PART 1
The Basics of NBI

1 Narrowband imaging: historical background and basis for its development

Shigeaki Yoshida

In Japan, where the incidence of gastric cancer is very much higher than in the rest of the world, greater attention has been paid to early diagnosis since the beginning of the 1950s when the "gastrocamera" was first introduced. In those days, the finding of early gastric cancer (EGC) was not frequent and most of these lesions were identified from the differential diagnosis of deeply ulcerated (type III) or polypoid (type I) lesions, which can be easily detected. In the 1970s, early diagnosis progressed and it became possible to detect those cancers showing the appearance of ulcer scar (type IIc) and plateau-like elevation (type IIa). Furthermore, at the beginning of the 1980s, early diagnosis of gastritis-like malignancy (type IIb-like) became more readily possible following the results of retrospective studies of rapidly growing advanced cancer [1]. With this increased appreciation of the appearance of early superficial lesions, the widespread use of biopsy and with careful scrutiny of the mucosa using dye-spraying techniques, EGCs appearing as just faint mucosal irregularities or discoloration came to be the most frequent EGC being diagnosed by the late 1980s [2].

Such results were also applied to esophageal and colorectal malignancies, and there has been a general acceptance in Japan that early malignancies in the alimentary tract may not appear polypoid or ulcerative. The desire to better recognize such malignancies, which may be difficult to distinguish from nonspecific inflammation or trauma, had prompted us to envision new endoscopic technology capable of revealing cancer-specific images of the surface structure of the mucosa. It is within this context that the field of narrowband imaging (NBI) was developed as a promising way to facilitate the endoscopic diagnosis of early neoplastic and pre-cancerous lesions in the alimentary tract.

NBI is an optical image enhancement technology that visualizes vessels on the surface of the mucosa and patterns on the surface of mucosa by employing the characteristics of the visible light spectrum. The development of NBI goes back to the study of spectroscopy more than 20 years ago. The Japanese government implemented the Second Term Comprehensive 10-Year Strategy for Cancer Control in 1994. Together with Professor N. Oyama of the Tokyo Institute of Technology and Olympus Medical Systems Corp., we received funding from the project and started the study in which we intended to digitalize the color and structure of mucosa in order to establish a more objective/quantitative pathologic diagnosis and hence better diagnostic yield. At that time, multiple facilities and industries had conducted studies to achieve optical biopsy using the characteristics of the visible light spectrum. We aimed to achieve differentiation of normal and abnormal mucosa using a custom-made spectrophotometer developed by Olympus Medical Systems Corp.

Using the method described in Figure 1.1, we obtained and analyzed more than 2000 samples from esophagus, stomach, and colon. However, we faced multiple challenges to establish a stable diagnostic standard. The spectrum showed different patterns in normal and abnormal tissues but the spectral pattern differed from patient to patient, so that it was quite difficult to achieve stable classification between normal and abnormal. Furthermore, spectral data were not stable under the measuring conditions employed.

However, throughout the study we noticed a specific spectral pattern when selecting certain narrowband wavelengths (Figure 1.2). To highlight the specific pattern, we shifted our study from qualitative analysis using spectroscopy to qualitative imaging that enhanced details of the mucosal surface. As a result, when employing a

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narrowband filter, we found excellent light enhancement deep in the mucosa at red light wavelengths, shallow mucosal surface features at blue light wavelengths, and levels in between at green light wavelengths [3]. Based on the findings, we continued the study with the research and development group at Olympus and finally found that narrowband blue light wavelengths matched the light absorption characteristics of blood hemoglobin and enhanced details of the mucosal surface.

In December 1999, we obtained the world's first clinical images using NBI in our facility (Figures 1.3–1.6). The original technology only generated black and white monochrome images with limited information for diagnosis, making it impractical for clinical applications. The challenge was shortly solved by the introduction of newer improved filters and the development of a prototype incorporating a circuit board exclusively for NBI color display.

Since these first clinical NBI pictures were achieved, we have actively expanded the study in cooperation with multiple research facilities. As a result of this collaborative investigation, the application of NBI diagnosis has expanded rapidly [4,5]. Starting with the diagnosis of colonic tumor and squamous cell carcinoma of esophagus, the applications of NBI were established in other fields such as superficial carcinoma in pharynx, Barrett's esophagus and adenocarcinoma, stomach cancer, and inflammatory bowel disease. Multiple studies have been published in these areas; the results have been published in academic society proceedings, research committee reports and clinical papers in peer-reviewed journals. Much of this data is discussed in detail in subsequent chapters of this book.

In December 2005, the NBI system became commercially available from Olympus, and the technology and diagnosis expanded further, not only in Japan but also worldwide.

In summary, endoscopic diagnosis has been rapidly progressing. Beyond technical advances such as chromoendoscopy and improvements in image quality, endoscopic diagnosis has now advanced to the area of pathology. This is possible because the imaging technology now allows assessment of the three-dimensional architecture of tissue by fine examination of the mucosal surface with magnifying endoscopy. In the coming years, special light observation such as NBI may be able to provide even more information about a targeted lesion, in order to clarify the indication of new cancer therapies.

