Narrow band imaging and multiband imaging

The American Society for Gastrointestinal Endoscopy (ASGE) Technology Committee provides reviews of existing, new, or emerging endoscopic technologies that have an impact on the practice of GI endoscopy. Evidence-based methods are used, with a MEDLINE literature search to identify pertinent clinical studies on the topic and a MAUDE (Food and Drug Administration Center for Devices and Radiological Health) database search to identify the reported complications of a given technology. Both are supplemented by accessing the "related articles" feature of PubMed and by scrutinizing pertinent references cited by the identified studies. Controlled clinical trials are emphasized, but in many cases data from randomized controlled trials are lacking. In such cases, large case series, preliminary clinical studies, and expert opinions are used. Technical data are gathered from traditional and Web-based publications, proprietary publications, and informal communications with pertinent vendors.

Technology Status Evaluation Reports are drafted by 1 or 2 members of the ASGE Technology Committee, reviewed and edited by the committee as a whole, and approved by the Governing Board of the ASGE. When financial guidance is indicated, the most recent coding data and list prices at the time of publication are provided. For this review the MEDLINE database was searched through September 2007 for articles and references within related to narrow band imaging and multiband imaging by using the key words "narrow band imaging," "NBI," "multiband imaging," "MBI," and "FICE." Practitioners should continue to monitor the medical literature for subsequent data about the efficacy, safety, and socioeconomic aspects of these technologies.

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BACKGROUND

Narrow band imaging (NBI) and Multi-Band Imaging (MBI)* are real-time, on-demand endoscopic imaging techniques designed to enhance visualization of the vascular network and surface texture of the mucosa in an effort to improve tissue characterization, differentiation, and diagnosis. These techniques are considered as potential alternatives to chromoendoscopy because they both provide contrast enhancement of tissue surface structures, although NBI and MBI have not been as extensively studied as chromoendoscopy.

Enhancement of particular mucosal features with NBI and MBI is achieved by observation of light transmission at selected wavelengths (or colors) because the interaction of particular tissue structures with light is wavelength dependent. Selective light transmittance is accomplished by optical filtering of white light in NBI and by software-driven image processing in MBI.

TECHNOLOGY UNDER REVIEW

Conventional white-light imaging

Standard videoendoscope systems use the entire spectrum of visible light (400-700 nm) for tissue illumination. Although the broadband, white-light illumination in conventional videoendoscopes was designed to simulate daylight and enable the endoscopist to examine tissue in its natural color, detailed assessment of particular features, such as mucosal microvasculature, is only feasible when these features are visualized at specific illumination wavelength(s) or wavelength ranges (bands).

Conventional videoendoscopic images can be obtained by one of two systems: red-green-blue (RGB) sequential videoendoscopes and color charge-coupled device (CCD) videoendoscopes.[1] In an RGB sequential system, light from a xenon arc lamp is filtered through a rotating broadband RGB filter located between the lamp and the endoscope's light guide to obtain sequential bursts of red, green, and blue light that give rise to the visual strobe effect. After tissue illumination, the reflected red, green,

* "Narrow Band Imaging" and "NBI" are registered trademarks of Olympus Medical Systems Corporation; "Multi Band Imaging" and "MBI" are registered trademarks of Fujinon Corporation.

and blue tissue images are sequentially captured by a monochromatic CCD at the tip of the endoscope and transmitted to a video processor. The 3 images are fed into the electron guns that illuminate the red, green, and blue phosphor dots on the monitor, respectively, to create a final composite image in full natural color.

Although RGB sequential endoscopes place their color imaging filters in front of the light source (ie, RGB rotating filter), color CCD endoscopes use a micromosaic color filter mounted over the CCD itself. Continuous white-light illumination from the xenon lamp is delivered to tissue by the endoscope's light guide, and the reflected light and image created on the CCD surface is then processed by circuitry in the video processor before display. Similar to the RGB system, tissue structures that heavily reflect the red, green, and blue light are displayed on the R, G, and B video channels on the video monitor, respectively.

