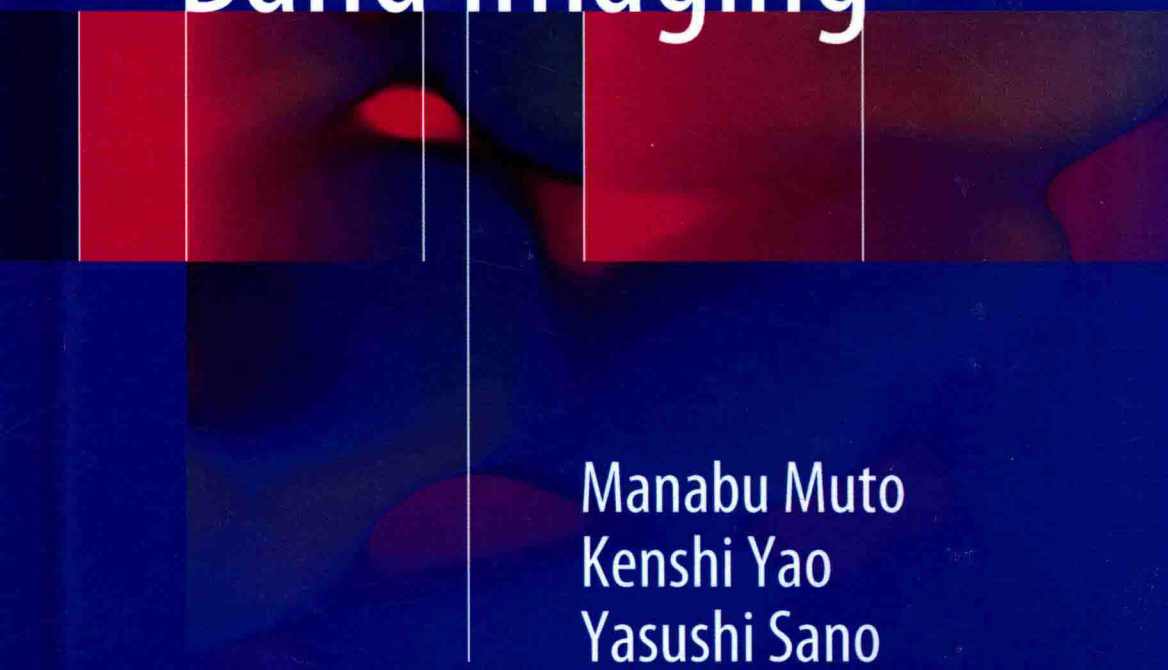
Atlas of Endoscopy with Narrow Band Imaging



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Editors

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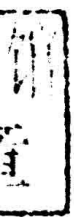

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Foreword

It is my recollection that I dreamed of quantitative color analysis in the mid-1980s. At that time, we saw a rapid increase in flat nonulcerated early gastric cancers (gastritis-like early gastric cancers), and it became increasingly important to detect small changes in color or elevation. Our only available response was to "biopsy any suspicious lesions to confirm". In 1989, we received research funding for the First Comprehensive 10-year Strategy for Cancer Control and attempted to develop a colorimetry-capable dot sequential electronic endoscope at the National Cancer Center Hospital, in collaboration with Toshiba Medical Systems Corp. and the Oyama Research Department of the Tokyo Institute of Technology. This resulted in 1993 in a prototype capable of displaying the color of the target area as a coordinate on a color map using an algorithm. It was unable to identify cancer-specific colors, however, and we had to conclude that it had no clinical usefulness.

The reason for this was thought to be an insufficient quantity of information. Accordingly, as part of the Second Comprehensive 10-year Strategy for Cancer Control commencing in 1994, at the National Cancer Center Hospital East, in collaboration with Olympus Medical Systems Corp. and the Oyama Research Department of the Tokyo Institute of Technology, we first developed a spectrometer capable of endoscopic colorimetry, then collated spectrometric data concerning early cancers and noncancerous regions in the upper and lower gastrointestinal tract. Analysis of a large volume of textbook data from over 2,000 cases enabled differentiation between cancerous and noncancerous regions as groups, but it could not be applied at all to individual lesions, and this study reached an impasse after less than 5 years. It was Mr. Kazuhiro Gono, involved in this project on the Olympus side, who thought at that time, based on the fact that although the spectrometric pattern was different in each patient, the difference between the cancerous and noncancerous regions occurs within a narrow spectral range and that cancer screening might be possible using a narrow band filter. He photographed his own oral mucosa using a narrow band filter, finding that the surface microstructure was brought into particularly sharp relief when viewed through a short wavelength (blue light) filter. This was in December of 1999, as the end of the year drew close.

