

INCREASING INFORMATION CAPACITY OF NARROW BAND IMAGING RESULTS IN DIAGNOSIS OF PREMALIGNANT LESIONS AND EARLY CANCER OF ESOPHAGUS

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The aim of the investigation is to improve the diagnostic value of narrow band imaging in verification of premalignant lesions of esophagus by the means of the technique of automatic detection of abnormalities revealed in the course of examination.

Materials and Methods. The research covered 1204 high resolution esophagoscopies with NBI (narrow band imaging). The mean age of the examined patients was 49±11 years. The patients' narrow band images were subject to colour segmentation using "EndoView" Program.

Results. A new technique allowed to diagnose 14 patients with Barrett's esophagus (1.16%), 3 patients with intestinal metaplasia (0.25%) and 2 patients with a low grade dysplasia (0.16%). 9 patients also had a low grade dysplasia in the area of peptic ulcers and strictures of esophagus (0.75%) and 3 patients demonstrated a high grade dysplasia/early cancer of esophagus (0.25%). The "EndoView" Program also enabled to reveal 7 more patients with small-focal abnormalities in esophagus, and in one of them an early esophageal cancer was diagnosed.

Conclusion. Colour segmentation of narrow band images increases the chances to diagnose the smallest abnormalities in esophagus. NBI endoscopy allows specifying premalignant lesions in esophageal mucosa in both low grade and high grade dysplasia that makes endoscopic examination highly informative and the case management strategy — more reasonable.

Key words: NBI endoscopy, colour image segmentation, Barrett's esophagus, early esophageal cancer.

The diagnosis of early esophageal cancer is a highly topical problem in Russia. In 75% of patients esophageal cancer has been diagnosed at II, III stages [1, 2] and cancer has been diagnosed at an early stage only in 5% of patients [3]. Over the last ten years we have been registering the reduction of incidence rate but five-year survival rates are still very low (about 1%) [4], thought one-year-mortality rates steadily tend to grow (reaching 63.2%) [5]. The situation stipulates an importance of timely diagnosis of not only cancer at an early stage but also premalignant lesions in esophageal mucosa including epithelial metaplasia and dysplasia.

Undoubtedly, endoscopy still remains the leading method in visualization of esophageal mucosa state. Only esophagoscopy enables to see and identify focal abnormalities, estimate the efficiency of treatment and define whether there are indications for case follow-up. Modern video endoscopic systems have additional options, due to which it is possible to receive clearer, multiple magnified images enabling doctors performing esophagogastroduodenoscopy to see initial abnormalities

in esophageal mucosa. At present Russian endoscopy is implementing precise diagnosis techniques such as narrow band, autofluorescence and confocal endoscopy. The examination of esophagus in a narrow light spectrum allows a specialist to better allocate the areas of pathological processes in mucosa, define the nature of such abnormalities as well as discover negligible pathologies hardly visible in usual examination. However, shortage of such equipment in Russia and a lack of experienced doctors carrying out such examinations prevent from detecting early cancer. In addition, there are no any formal descriptions of pathological esophageal conditions revealed using narrow band images nowadays that makes endoscopic research subjective.

The aim of the investigation is to improve the diagnostic value of narrow band imaging in verification of premalignant lesions of esophagus by the means of the technique of automatic detection of abnormalities revealed in the course of examination.

Materials and Methods. Narrow band imaging, a built-in function in EVIS EXERA II video imaging system (Olympus,

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Japan), helps to carry out a high quality examination of esophagus by a single press of the button on an endoscope handle. This technology works on an optical filter built in a light source and narrowing a white wave spectrum up to 415 and 540 nm that matches the length of blue and green waves. Penetrating depth of the blue light is limited by the mucosa structures while the green light penetrates down to submucosal layer. Both light waves are well absorbed by hemoglobin and makes it possible to define the structure and capillary pattern of the mucosa as well as the submucosal vessels [6].

The endoscopy department of Republic Clinical Hospital of Yoshkar-Ola has been equipped with the video imaging system 180 series EVIS EXERA II since February 2009. Over the period since January 2010 till March 2011 using this video imaging system we have examined 1024 patients aged from 18 to 85 years old (626 males and 578 females) with "esophageal" complaints — heartburn, the feeling of lump or pain behind the breastbone, regurgitation, gaseous eructation, discomfort when swallowing and gastric transit, and hiccup. The average age of examined patients was 49 ± 11 yrs. The research included therapeutic and surgical inpatients who underwent a planned esophagogastroduodenoscopy (EGDS) with an examination of the descending part of duodenum. To improve the visualization of the esophagus mucosa, the non-allergic patients were given two metering spoons (10 ml) of Espumisan per os as an anti-foaming agent. The patients were examined under local anesthesia using 10% lidocaine solution in spray form.

