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# Characterization of Colorectal Lesions Using a Computer-Aided Diagnostic System for Narrow-Band Imaging Endocytoscopy

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Recently, the American Society of Gastrointestinal Endoscopy established the Preservation and Incorporation of Valuable Endoscopic Innovations[1] for diminutive colorectal polyps. Preservation and Incorporation of Valuable Endoscopic Innovations suggests that, if an endoscopist diagnoses an agreement of >90% in determining postpolypectomy surveillance intervals and a negative predictive value of >90% with adenomatous histology, pathologic diagnosis might not be necessary. Although magnifying chromoendoscopy,[2] narrow-band imaging (NBI),[3] endocytoscopy (EC),[4] and confocal laser endomicroscopy[5] are highly accurate, interpretation of these modalities is difficult for novices. Furthermore, achieving a negative predictive value of >90% for adenoma is not easy using these modalities[3] and requires comprehensive experiments.[6] To achieve a breakthrough on this issue, we developed a computer-aided diagnosis (CAD) system for EC. This system automatically provides highly accurate diagnosis as expert endoscopists concurrently take EC images (Video Clip 1).[7] Our previous system, based on glandular structural and cellular atypia, required endoscopists to use dye for staining. In contrast, the endocytoscopic vascular pattern can effectively evaluate microvessel findings using EC with NBI (EC-NBI) without using any dye. We reported that EC-NBI has a highly accurate diagnostic ability, similar to other modalities.[8] Because dye staining complicates the procedure, our CAD system for EC-NBI represents a powerful tool for novices and experts who do not use dyes on a routine basis. Therefore, we developed a tentative CAD system model for EC-NBI image.

## Description of Technology

We developed custom software (EndoBRAIN, Cybernet Systems Co., Ltd., Tokyo, Japan) to analyze EC images. We collected a consecutive series of 1079 EC-NBI images (431 nonneoplasms and 648 neoplasms) from 85 lesions to form an image database. To validate the CAD system, we randomly extracted 100 images (50 nonneoplasms, 50 neoplasms) from the database. The remaining 979 images (381 nonneoplasms, 598 neoplasms) were used for machine learning. The inclusion criteria were colorectal lesions that had been detected during colonoscopy using EC and subsequently resected between December 2014 and April 2015. The exclusion criteria were inflammatory bowel disease; lesions for which no clear EC-NBI were available; sessile serrated adenomas/polyps (SSA/Ps); and nonepithelial

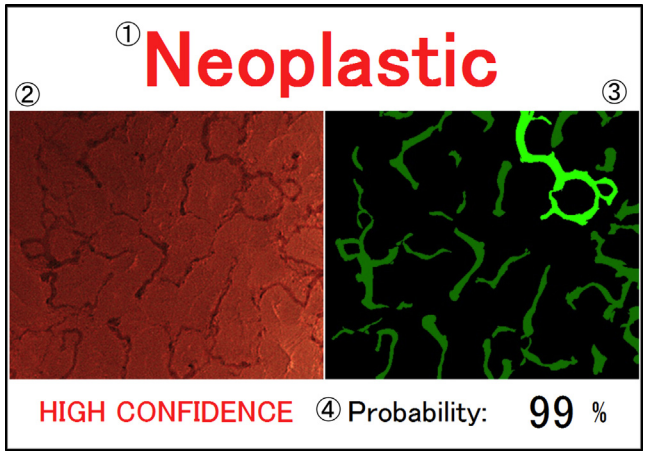


**Figure 1.** Output image. (1) Computer diagnosis. (2) Input endocytoscopy with narrow band imaging. (3) Extracted vessel image, in which the green area denotes the extracted vessels. The light-green vessel has the maximum diameter. (4) Probability of computer diagnosis is calculated by the support vector machine classifier.

***Abbreviations used in this paper:*** **CAD, computer-aided diagnosis; EC, endocytoscopy; EC-NBI, endocytoscopy with narrow-band imaging; NBI, narrow-band imaging; SSA/P, sessile serrated adenoma/polyp.**

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**Table 1.** Diagnostic accuracy for adenomatous lesions

| | Sensitivity | Specificity | Accuracy | PPV | NPV |
|---|---|---|---|---|---|
| Overall | 84.5 (72.6–92.7) | 97.6 (87.4–99.9) | 90.0 (82.4–95.1) | 98.0 (89.4–99.9) | 82.0 (68.6–91.4) |
| High confidence | 97.6 (87.1–99.9) | 95.8 (78.9–99.9) | 96.9 (89.3–99.6) | 97.6 (87.1–99.9) | 95.8 (78.9–99.8) |

NOTE. All values are percentages at the 95% confidence interval (CI).

tumors. Because there is some controversy over whether SSA/Ps are neoplastic lesions, SSA/Ps were excluded. In this study, neoplastic lesions include low- or high-grade adenoma and invasive cancer, whereas nonneoplastic lesions include only hyperplastic polyps. The present study was approved by the Ethics Committee of Showa University Northern Yokohama Hospital (No. 1507–08), and was conducted according to the Declaration of Helsinki. The algorithm of our CAD system for EC-NBI has 3 phases: (1) image processing and quantification, (2) machine learning, and (3) diagnosis output. Details of the algorithm and endocytoscope are given in the supplementary information (Supplementary Document).

## Video Description

Video Clip 2 shows the clinical usage of our CAD system for EC-NBI. The first and second cases represent adenomatous lesions. The third and fourth lesions are hyperplastic polyps. When the endoscopist pushes a button on the endoscope, the captured images are sent to a laptop computer. The diagnosis (nonneoplastic or neoplastic) is output within 0.3 second. Figure 1 shows a screenshot from our CAD system.

To validate our system, 100 randomly extracted images were analyzed by the CAD system ex vivo. Supplementary Table 1 shows the clinicopathologic features of the present study sample. In the present study, the CAD system provided diagnosis for 100% (100/100) of the validation samples with a diagnosis time of 0.3 second per image. The sensitivity, specificity, accuracy, positive predictive value, and negative predictive value for neoplasms are given in Table 1. When the probability obtained by the support vector machine classifier was >90%, the output was considered to be a "high-confidence" diagnosis. High-confidence pathologic prediction was made in 65% (65/100) of the subject images. When limited to high-confidence output, all diagnostic accuracies for neoplasms were >95%. Furthermore, these validation samples included 3 intramucosal cancers and 2 invasive cancers. The system diagnosed all these lesions as "neoplastic." As for nonneoplasms, diagnostic accuracies were also extremely high (Supplementary Table 2). Additionally, for a sufficient number of images, our algorithm could be applied to other organs (ie, esophagus and stomach). However, there are some limitations of the present CAD system. It cannot diagnose cancers and SSA/Ps, because there are currently few EC-NBI images of invasive cancers and SSA/Ps for training. If there were more suitable images, we could develop a system that provides 4-class diagnosis (nonneoplastic, adenoma, invasive cancer, SSA/P).

## Take Home Message

Our new CAD system provides fully automated computer diagnosis without the need for any dye solution. Although 35% of the diagnoses were low confidence, the CAD system had an extremely high accuracy when applied to high-confidence diagnoses. Therefore, when there is high confidence regarding the diagnosis output, "diagnose-and-leave" and "resect-and-discard" strategies could be adopted in daily practice, even by novice endoscopists.

## Supplementary Material

Note: To access the supplementary material accompanying this article, visit the online version of *Gastroenterology* at www.gastrojournal.org, and at http://dx.doi.org/10.1053/j.gastro.2016.04.004.

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**Conflicts of interest**
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