INTRODUCTION

Colonoscopic detection and removal of polyps represent the most important prevention method for colorectal cancer (CRC) [1], with a decrease of 76-90% in CRC incidence, in large cohorts of patients who had adenomas removed [2]. However, because 17-24% of polyps are missed during colonoscopy [3], new endoscopic techniques have been developed to increase the detection rate of adenomas. These techniques include: high-definition endoscopy, conventional or virtual chromoendoscopy (i.e., narrow band imaging [NBI], i-Scan digital contrast [i-SCAN], and flexible spectral imaging color enhancement [FICE] technologies), and autofluorescence imaging [4]. Due to the ability to differentiate between neoplastic and other types of polyps (i.e. non-neoplastic polyps), these methods allow a better characterization of polyps and thus affect decision-making about polyps removal during colonoscopy. Even in the case when only adenomas are removed, a decrease in the complication rates after polypectomies is observed, the procedure time is reduced, and the cost of histological analysis is lowered [5-7].

Chromoendoscopy has a sensitivity of 91% and a specificity of 89% in differentiating neoplastic lesions from non-neoplastic polyps according to the Kudo’s classification [8]. NBI, also called “electronic” or digital chromoendoscopy, uses optical filters to enhance the visualization of vascular details and mucosal surface morphology [9,10]. The sensitivity and specificity of NBI are similar to those of chromoendoscopy [11]. The working principle of NBI relies on the properties of the hemoglobin as the major tissue chromophore. The peak absorption of oxyhemoglobin is at 415 nm (blue light). A secondary peak of absorption is at 540 nm (green light). NBI technique uses a special filter placed in the light source that allows only narrow band of blue and green light to pass through. The vasculature of the mucosa appears bluish green; as a result the...
surface vascular pattern as well as the morphology of the tissue are enhanced [12]. Adenomas are easily recognized using NBI technique due to the presence of enhanced microvascular density [13]. Although several studies investigated the utility of NBI in detection, characterization, and differentiation of colon lesions [8-11], only few of these studies focused on the usefulness of NBI in daily practice.

The aim of this paper was to determine the diagnostic yield of NBI colonoscopy for polyp detection and characterization in comparison with standard colonoscopy. The primary endpoints were polyp detection rate (PDR) and adenoma detection rate (ADR) in patients who underwent NBI or standard colonoscopy.

**MATERIALS AND METHODS**

**Patient selection**

A prospective, randomized study was carried out during October 2013 and July 2014, at an ambulatory center of digestive endoscopy in Cluj-Napoca, Romania. Patients who underwent total colonoscopy were included in the study. The working protocol was approved by the Ethical Committee of University of Medicine and Pharmacy Cluj-Napoca (374/2014) and informed consent was obtained from patients before every procedure.

The methodology in our study was similar to those described in a previous study [14]. Patients were randomized prior to sedation. Patients were asked to pick an envelope after the informed consent was obtained. The envelopes were numbered inside from 1 to 600. Patients who selected odd numbers were included in the group examined by standard colonoscopy (non-NBI group), and those with even numbers were included in the group examined by NBI colonoscopy (NBI group).

**Inclusion and exclusion criteria**

The inclusion criteria were: patients scheduled for colonoscopy due to lower gastrointestinal symptoms, screening for CRC in patients with a first-degree relative with CRC, and surveillance of patients with previous polyps or CRC.

The exclusion criteria included: incomplete colonoscopies, familial adenomatous polyposis, CRC, inflammatory bowel disease, detection of CRC during examination, and coagulopathy.

After the exclusion criteria were applied, out of 580 patients, 505 were included in the study. Among the 505 patients, 226 were examined by NBI technique and 279 by standard colonoscopy.

**Bowel preparation**

For bowel preparation, a split-dose of polyethylene glycol solution was used in most patients. Endoscopists assessed the quality of bowel preparation as good (almost 100% of colonic mucosa visualized), satisfactory (more than 90% of colonic mucosa visualized), and precarious (less than 90% of colonic mucosa examined). Patients with inadequate bowel preparation were excluded from the study.

