Communication from the ASGE Technology Committee

STATUS EVALUATION REPORT

Electronic chromoendoscopy

The ASGE Technology Committee provides reviews of existing, new, or emerging endoscopic technologies that have an impact on the practice of GI endoscopy. Evidence-based methodology is used, performing a MEDLINE literature search to identify pertinent clinical studies on the topic and a MAUDE (U.S. Food and Drug Administration Center for Devices and Radiological Health) database search to identify the reported adverse events 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 October 2013 for relevant articles by using the key words "narrow band imaging," "NBI," "Flexible spectral Imaging Color Enhancement," "FICE," "multiband imaging," "MBI," "i-SCAN," "electronic chromoendoscopy," and "virtual chromoendoscopy." Technology Status Evaluation Reports are scientific reviews provided solely for educational and informational purposes. Technology Status Evaluation Reports are not rules and should not be construed as establishing a legal standard of care or as encouraging, advocating, requiring, or discouraging any particular treatment or payment for such treatment.

BACKGROUND

The term *electronic chromoendoscopy* refers to endoscopic imaging technologies that provide detailed contrast enhancement of the mucosal surface and blood vessels. These technologies offer an alternative to dye-based chromoendoscopy. Electronic chromoendoscopy technologies include narrow-band imaging (NBI) (Olympus Medical Systems Tokyo, Japan), flexible spectral imaging color enhancement (FICE) (Fujinon, Fujifilm Medical Co, Saitama, Japan), and i-SCAN (PENTAX Endoscopy, Tokyo, Japan).

Enhancement of particular mucosal features with electronic chromoendoscopy is achieved by the observation of light transmission at selected wavelengths 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, whereas FICE and i-SCAN both accomplish this through software-driven post-image processing. These 3 modalities are the topics of this review.

TECHNOLOGY UNDER REVIEW

Standard and high-definition white-light imaging

The video endoscope is equipped with a charge-coupled device (CCD) located at the tip of the endoscope. Standard-definition (SD) endoscopes contain CCD chips that offer images in a 4:3 aspect ratio, which produce signal images with resolutions of 100,000 to 400,000 pixels. High-definition (HD) CCD chips offer images in either 4:3 or 5:4 aspect ratios and produce signal images with resolutions of 850,000 to 2 million pixels.[1] This signal is converted to a color image by either a red green blue (RGB) sequential system or a color CCD system by the video processor.[1] An in-depth review of this technology is covered in another Technology Committee document entitled "High-Definition and High-Magnification Endoscopes."[2]

The light source used in endoscopy is typically a xenon arc lamp ranging from 100 to 300 W. This specialized lamp produces light by passing electricity through ionized xenon gas at high pressure. It produces a bright white light that closely mimics natural sunlight in the visible spectrum (400-700 nm). By simulating daylight, xenon lamps allow tissue examination in their natural colors during endoscopy.

Narrow-band imaging

NBI is an endoscopic optical image enhancement technology, proprietary of Olympus Medical Systems. NBI is based on the penetration properties of light, which is directly proportional to wavelength.[3] Short wavelengths penetrate only superficially into the mucosa, whereas longer wavelengths are capable of penetrating more deeply

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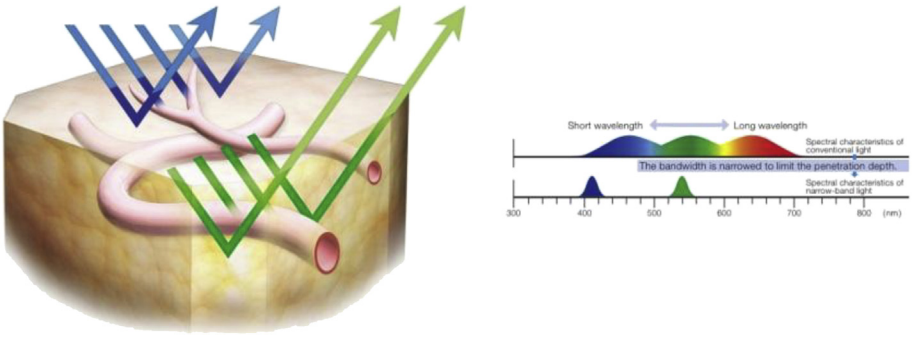