With patient consent, we promptly commenced clinical photography. At that time, however, we had no choice but to use monochromatic imaging, so at first we had no idea what we were seeing. Subsequently, we made rapid progress through basic studies and improvements in equipment (introduction of frame

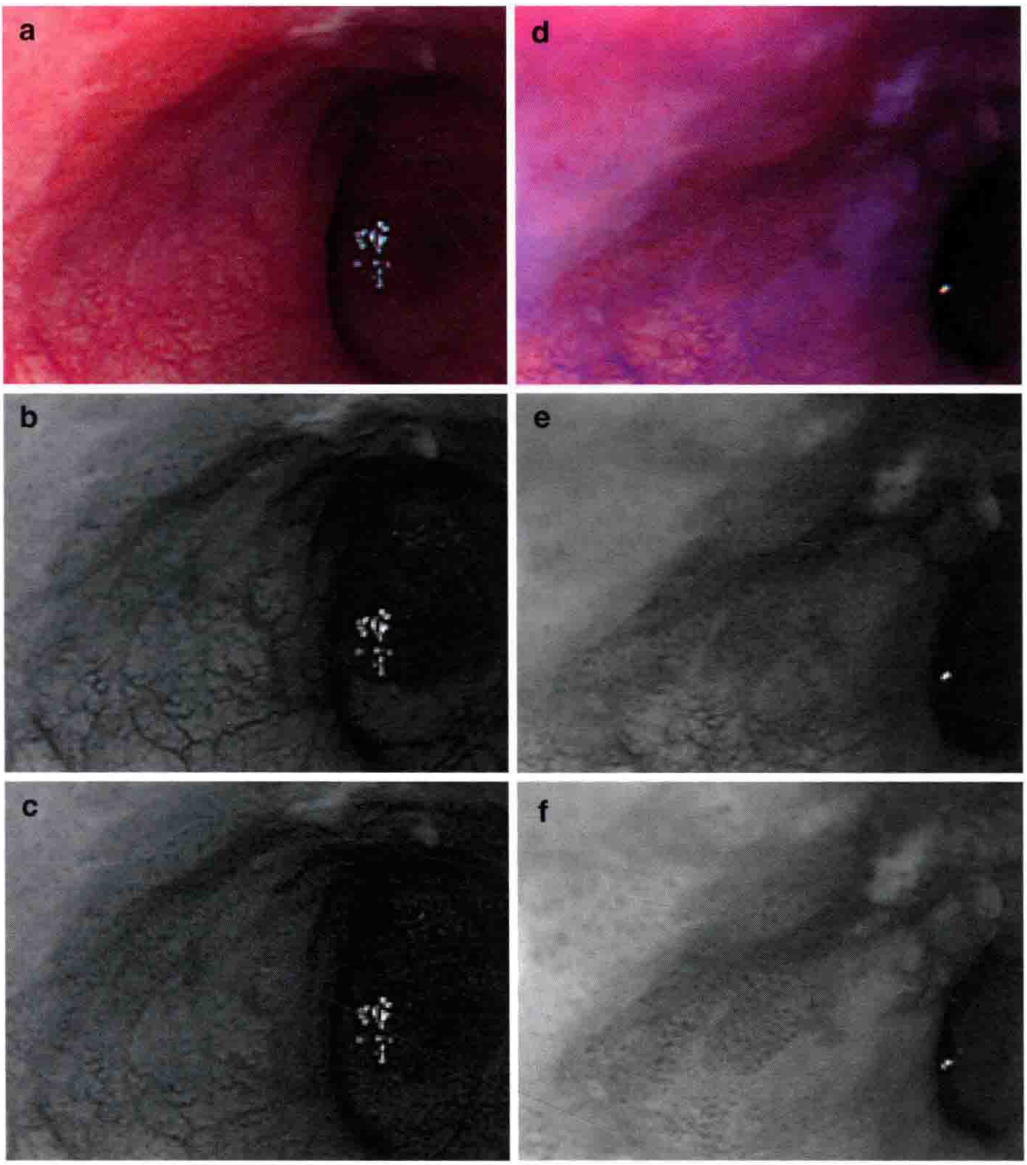
sequential pseudocolor imaging). Drs. Manabu Muto and Yasushi Sano, two of the editors of this atlas, worked on the clinical application of this method in examining pharyngeal and esophageal lesions, and colorectal lesions, respectively. They made steady progress in elucidating the mechanisms of observed phenomena and confirmed the usefulness of NBI through a number of clinical trials. Furthermore, for gastric lesions, where at first it was difficult to understand the NBI findings or discern any clinical benefits, the revolutionary approach by Dr. Kenshi Yao and his magnifying endoscopic methods made it possible to establish the diagnostic power of NBI.

In this way, with the publication of this atlas, edited by three pioneers involved in the development of NBI since the beginning, we can see that the contents are full of both a deep affection for this method and an understanding of its limitation. Reading this atlas, with its emphasis on actual cases, we are at first drawn to the beautiful images, but the structure is also practical, with thorough but concise explanations. This is an essential text for the endoscopist, of great interest to both the beginner just commencing NBI and to the experienced specialist. NBI can also be referred to as microangiography, as seen from the mucosal surface. Capillaries are found in every part of living organisms, so we anticipate clinical applications for NBI in many areas apart from gastroenterology, including examinations of the bronchi, bladder, uterine cervix, and also the retina. Accordingly, studies of the use of NBI in diagnosing disorders of the gastrointestinal tract have the potential to pave the way for a variety of future clinical applications, not confined to cancer detection alone. In anticipation of further deepening of these studies, it is my heartfelt wish that, with continual revisions, this atlas should become the "eternal textbook" in this field.