A target examination of esophagus was performed in two stages: during introduction and extraction of a gastroscope from the stomach. At the first stage we studied the presence of spots of damaged esophageal epithelium in the white light by switching digital zoom modes x1.2, x1.5 successively. In order to discover small focal abnormalities we examined it in a narrow band light spectrum successively zooming the picture, too. After the gastroscope was extracted from the stomach, we studied the size and nature of discovered abnormalities of mucosa in a narrow band light spectrum (the type of cylindrical metaplasia of epithelium, the presence/absence of dysplasia and/or early neoplasia of epithelium) and collected samples for a morphological research.

Cardiac type of cylindrical metaplasia in a distal part of esophagus looked like a rounded foveolar structure. Fundic type of cylindrical metaplasia appeared to have oval (longitudinal) foveolar structure. Incomplete intestinal metaplasia was seen as regular fissured structure. In all types of cylindrical metaplasia vascular patten was well differentiated in a NBI mode and was studied with respect to unidirectionality and branching uniformity that corresponds to normal blood supply and the absence of dysplasia [7].

The condition for diagnosing epithelium dysplasia was the presence of damaged architectonics of mucosa and helical vessels of abnormal size. According to Kudo's classification [8] there was carried out the differential diagnostics between low and high grade dysplasia based on the degree of multi-direction and unevenness of capillary branching as well as

the degree of manifestation of structural damage of the epithelial pattern [9]. In cases when the mucosal surface showed an irregular fissured structure and differently directed capillary pattern low grade epithelium dysplasia was diagnosed. If any pattern was absent in the mucosal structure or pathological (thickened, branched, destroyed) blood vessels were seen, such epithelium was recognized as high grade dysplasia or early neoplasia.

After abnormal areas detection and their visual examination for neoplastic abnormalities there was performed a target biopsy in order to get the material for further histological examination.

The stage of esophageal cancer was determined based on the results of a pathologist's report after surgery.

As part of the research there were also recorded video segments for further study of the obtained results using original "EndoView" program. This program was designed both for prepared images and video files processing and the real-time analysis of video information incoming from an endoscope. The program makes it possible to classify each pixel of an NBI image as belonging to one of the distinguishing colours showing the state of mucosa and form an image reflecting the results of colour segmentation in a form of a map of distribution of these colours. Based on the results of the statistic analysis of NBI images there were prepared standard colour pallettes containing easy-to-read information about colour specifications of healthy tissues and tissues with various kinds of esophageal abnormalities. In the course of colour segmentation of narrow band images normal esophageal mucosa was presented in green colour while inflammatory or neoplastic abnormalities — in orange-red colour.

The following statistical indicators were used for describing the data: number of patients (n); share (percentage from the total number); average value of an indicator in the studied group (M); and a mean square deviation (σ). Statistical processing of obtained data was performed with the help of Microsoft Excel for Windows XP Professional software package.

Results and Discussion. When examining esophagus in white and narrow light spectrum there was discovered non-erosive reflux esophagitis in 325 patients (19.52%), the first degree reflux esophagitis — in 157 patients (13.04%), the second degree reflux esophagitis — in 72 patients (5.98%), the third degree reflux esophagitis in 42 patients (3.48%), and the fourth degree reflux esophagitis — in 23 patients (1.91%) (according to Savary-Miller classification of reflux esophagitis). The patients with the fourth degree reflux esophagitis were of primary medical interest, they having such complications as Barrett's esophagus — 14 patients (1.16%), peptic ulcer — 10 patients (0.83%), and peptic esophageal stricture — 6 patients (0.5%). Moreover, 3 patients were found to have esophageal papillomas (0.25%), 7 patients — esophagogastric junction polyps (0.58%), 3 patients — early esophageal cancer (T_0 stage) (0.25%), 4 patients — esophageal cancer at T_2 - T_3 stages (0.33%) and 1 patient with cancer at T_4 -stage (0.08%).