**Colonoscopy**

Three gastroenterologists performed the colonoscopies (mean cecal intubation rate: 99.2%) using video colonoscopes Olympus CL 160 (8 examinations) and Olympus CL 180, and Olympus Exera II and III endoscopy systems for NBI. The documentation of complete colonoscopies included photographs of the ileocecal valve, appendix, and terminal ileum.

Most colonoscopies (90.5%) were performed under superficial analgesedation using midazolam; in 8.4% of patients a deep analgesedation was used, and 1.1% of patients did not require sedation.

The withdrawal time was minimum 8 minutes in all patients. A detailed examination of every polyp was performed, and photographic documentation was obtained. In NBI group, the withdrawal examination was performed using only NBI filters. Polyps were considered to be on the right side of the colon if they were detected from the cecum to the splenic flexure, and to be on the left side of the colon if they were localized from the left colic flexure to the anus.

For each patient the following data were recorded: age, sex, referral reasons, number, size and location of polyps and histological analysis.

**Polyp characterization**

Polyps detected with NBI technique were characterized according to the NICE classification, which was recently validated by a panel of international experts [15]. Based on the NICE guidelines, polyps are classified according to the lesion color, microvascular architecture, and pit pattern classification of mucosa (the opening of crypts of Lieberkühn on the mucosal surface). Using this classification, three types of polyps were recorded: Type 1 - hyperplastic (Figure 1); Type 2 - adenomatous (Figure 2); and Type 3 - malignant (Figure 3).

All detected polyps were removed during colonoscopy. The dimension of a polyp was determined with biopsy forceps. Ninety-three percent of removed polyps were recovered and a histological analysis was performed to determine the type of a polyp, presence and degree of dysplasia, and whether the polyp was completely removed. Dysplasia was classified according to the Vienna classification into low-grade dysplasia (LGD) and high-grade dysplasia (HGD) [16]. Intramucosal carcinoma and in-situ carcinoma were included into HGD. Invasive carcinoma was considered if the malignant cells spread to the submucosa.
Statistical analysis

IBM SPSS Statistics for Windows, Version 20.0. (IBM Corp., Armonk, NY) was used for statistical analysis. Parametric data were expressed as means ± standard deviations. The comparison between groups was done using the Mann–Whitney U test. Non-parametric data were expressed as frequencies and compared using the Fisher’s exact or Chi-squared tests. Characteristics of groups such as polyp location and morphology were analyzed using the Student’s t, Mann–Whitney U, and Fisher’s exact test. The results were considered statistically significant if p value was less than 0.05. The correlation between NBI results and histological analysis was determined using the Pearson correlation coefficient (r = 0.8-1 was considered as a very high correlation, r = 0.6-0.8 as a high correlation, r = 0.4-0.6 as a reasonable correlation, and r > 0.4 as a low correlation). The diagnostic precision was calculated using the final histological report.

RESULTS

A total of 505 patients, who underwent complete colonoscopy, were included in the study. The patients were randomized into two groups: NBI group included 226 patients, and non-NBI group (patients who underwent standard colonoscopy) included 279 patients. The median age was 53.3 years in NBI group and 52.7 years in non-NBI group. No significant differences were observed between the groups with regard to the age, sex, quality of bowel preparation (Table 1), and referral reasons, except rectal bleeding (Table 2).

In 125 patients from NBI group and in 121 patients from non-NBI group at least one polyp was observed. In 80 patients
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from NBI group and in 56 patients from non-NBI group at least one adenoma was detected. In NBI group, the PDR was 55.3% and ADR was 35.39%. In non-NBI group, the PDR was 43.3% and ADR was 20.07%. The total number of polyps detected in the two groups and their locations are presented in Table 3.

