Gastrointestinal endoscopy began with the introduction of the gastroscope, which prompted active clinical use of endoscopes in subsequent years. After the gastroscope was introduced, various fibrescopes began to be used clinically. In 1983, electronic videendoscopes were also developed. Unlike fibrescopes, which directly check light signals, electronic videendoscopes convert electronic signals into images via semiconductor elements and allow various forms of electronic image processing and analysis.

Recently, it has been demonstrated that narrow band imaging (NBI) (Olympus Medical Systems Co., Tokyo, Japan) is useful in early diagnosis of cancers of the oropharynx, hypopharynx, esophagus, stomach and large intestine. This finding invited many responses not only from Japanese investigators but also colleagues in many other countries, and NBI has been attracting considerable attention amongst academic societies and research organizations. In Japan, the term “special light (observation)” is now used frequently. A succession of similar techniques were later made public and the meaning of the term “special light (observation)” came to have differ amongst academic societies and research organizations. In view of this problem and the necessity of establishing internationally applicable terminology for endoscopy, we propose object-oriented classification as new classification for endoscopic imaging.

Endoscopic imaging is divided into categories: (1) conventional endoscopy (white light endoscopy (WLE)); (2) image-enhanced endoscopy; (3) magnified endoscopy; (4) microscopic endoscopy; and (5) tomographic endoscopy. Image-enhanced endoscopy is sub-divided into optical, digital, optical-digital and chromoendoscopy methods (Fig. 1). Of all the various image-enhanced endoscopy methods currently available, “special light observation,” a term which has recently begun to be used at meetings of academic societies and research organizations, refers specifically to the optical-digital method.

The optical-digital method of “image-enhanced endoscopy” involves conversion of the optical characteristics of the light used for illumination or imaging with a light source differing in optical characteristics from ordinary white light. This method also involves signal processing within a video processor in a specially designed way to yield enhanced images. This method usually encompasses NBI, auto-fluorescence imaging (AFI) and infra-red imaging (IRI).

Light penetration can be restricted to surface layers using a blue filter from amongst the spectral transmittance of the three Red, Green and Blue (RGB) optical filters used in sequential framing to create a narrow band that cuts long wavelengths. With NBI, the central wavelength is optimized at 415 and 540nm, corresponding to the wavelengths most intensely absorbed by blood and those showing intense reflection and scattering at the mucosal surface. Using a narrow spectrum range, the objective of this method is to emphasize fine mucosal structures and mucosal microvasculature on the gastrointestinal (GI) tract surface.

A study using magnifying endoscopy combined with the NBI system has shown that microvascular patterns of superficial depressed...
Carcinomas of the stomach can be classified into two types: fine network patterns and corkscrew patterns, which correspond to well and poorly differentiated adenocarcinoma, respectively. Therefore, the NBI system can be a powerful tool in the optical pathology of gastric tumors and can be utilized in gastric cancer treatments such as endoscopic submucosal dissection (ESD).

The usefulness of magnifying endoscopy combined with the NBI system has been studied with regard to the detection of specialized intestinal metaplasia (SIM) in columnar-lined esophagus and Barrett’s adenocarcinoma. Fifty-eight patients, including 4 with superficial Barrett’s adenocarcinoma, were enrolled in this study. The most characteristic endoscopic patterns of SIM were revealed to be the cerebriform fine mucosal pattern (sensitivity 56%; specificity 79%) and ivy- or DNA-like capillary pattern (sensitivity 77%; specificity 94%). Magnifying endoscopy combined with the NBI system enabled precise visualization of the structure of capillaries in the superficial mucosal layer. The addition of capillary patterns for fine mucosal patterns appeared to improve the diagnostic value for detecting SIM and superficial Barrett’s adenocarcinoma upon observation using NBI.

A multicenter prospective randomized controlled study has been conducted in Japan on the detection rate and diagnostic accuracy for superficial squamous cell carcinoma in the esophagus (ESCC) and the head and neck region (HNSCC), NBI vs. WLE. Three hundred and twenty patients with ESCC were randomly assigned into 162 NBI followed by WLE, and 158 WLE followed by NBI. In the first examination, the detection rates for the superficial lesion using NBI were significantly higher than those using WLE (H&N region 22 vs. 2, \(P<0.0001\); Esophagus 130 vs. 65, \(P<0.0001\)). Diagnostic accuracy for histologically confirmed ESCC and HNSCC using NBI was high compared to WLE (90.1% and 56.8%, respectively). These results indicate that NBI could be a standard examination for achieving accurate diagnosis of superficial ESCC and HNSCC (Fig. 2).
Fig. 2  Endoscopic images of superficial esophageal squamous cell carcinoma (0-IIc)
Conventional endoscopic findings show reddish area formation (a). The demarcated brownish area can be seen with NBI observation (b). Magnified endoscopic findings combined with NBI show changes in dilatation, tortuosity, and calibre of the intra-papillary capillary loop (IPCL) pattern (c). The size of the area unstained by iodine (d) and the NBI observations corresponded closely. A lesion was diagnosed as well differentiated squamous cell carcinoma (m3).