As a result of visual examination of narrow band images, patients with Barrett's esophagus demonstrated a fundic type of cylindrical metaplasia (Fig. 1) in 6 cases (0.5%), a

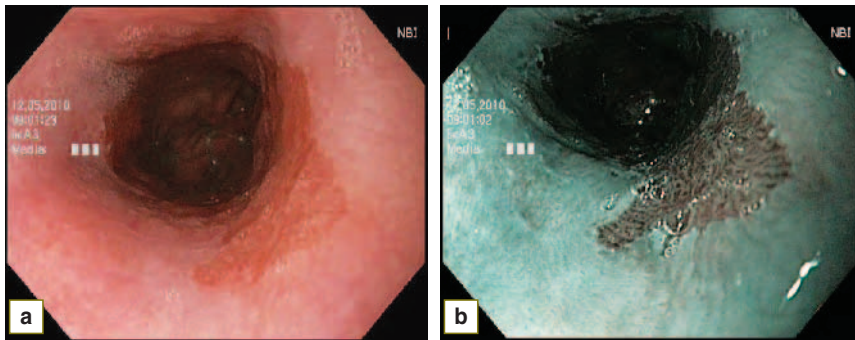


Fig. 1. Barrett's esophagus, fundic type of cylindrical metaplasia of esophageal epithelium: *a* — white light image; *b* — NBI image

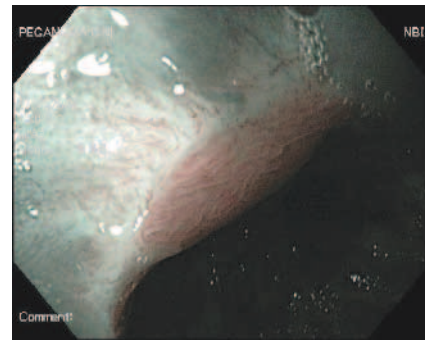


Fig. 2. Barrett's esophagus developed on the basis of hiatal hernia (intestinal metaplasia of esophageal mucosa in NBI)

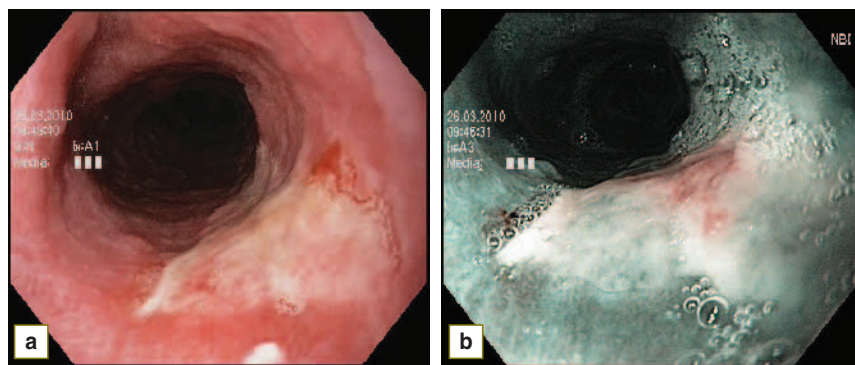


Fig. 3. Isolated ulcer of the thoracic part of esophagus (low grade dysplasia): *a* — white light image; *b* — NBI image

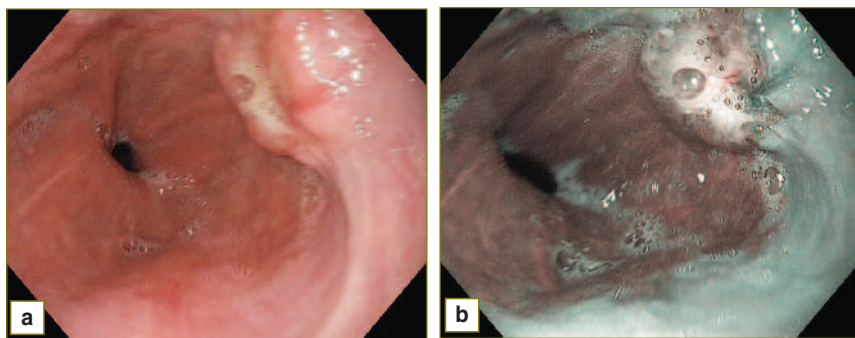


Fig. 4. Early esophageal neoplasia T_{0-1b} (moderately differentiated adenocarcinoma): *a* — white light image; *b* — NBI image