Such endoscopic diagnosis through special light observation holds great promise. None of these advances could have been achieved without the great contribution of Professor H. Niwa, Board Chairman of the Japan Gastroenterological Endoscopic Society, and his colleagues who have devoted themselves to the development of multiple modalities of optical diagnosis, such as ultraviolet gastrocamera, infrared and autoflorescence imaging, since the project was first initiated while working together at Tokyo University. We must recognize the history of endoscopic diagnosis and the contribution and diligence of these individuals in bringing the field to where it is today. I hope that special light diagnosis through NBI will become an increasingly reliable tool with more clinical evidence to support its applications. As this occurs, the technology should make important contributions to improve and facilitate diagnosis in clinical practice.

Video clips to accompany this book can be found in the online material at www.wiley.com/go/cohen/NBI

References

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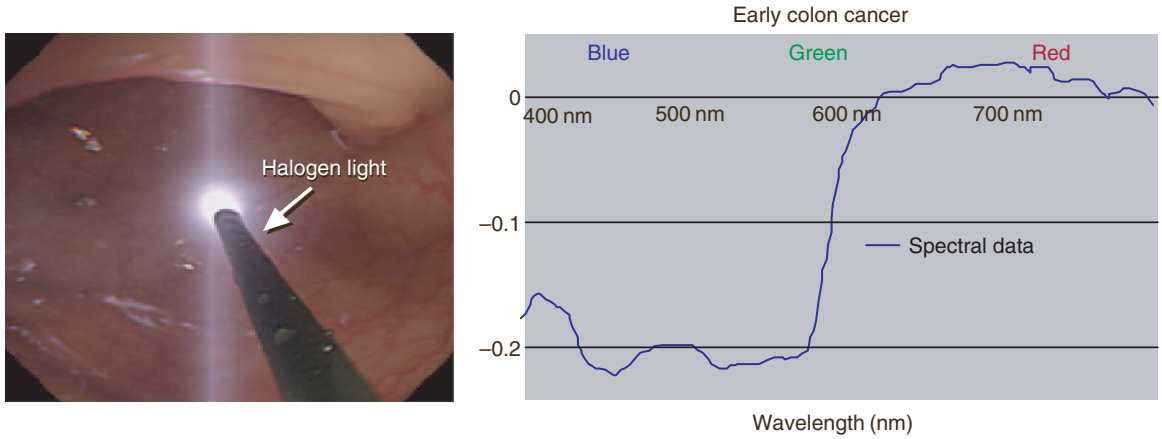

Figure 1.1 Spectral reflectance analysis. Spectral data were sampled at intervals of 2 nm ranging from 400 to 800 nm. In each examination, we measured spectral reflectance in both normal and neoplastic areas. (Copyright S. Yoshida.)

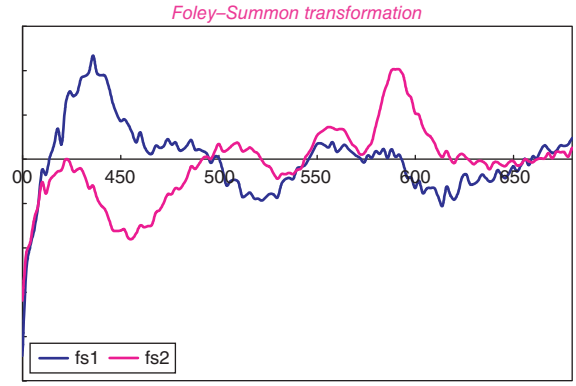

Figure 1.2 Spectral sensitivity functions for discrimination of cancerous regions. (Copyright S. Yoshida.)

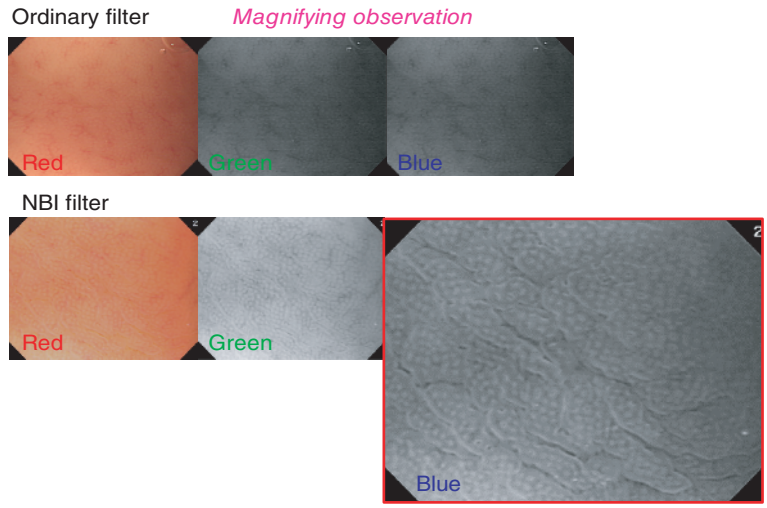

Figure 1.3 Normal gastric mucosa: mucosal crypt pattern of the stomach can be observed without dye spraying by blue-filtering of NBI. (Copyright S. Yoshida.)