Fig. 3  Endoscopic images of a laterally-spreading tumor (LST) with granular changes to the rectum (25mm in size, white light endoscopy used) (a) and auto-fluorescence endoscopy (b)
The one-push button changes the light from white light endoscopy to auto-fluorescent endoscopy simply and easily. With auto-fluorescent endoscopy, the tumor margin can be seen clearly as magenta color. The lesion was diagnosed histologically as well differentiated adenocarcinoma after endoscopic mucosal resection (EMR).
With regard to colorectal lesions, it has been reported that accuracy in the differentiation of neoplastic and non-neoplastic lesions was the same for chromoendoscopic imaging and NBI. Sano et al. reported that capillary vessels were enhanced more than usual in colorectal neoplasm, and classified capillary patterns (CP) into major three classes: CP Type I is invisible or faintly visible microvessels; CP Type II is clearly visible and slightly thicker capillaries with loose capillary density; and CP Type III is clearly visible and uneven-sized thicker capillaries with branching, curtailment, and irregularity with thick capillary density. In this third type, vascular casts of colonic carcinoma are characterized by a disorganized structure and density of microvessels, and the increased number and density of microvessels results in formation of nodular clusters of capillaries. In addition, many endoscopists in Japan are researching capillary patterns from various standpoints in order to further the quality of endoscopic diagnosis.

NBI is also indicated to be an effective examination method in evaluating the mucous membrane and discovering displasia and colitic cancer in inflammatory bowel disease. NBI is an examination method with great potential.

Fluorescence endoscopy used to detect early carcinomas and discriminate between normal and neoplastic lesions has recently attracted considerable attention. Collagen, the fluorescence of which is in the green wavelength range, is one of the major sources of tissue autofluorescence (AF). However, there are important tissue changes other than, or in addition to, changes in gross tissue morphology. These may include alterations in the local blood volume, tissue metabolic activity, and relative fluorophore concentrations.

For AF endoscopy, a new AF imaging videoscope system (AFI, Olympus Medical Systems Co.) has been developed. The new AFI system features a switch for selecting either Red, Green, or Blue (RGB) illumination light for WLE or an excitation/reflected light-illumination light combination for AFI. The light source incorporates a rotary filter, which is designed in a double-wheel configuration with two concentric wheels: an RGB filter wheel for normal imaging and an AFI filter wheel. When the AFI mode is selected, the light emitted from the xenon lamp is input into the rotary filter and divided between the 390 to 470 nm excitation light and 540 to 560 nm green light. The AFI scope incorporates a monochrome CCD that has a barrier filter for capturing the excitation light to capture weak AF. A pseudo-color image is reconstructed based on the AF input signals so that high AF intensity is a greenish color and low intensity is magenta.

If the blue light for excitation reaches the subepithelial layer, AF is generated. Fluorescent observation attempts to convert AF into an image which highlights a tumorous lesion as an area differing in fluorescence intensity or color from the adjacent intact tissue with the goal of facilitating the detection and diagnosis of tumorous lesions. The new AFI system is very easy to use because the one-push button changes the light from WLE to AF simply and easily.

A comparative study was conducted with the WLE and AFI systems to differentiate neoplastic from non-neoplastic lesions in 190 cases. Results found the sensitivity, specificity and accuracy to be 98%, 92% and 99%, respectively. These results suggested that AFI might enable easy differentiation of neoplastic from non-neoplastic lesions in the colon (Fig. 3). In addition, we conducted a prospective blinded study that systematically compared AFI with WLE use in the detection of superficial gastric neoplasia. One quarter of the elevated gastric neoplasia cases were detected only with AFI. It is thought that AFI is a system with great promise for diagnosing early carcinomas and premalignant lesions in the GI tract as an adjunct to WLE. In particular, it has potential as a method of identifying small or flat tumors, tumor margins, grading, and premalignant lesions, and for assessing tumor response to therapy.

Dramatic advances in the diagnosis of disease in the GI tract have been made with “image-enhanced endoscopy” in electronic endoscope, including NBI and AFI as mentioned above. The frequency of less-invasive targeting treatment methods, with which affected sites may be treated more precisely and non-affected sites may be preserved as much as possible by utilizing diagnostic images, is expected to increase. Diagnostic endoscopy will be divided into two opposite directions in the future. In one direction, the diameter of endoscopes is decreasing and examination will progress to screening tests using wireless capsule endoscopy. In the other direction, highly precise imaging techniques are progressing. In the former, who will perform the screening
References


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test and how the medical expenses should be structured will become issues. Endoscopy performed by a properly trained endoscopist is safer and better, produces a higher yield, and is more cost effective, as the endoscopist translates endoscopic information into the patients’ management files.