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Image-enhanced capsule endoscopy for characterization of small bowel lesions

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A B S T R A C T

Video capsule endoscopy has revolutionized direct endoscopic imaging of the gut.
Small-bowel video capsule endoscopy (SBVCE) is now the first-line procedure for exploring the small bowel in case of obscure digestive bleeding and has also some room in case of Crohn's disease, coeliac disease and polyposis syndrome. In case of obscure digestive bleeding the main lesions are angioectasias, erosions/ulcerations and tumors. As for conventional optical endoscopy search was done for improving the detection and characterization of small-bowel lesions. The Fujinon Intelligent Chromoendoscopy (FICE) has been adapted on the software of the SBVCE (Given Imaging®/Medtronics). Although there are some conflicting results on the efficacy of FICE for detecting more lesions than with conventional light, it is now recognized that FICE – particularly the setting 1 – may enhance the delineation or characterization of lesions. The use of three-dimensional representation technique is now feasible but still needs further research.

Introduction

The small bowel video capsule endoscopy (SBVCE) system consists of a wireless capsule containing a video camera, a sensing system and a personal computer workstation. SBVCE has revolutionized direct imaging of the small-bowel and is now widely used in clinical practice worldwide [1].

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The most common applications of SBVCE include investigation of obscure GI bleeding, suspected Crohn's disease, suspected or refractory celiac disease, suspected small-intestinal tumors and surveillance of patients with hereditary polyposis syndrome [2].

In case of obscure GI bleeding, the main lesions are angioectasias, erosions/ulcerations or tumors.

In conventional optical endoscopy, several methods have been developed for improving the detection and characterization of lesions including chromoendoscopy [3,4]. Improvements in image resolution software processing and optical filter technology have resulted in the production of high-definition endoscopes as well as optical contrast techniques such as narrow-band imaging, flexible spectral imaging color enhancement and i-scan.

Along with autofluorescence imaging and confocal laser endomicroscopy, these techniques have complemented and enhanced white light endoscopy.

There was also a search for improving lesion detection and characterization by video capsule endoscopy. For this purpose, the Fujinon Intelligent Chromoendoscopy method was adapted on the software of the SBVCE.

Fuginon intelligent chromoendoscopy-assisted capsule endoscoy (FICE): technique

FICE is a spectral estimation technology based on arithmetical processing of ordinary images, manufactured by Fujinon Corporation (Saitama, Japan). This dyeless imaging technique has been initially used on conventional endoscopes either for gastroduodenoscopy [5], colonoscopy [6] or double-balloon enteroscopy [7]. Use of FICE for capsule endoscopy does not require any re-engineering of the capsule, only integration of FICE software in the computer workstation. The wavelength spectrum used for creation of optical images is influenced by various factors: the spectrum of the light source, the optical device and the spectral sensitivity of the sensing element. However, these factors differ between flexible enteroscope and capsule endoscopy. Different FICE estimation algorithms with different estimation coefficients are required to optimize imaging. The spectral wavelengths of the FICE settings for capsule endoscopy are: Set 1: red 595 mm, green 540 mm, blue 535 mm; Set 2: red 420 mm, green 520 mm, blue 530 mm; and Set 3: red 595 mm, green 570 mm, blue 415 mm.

So, the FICE technology decomposes images by the specific wavelengths (red, green and blue) and then directly reconstructs the images with enhanced surface contrast. This leads to the enhancement of tissue microvasculature as a result of the differential optical absorption of light by hemoglobin in the mucosa. The FICE software has been incorporated in the RAPID 6.0 video capsule endoscopy workstation (Given Imaging®/Medtronics). With this innovation the examiner can easily select between conventional images and images reconstructed under three different FICE settings by the click of an icon in the Rapid Reader software for optimal mucosal visualization.(Figs. 1–4).

Pohl et al. were the first to report the use of FICE that was incorporated in the video capsule workstation in 10 consecutive patients with some positive aspect [8].

FICE in SBVCE: clinical data

Imagawa H et al. assessed whether visualization of lesions was improved by FICE image analysis. Five physicians compared FICE images with corresponding conventional images of 145 lesions obtained from 122 patients who underwent an SB capsule endoscopy. The lesion was classified as angioectasia, erosion/ulceration or tumor, and the 3 different sets of FICE were viewed [9]. Physicians rated the visibility of the lesions on FICE images as improved, equivalent or decreased. With FICE setting 1, improvement was achieved in 83% of angioectasia images, 53% of erosion/ulceration images and 25% of tumor images. With setting 2 improvement was achieved for 87%, 25% and 20%, respectively. With setting 3, only equivalence was achieved.

In another study, the SBVCE examinations (Pillcam SB2, Given Imaging®) – that were performed in patients with OGIB – were retrospectively analyzed by two GI fellows (observers) with and without FICE enhancement [10]. Randomization was such that a fellow did not assess the same examination with and without FICE enhancement. The senior consultant described findings as P0, P1 and P2 lesions which were considered as reference findings.