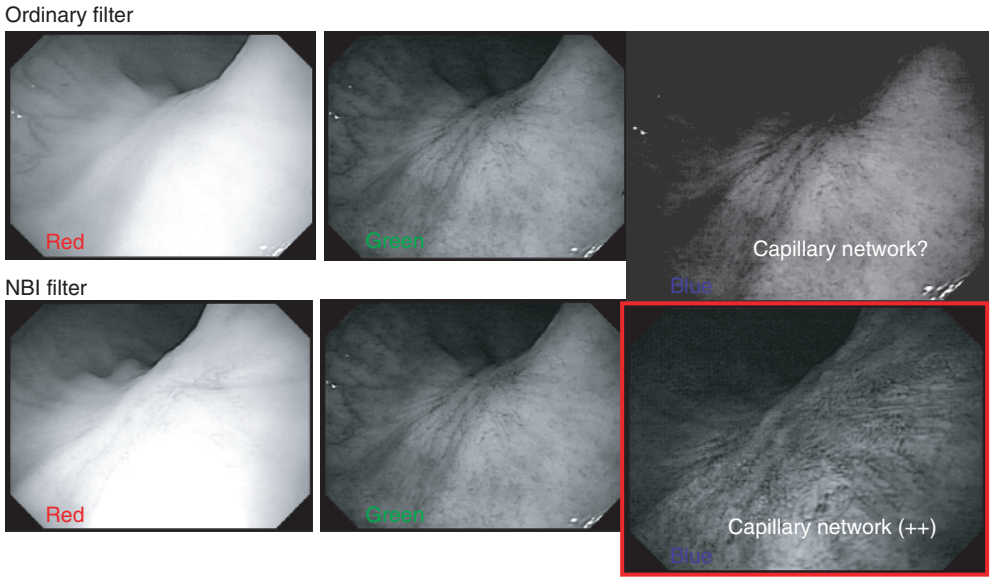

Figure 1.4 Gastric ulcer scar: capillary network can be observed without dye spraying by blue-filtering of NBI. (Copyright S. Yoshida.)

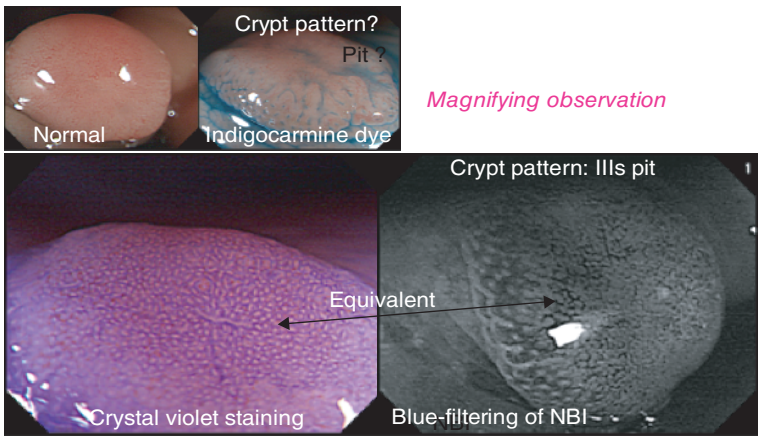

Figure 1.5 Flat adenoma of sigmoid colon: crypt pattern of the depressed area can be observed without dye spraying by blue-filtering of NBI. (Copyright S. Yoshida.)

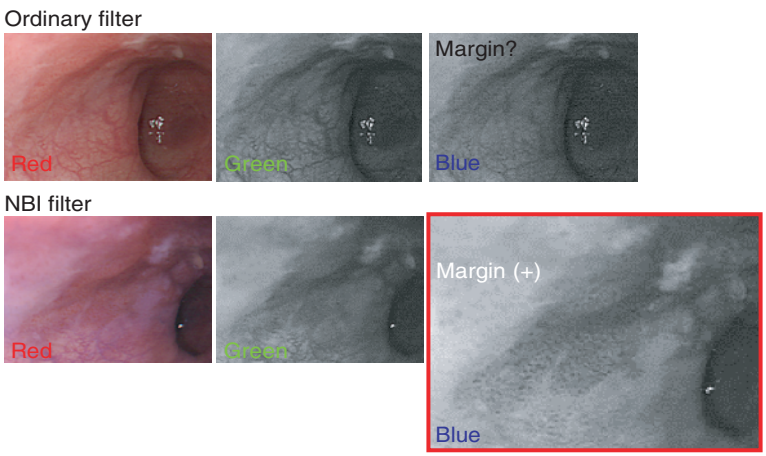

Figure 1.6 Esophageal cancer (type 0–IIc): the margin of the lesion is clearly detected by blue-filtering of NBI. (Copyright S. Yoshida.)