On a personal note, the resurrection of the experimental apparatus developed for the First Comprehensive 10-year Strategy for Cancer Control, as the Fuji Intelligent Chromo Endoscopy system in association with the discovery of NBI, was a great relief for me as one involved in the early stages. On reflection, it is somewhat ironic that our research, commenced with a vision of colorimetry (quantification of color tone), should abandon natural light and end up with endoscopic evaluation dependent on specific wavelengths. Nevertheless, reading this atlas will leave you in no doubt as to the great potential of examination using specific wavelengths.

I wish the authors all the best as they make further progress in their research in their respective areas, and I am pleased to recommend this atlas to anyone interested in the field of endoscopy with narrow band imaging.

Aomori, Japan — Shigeaki Yoshida, MD



Prototype NBI photos (esophageal cancer: type 0-IIc): (**a**) standard filter, (**b**) green light filter, (**c**) blue light filter, (**d**) NBI filter, (**e**) green light filter, and (**f**) blue light filter

Preface

I believe that narrow band imaging (NBI) will soon become an essential modality of endoscopic examinations. During the planning discussions for this atlas, my fellow editors Dr. Kenshi Yao and Dr. Yasushi Sano and I were in agreement on the following three points: "The photos should be clear and easy to understand", "Diagnoses should be simple and reproducible", and "Explanations should be concise and easy to understand". You can also see from the layout design that this atlas was produced with these three principles in mind. Considering the size of this book, we aimed for something compact that could easily be taken into the endoscopy room. It is my recollection that it took less than 30 min to decide on these concepts.

In terms of content, we planned to present characteristic images of individual lesion types, based on the principles of NBI. The three authors are Dr. Sano, who has been involved in the development of NBI from the beginning and has studied the diagnosis of early colorectal cancer using magnifying endoscopy with narrow band imaging (M-NBI); Dr. Yao, who early on identified vascular abnormalities in early gastric cancers and has advanced the diagnosis of early gastric cancer using M-NBI; and I, working with Dr. Sano from the beginning in the development of NBI, and also studying risk factors for squamous cell carcinoma of the head and neck and esophagus, working towards methods of early detection.

NBI works best in combination with magnifying endoscopy, high-vision endoscopy, and high-vision monitors. Accordingly, wherever possible we have included photographs taken under these optimum conditions. We anticipate that the information in this volume, although it demonstrates that NBI is an advanced diagnostic modality, will be readily accessible to all new endoscopists, and not only to specialist gastroenterologists.

NBI can be said to have revolutionized the field of diagnostic endoscopy. One reason is that it enables a more objective assessment of a lesion. Along with improvements in the diagnostic ability of endoscopic examinations and training in endoscopic diagnosis, this provides considerable benefits for patients undergoing endoscopy. On the other hand, at the present time we still hear some endoscopists complain that they do not know how to use NBI or assess lesions. We have been very particular in presenting simple and easy-to-understand diagnoses with the aim of answering these complaints.

We cannot discuss the development of NBI without mentioning Dr. Shigeaki Yoshida (Medical Director Emeritus, National Cancer Center Hospital East, and

Aomori Prefectural Hospital Business Manager), Professor Hisao Tajiri (Jikei University School of Medicine), and Mr. Kazuhiro Gono (Olympus Medical Systems). NBI is unmistakably the successful product of industry–university joint research, from basic research to clinical application, with clear clinical significance. Following the development of NBI, we can expect more early gastric cancers to be detected. It can be considered a revolutionary technique that will save many people from suffering associated with cancer. The usefulness of NBI is now under wide scrutiny, not just in the field of gastroenterology, but also for the head and neck and bronchi, and in gynecology and urology. We anticipate that NBI will also prove useful in other fields in the future.

Kyoto, Japan Manabu Muto

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Contents

Part I

Basics of NBI

Principles and History of NBI

1

Kazuhiro Gono

1.1 Introduction

Narrow band imaging (NBI) is a method of image enhancement [1, 2]. Although it is classified as an "optical digital method," it enhances images using optical technology, processing them in a different way to previous optical digital methods [3]. An understanding of the optical properties of living tissue was deeply involved in the development of NBI.

In this section, I will present the operating principles of NBI. To aid your understanding, I will also cover absorption and scattering and the interactions between living tissues and light. In addition, I will touch upon the two different imaging methods used with NBI, the simultaneous and frame sequential methods.

1.2 History of the Development of NBI

The development of NBI began with that of the endoscopic spectroscopy system (ESS). From the second half of the 1990s, as part of the "Comprehensive 10-year Strategy for Cancer Control," the National Cancer Center Hospital East, and the Oyama Research Department of the Tokyo Institute of Technology, in collaboration with Olympus Medical Systems Corp., we worked on quantitative colorimetry (spectrometry) of the gastrointestinal mucosa, with the aim of diagnostic application. As part of that study, we passed an optical fiber probe down an endoscope instrument channel, collected objective color data (spectral reflectance rates) from the stomach and colon, and developed an algorithm for their diagnostic application. Although we were able to show objective differences between tumor and nontumor

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