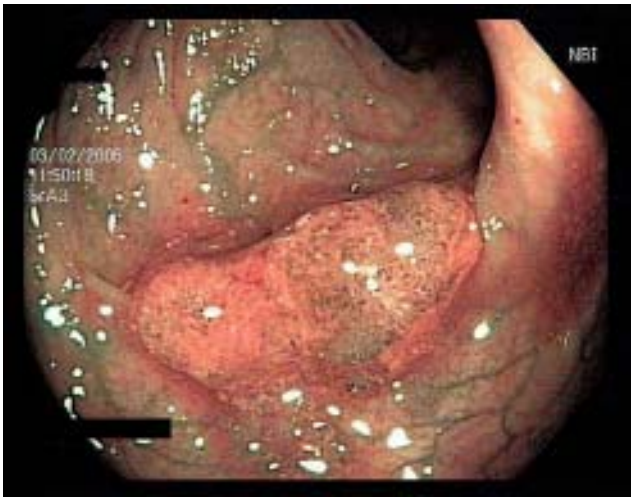


Fig.12 NBI examination of a colonic adenoma showing a small area of Kudo-type V pit pattern (probable carcinoma) located at the anastomotic site after curative resection of colorectal cancer.

of distorted areas and allows biopsies directed to these areas (Fig.6). Gastric ulcer/ulcerations explored by means of this technique may show regular (Fig.7) or irregular (Fig.8) pit pattern. Neoplasia is suggested when zones of irregular elevation, or zones with an amorphous pattern, are present; NBI technique will help in assessing the nature and extent of these lesions (Fig.9).

Lesions of the small bowel

NBI improves the examination of the duodenum and its villi (Fig.10), allowing a classification of villous atrophy in patients with celiac disease, as well as a better vizualization of duodenal polyps.

Malignant and premalignant lesions of the large bowel

Magnification colonoscopy with NBI has been investigated as a new tool of differentiating hyperplastic and adenomatous polyps (Fig.11), increasing detection of flat adenomas and cancers during screening colonoscopy (16), ensuring complete tissue resection during endoscopic mucosal resection and identifying dysplastic lesions in the setting of inflammatory bowel disease (17). NBI colonoscopic evaluation is focused on the mucosal pit pattern – the shape of the colonic crypt oriffice, classified according to Kudo (types I-V) (6). This technique allows to distinguish neoplasia from non-neoplastic lesions according to the pit pattern: type I and II are non-neoplastic, type III-V are neoplastic lesions (Fig.12).

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