Figure 1. Narrow-band imaging is based on the penetration properties of light, which is directly proportional to wavelength.

into tissue (Fig. 1). The placement of a NBI filter directly in front of the xenon arc lamp produces 2 narrow bands of light centered at the specific wavelengths of 415 nm and 540 nm. These 2 wavelengths correspond to the primary and secondary light absorption peaks of hemoglobin, respectively.[4] Capillaries in the superficial mucosa are highlighted by the 415-nm wavelength and appear brown. The longer 540-nm wavelength penetrates slightly more deeply into the mucosa and submucosa and makes the deeper veins appear blue-green (cyan).[3] Because most of the NBI light is absorbed by the blood vessels in the mucosa, the resulting images emphasize the blood vessels in sharp contrast with the nonvascular structures in the mucosa (Fig. 2).

NBI systems. The first commercially available NBI systems were the Evis Exera II 180 system (color CCD system) and the Evis Lucera 260 spectrum series (RGB sequential system). The Evis Exera II is commercially available in the United States. These 2 systems feature white-light and narrow-band illumination integrated into a single light source. The switch between white-light endoscopy (WLE) and NBI is accomplished by the touch of a button on the endoscope or on the front panel of the light source, which results in movement of a narrow-band filter in front of the xenon arc lamp after a 1- to 2-second delay.

The next generation processors and light sources, Evis Exera III (United States and Europe) and Evis Lucera Elite (Japan) were released in 2012. An issue with the first-generation NBI systems was that the narrow-band images produced were less bright than images with white light. This was attributed to the fact that NBI uses only a narrow band of light (comprising 2 wavelengths only) while filtering out the other wavelengths of white light. The second-generation NBI systems in the Evis Exera III and Evis Lucera Elite have corrected this issue through improvements in the light source. When the endoscopist switches from white light to NBI, the brightness of the lamp in the light source increases accordingly. Improvements made in the system's lenses and mirrors have also made the light more concentrated by minimizing lamp light permeating from the glass fiber within the endoscope.

Tables 1 and 2 list the specifications of NBI-equipped GI endoscopes and processors that are available in the United States.

Flexible spectral imaging color enhancement

FICE is a proprietary digital imaging post-processing system of Fujinon.[5] FICE takes white-light endoscopic images from the video processor and mathematically processes the image by emphasizing certain ranges of wavelengths. Three single-wavelength images can be selected and assigned to the red, green, and blue monitor inputs, respectively, to display a composite color-enhanced image in real time (Fig. 3).

Ten factory-determined presets are available in current FICE configured processors for a differentiated color display of the mucosa. Each preset can be button-activated from a computer keyboard. The factory-preset wavelengths can also be manually altered. There are 60 possible permutations of the available wavelengths (from 400 to 695 nm) that can be manipulated in 5-nm increments. The endoscope push-button controller can be programmed to enable switching between the conventional white-light image and up to 3 FICE presets. The switch to FICE from WLE occurs almost instantaneously. The optimal FICE preset(s) for tissue diagnosis or differentiation have not been established.

Tables 3 and 4 summarize the specifications of FICE-equipped GI endoscopes. FICE is currently not commercially available in the United States.

i-SCAN

i-SCAN is a software-based digital, postprocessing image enhancement technology from PENTAX Endoscopy that provides digital contrast to endoscopic images.[6] Similar to FICE, i-SCAN provides enhanced images of the mucosal surface and the blood vessels through post-image processing. There are 3 i-SCAN modes: i-SCAN 1, i-SCAN 2, and i-SCAN 3. Touching a button on the endoscope can access