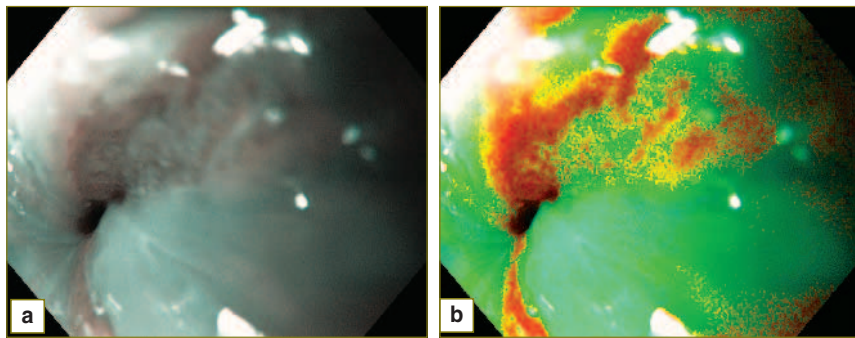


Fig. 5. Heterotopia areas in the upper esophageal sphincter: *a* — NBI image; *b* — colour segmentation of an NBI image

cardiac type of cylindrical metaplasia in 3 cases (0.25%), an intestinal type (Fig. 2) of cylindrical metaplasia in 2 cases (0.16%) and a mixed type in 3 cases (0.25%); cardiac/fundic type of metaplasia in 2 cases (0.16%) and fundic/intestinal type of metaplasia in 1 case (0.08%).

5 patients showed areas of low grade epithelium dysplasia with peptic esophageal ulcer (0.41%), 3 patients — peptic esophageal stricture (0.25%), 2 patients — intestinal metaplasia with Barrett's esophagus in clinical picture (0.16%) and one patient with isolated ulcer in the thoracic part of esophagus (Fig. 3). High grade dysplasia/early esophageal neoplasia was found in the abdominal part of esophagus of 1 patient (0.08%) (Fig. 4), and in 2 patients (0.16%) — in the inferior segment of esophagus.

The type of vessel patterns seen on the surface of esophagogastric junction polyps and esophageal papillomas in a narrow band imaging mode corresponded to the hyperplasia of the squamous cell epithelium, no elements of dysplasia being detected.

In the course of further analysis of video files by exposing recorded NBI images to colour segmentation in the "EndoView" program there were additionally found 6 patients with heterotopia areas in the cervical part of esophagus (0.5%) (Fig. 5), and one patient (0.08%) with early cancer (IIa+b type) of the thoracic part of esophagus (Fig. 6).

In all cases the results of narrow band imaging of esophagus with further colour segmentation corresponded to the results of histological examinations. This gives the right to claim that narrow

band imaging is one of the leading generally accessible express methods of diagnosis of premalignant lesions and early esophageal cancer. The NBI function combined with magnification and high resolution enables to perform differential diagnostics of various types of the metaplasia in patients with Barrett's esophagus and, if there is intestinal metaplasia or dysplasia, plays an important role in determination of conditions for the case follow-up [10–12]. The detection of low grade dysplasia enables to predict the risk of esophageal adenocarcinoma development and the detection of high grade dysplasia/early cancer enables to define the terms and conditions for a surgery [13–15].

The analysis of the obtained results using the colour segmentation method proves the efficiency of automatic processing of narrow band images in the "EndoView" program in order to increase the information capacity of endoscopic examination of esophagus.

Conclusions. Narrow band magnification and high resolution endoscopy helps to improve the visualization of the surface of esophageal mucosa and define the degree of damage of the vessel pattern architectonics which enables to detect abnormal areas with increased risk of malignancy and early cancer. Based upon a complete agreement of the results of endoscopic and histological reports, it is completely safe to say that examination of the epithelial surface and the vessel pattern of esophagus in a narrow light spectrum is an important transient stage in endoscopic diagnostics — from a macroscopic level to a microscopic one.

An additional technique increasing the chances of detecting micro-focal pathologies of esophagus, especially at the stage of mastering the narrow band imaging endoscopy, can be automatic highlighting and then colour segmentation of obtained NBI images in the "EndoView" program.

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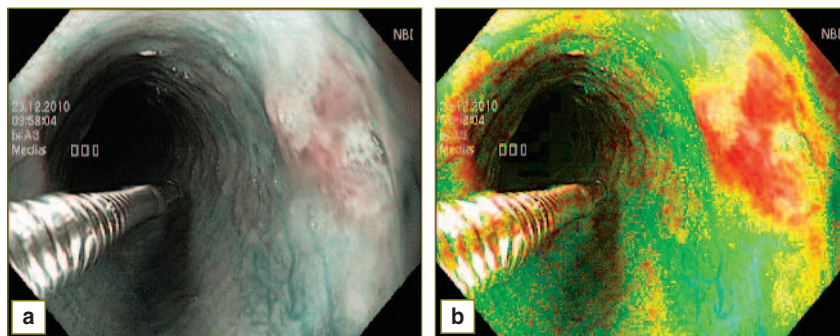


Fig. 6. Early esophageal cancer (Ila+b type): a — NBI image; b — colour segmentation of an NBI image

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