NBI

NBI (Olympus Medical Systems, Tokyo, Japan) was developed primarily to emphasize the mucosal microvasculature and to identify vascular alterations indicative of pathologic conditions.[2-5] The technology consists of placing narrow bandpass filters in front of a conventional white-light source to obtain tissue illumination at selected, narrow wavelength bands. These bands produce the greatest contrast between vascular structures and the surrounding mucosa.

Initial NBI development consisted of a 3-band NBI prototype system for the RGB sequential endoscope given the ease of integrating 3 NBI filters into the rotating filter wheel of the RGB sequential system. The narrow band filters were selected on the basis of studies that determined a set of filters that achieved the preferred appearance for mucosal vascular patterns (Table 1).[2] The selected NBI filters restricted tissue illumination to the blue spectral range given the shallow depth of penetration of short-wavelength blue light into tissue (ie, limited to mucosa), relative to deeper penetrating, longer-wavelength light (eg, red light). Moreover, blue illumination at one of the chosen narrow band wavelengths (ie, 415 nm) corresponds to the main peak on the absorption spectrum of hemoglobin. Structures with a high hemoglobin content (ie, blood vessels) absorb the 415-nm light and thus appear darker and provide stark contrast to the brighter surrounding mucosa that reflects the light.

In contrast to the initial 3-band NBI prototype, currently available NBI systems use 2 narrow band filters that provide tissue illumination in the blue (415 nm) and green (540 nm) spectrum of light. The deeper penetrating 540-nm light corresponds to a secondary hemoglobin absorption peak. Capillaries in the superficial mucosal layer are emphasized by the 415-nm light and are displayed in brown, whereas deeper mucosal and submucosal vessels are made visible by the 540-nm light and are displayed in cyan (Fig. 1).

NBI systems. Except for modifications within the light source, instrument components of NBI-equipped endoscopes are otherwise identical to those of conventional RGB sequential or color CCD videoendoscopes. NBI can also be coupled with electronic or optical (zoom) magnification for enhanced visualization of mucosal details.

TABLE 1. Narrow band filters and display of 2-band versus 3-band NBI systems

NBI systems	NBI filters (center wavelength) (bandwidth)	Video channels used for image display
2-Band RGB sequential and color CCD NBI	415 nm (30 nm)	Blue and green
	540 nm (20 nm)	Red
3-Band RGB sequential NBI*	415 nm (30 nm)	Blue
	445 nm (30 nm)	Green
	500 nm (30 nm)	Red

*Prototype.

The initial prototype 3-band NBI system configured for the RGB sequential illumination videoendoscope contains 2 separate light sources, one for standard white-light imaging and one for NBI. Although the same video processor is used for both light sources, switching between white-light imaging and NBI requires disconnecting the endoscope from one light source and connecting it to the other. The NBI light source contains an optical filter with narrow band transmission at 415, 445, and 500 nm that replaces the broadband RGB filter found in the rotating filter wheel of a conventional light source. After tissue illumination, the reflected blue images are processed and converted into a composite pseudocolor NBI image on the monitor (Table 1).

Commercially available NBI systems include either 2-band NBI RGB sequential endoscopes (Evis Lucera 260 Spectrum) or color CCD endoscopes (Evis Exera II 180, Olympus Medical Systems, Tokyo, Japan). The same narrow band filter is used in both videoendoscope systems, with center wavelengths at 415 and 540 nm. Both systems have white-light illumination and narrow band illumination integrated into a single light source. Switching from white-light mode to NBI mode occurs by mechanical insertion of the narrow band filter in front of the xenon arc lamp. The final composite NBI image is displayed by feeding the 415-nm image in the blue and green channels and the 540-nm image in the red channel of the monitor (Table 1).

Table 2 summarizes the specifications of NBI-equipped GI endoscopes (Evis Exera II 180) that are available in the United States. The NBI RGB sequential illumination endoscopes (Evis Lucera 260 Spectrum) are not commercially available in the United States.

MBI

MBI is marketed as FICE (Fuji Intelligent Color Enhancement, Fujinon, Saitama, Japan), a digital image processing technique that enhances the appearance of