Computer-aided system for predicting the histology of colorectal tumors by using narrow-band imaging magnifying colonoscopy (with video)

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Background: Narrow-band imaging (NBI) classification of colorectal lesions is clinically useful in determining treatment options for colorectal tumors. There is a learning curve, however. Accurate NBI-based diagnosis requires training and experience. In addition, objective diagnosis is necessary. Thus, we developed a computerized system to automatically classify NBI magnifying colonoscopic images.

Objective: To evaluate the utility and limitations of our automated NBI classification system.

Design: Retrospective study.

Setting: Department of endoscopy, university hospital.

Main Outcome Measurements: Performance of our computer-based system for classification of NBI magnifying colonoscopy images in comparison to classification by two experienced endoscopists and to histologic findings.

Results: For the 371 colorectal lesions depicted on validation images, the computer-aided classification system yielded a detection accuracy of 97.8% (363/371); sensitivity and specificity of types B-C3 lesions for a diagnosis of neoplastic lesion were 97.8% (317/324) and 97.9% (46/47), respectively. Diagnostic concordance between the computer-aided classification system and the two experienced endoscopists was 98.7% (366/371), with no significant difference between methods.

Limitations: Retrospective, single-center in this initial report.

Conclusion: Our new computer-aided system is reliable for predicting the histology of colorectal tumors by using NBI magnifying colonoscopy.

A narrow-band imaging (NBI) system can be used to examine microvessels on the superficial layer as well as the fine structure of colorectal lesions, with a single touch of a button on the grip of the colonoscope. Usefulness of the NBI system during magnifying colonoscopy for differential diagnosis between neoplastic and nonneoplastic lesions has been reported.[1,2] However, intraobserver and interobserver variance is a problem for colorectal lesion classification under NBI.[3] Interpretation of endoscopic findings remains subjective and can vary among individual endoscopists, especially novices. With some exposure to narrow-band images, novices' diagnostic accuracy improves, but not to the level of the experienced endoscopist.[4] The recent Preservation and Incorporation of Valuable Endoscopic Innovations (PIVI) initiative of the American Society for Gastrointestinal Endoscopy addressed real-time endoscopic assessment of the histology of diminutive colorectal polyps.[5] Even with training and exposure to NBI images, there is a steep learning curve in meeting the performance thresholds recommended under the PIVI initiative.[6,7] Although clinical training coupled with experience is a realistic approach to histologic prediction, a better approach would be objective evaluation of the classification criteria, such as

Abbreviations: NBI, narrow-band imaging; PIVI, Preservation and Incorporation of Valuable Endoscopic Innovations.

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computer-aided evaluation. This would provide a more objective diagnosis and allow non-expert endoscopists to achieve high diagnostic accuracy. The computer output also could be used as a "second opinion" to avoid oversights during colonoscopy and assist endoscopists' decision-making. Thus, we devised a computer-aided system for predicting the histology of colorectal tumors by using NBI magnifying colonoscopy, and we evaluated the reliability of this system in the study described herein.

Take-home Message

- The authors developed a new, reliable, computer-aided system for predicting the histology of colorectal tumors on narrow-band imaging magnifying colonoscopy images.

METHODS

Lesions and endoscopic procedure

We produced a set of validation images by gathering 371 NBI magnifying endoscopic images of colorectal lesions found in patients who underwent endoscopic or surgical resection at Hiroshima University Hospital during the period January 2005 through July 2010. The set did not include images that were considered unsuitable for evaluation (exclusion criteria: out-of-focus images, images that were blurred, images with halation). The colorectal lesions were of the following types: inflammatory (n = 3), hyperplasia (n = 44), adenoma (n = 188), carcinoma with intramucosal invasion (n = 66), and carcinoma with submucosal invasion (n = 70). Instruments used in this study were a magnifying videoendoscope system (CF-H260AZI; Olympus Optical Co, Ltd, Tokyo, Japan), which provides magnification power up to ×75 (optics magnification), and a standard optical videoendoscopic system, two light sources, and a digital image filing system. One light source was for the standard optical filter (broadband), and the other was for the NBI system. The lesions were first detected by conventional colonoscopy and then observed by NBI at maximum magnification. Informed consent was obtained from patients and/or family members for endoscopic examination and pathologic examination of tissue samples. The study was conducted with full approval of the ethics committee of Hiroshima University Hospital.

Pathologic examination

After detailed observation by NBI magnification endoscopy, we performed biopsy, endoscopic resection, or surgical resection for pathologic analysis. Results of pathologic analysis were taken as the reference standard for classification. Pathologic examination was performed on hematoxylin-eosin stained sections by a single pathologist unaware of the features of each case. After histologic diagnosis, the 371 lesions were classified into two groups according to histologic grade: nonneoplastic lesions (n = 47) and neoplastic lesions (n = 324).

Image classification by two experienced endoscopists

The stored NBI images were classified individually by two experienced endoscopists, one with more than 10 years and the other with more than 15 years of experience in the field of colonoscopy. The two endoscopists, who were blinded to the histologic findings, classified tumors according to the Hiroshima classification system (Fig. 1), as described previously.[8,9] For cases in which there was a discrepancy in judgment, the two endoscopists were asked to discuss the image and reach a joint decision. The NBI-based classifications determined by the two endoscopists are shown in relation to the histologic findings in Table 1.

Extraction of magnified NBI regions

From each magnified NBI image recorded at maximum optical magnification (Figs. 2A, 3A, and 4A), a 100 × 300 to 900 × 800–pixel region judged to represent a particular Hiroshima classification type was selected manually as a region of interest (Figs. 2B, 3B, and 4B) by an endoscopist who was blinded to the histologic findings.

Computer-aided system for lesion classification

We developed a custom software program (HuPAS version 3.1, Hiroshima University, Hiroshima, Japan) that can represent features from each region of interest and classify the region according to corresponding features on training images.[10] We used a "bag-of-features" representation of images. An image is represented by a histogram of visual words, produced by hierarchical *k*-means clustering of local features. We used a dense sampled scale-invariant feature transform descriptor as local features. The clustering is performed over all training images to generate *k* clusters (visual words). Scale-invariant feature transform descriptors are computed at points on a regular grid and at two scales of the local patch centered at each point. All descriptors of 128 dimensions are simply used by clustering. We used a regular grid because the texture in NBI images fills the whole image. As a classifier, we used a support vector machine with linear kernel (Fig. 5).

Classification by HuPAS version 3.1

We prepared a set of 1519 cut-out images (training images) from colorectal lesions recorded at maximum NBI magnification. The training images were obtained from another set of images used as validation images for