Histological analysis of polyps in NBI group

In NBI group, a total of 325 polyps were detected: 215 adenomas (66.15%), 106 hyperplastic polyps (32.62%), and 4 carcinomas (1.23%). The majority of adenomas were tubular (n = 190; 88.37%). Serrated adenomas were detected in 19 patients (8.8%). Left-sided adenomas were more prevalent than right-sided (11% versus 8%, respectively). Right-sided adenomas represented one-third of all detected adenomas (n = 73; 33.95%). The largest polyps were detected in the sigmoid colon (9.69 ± 0.77 mm) and the smallest polyps were observed in the transverse colon (7 ± 0.59 mm).

Comparative analysis between NBI and non-NBI groups

The total number of detected polyps in NBI group was significantly higher compared with non-NBI group (325 polyps in 226 patients versus 189 polyps in 279 patients, respectively; p < 0.001). The PDR in NBI group was 55.3%, versus 43.3% in non-NBI group. In addition, a statistically significant difference was observed in the ADR between NBI and non-NBI group (35.39 % versus 20.07%, respectively; p = 0.01).

The proportion of detected adenomas in the left-sided colon was significantly higher in NBI group compared with

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<th>TABLE 1. General characteristics of patients in NBI and non-NBI groups</th>
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NBI: narrow band imaging

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<th>TABLE 2. Referral reasons in NBI (n=226) and non-NBI (n=279) groups</th>
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<td>Symptoms</td>
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NBI: narrow band imaging; CRC: colorectal cancer

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<tr>
<th>TABLE 3. Number and location of detected polyps in NBI (n=325) and non-NBI (n=189) groups</th>
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<td>Polyp distribution</td>
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<td>Left colon (descending and sigmoid colon)</td>
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<td>Rectum</td>
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NBI: narrow band imaging

Histological analysis of polyps in non-NBI group

In non-NBI group, a total of 189 polyps were detected: 118 adenomas (62.43%), 70 hyperplastic polyps (37.03%), and 1 carcinoma (0.5%). The majority of adenomas were tubular (n = 98; 83.05%). Serrated adenomas were detected in 11 patients (9.32%). Left-sided adenomas were more prevalent than right-sided (7% versus 4%, respectively). Right-sided adenomas represented one-third of all detected adenomas (n = 38; 32.2%). The majority of hyperplastic polyps were left-sided (71.42% [50/70]). The largest polyps were detected in the sigmoid colon (14.7 ± 2.48 mm) and the smallest polyps were observed in the rectum (5.84 ± 0.86 mm).

FIGURE 3. NBI colonoscopy. (A) Polyp type 3 according to the NICE; malignant tumor with no surface pattern, and with erosions. (B) Histological appearance of the malignant polyp (mucinous adenocarcinoma). NBI: Narrow band imaging; NICE: NBI International Colorectal Endoscopic.

NBI: narrow band imaging; CRC: colorectal cancer

from NBI group and in 56 patients from non-NBI group at least one adenoma was detected. In NBI group, the PDR was 55.3% and ADR was 35.39%. In non-NBI group, the PDR was 43.3% and ADR was 20.07%. The total number of polyps detected in the two groups and their locations are presented in Table 3.

Histological analysis of polyps in NBI group

In NBI group, a total of 325 polyps were detected: 215 adenomas (66.15%), 106 hyperplastic polyps (32.62%), and 4 carcinomas (1.23%). The majority of adenomas were tubular (n = 190; 88.37%). Serrated adenomas were detected in 19 patients (8.8%). Left-sided adenomas were more prevalent than right-sided (11% versus 8%, respectively). Right-sided adenomas represented one-third of all detected adenomas (n = 73; 33.95%). The largest polyps were detected in the sigmoid colon (9.69 ± 0.77 mm) and the smallest polyps were observed in the transverse colon (7 ± 0.59 mm).
DISCUSSION

Because conflicting results have been reported regarding the role of NBI technique in polyp detection [12,14,17,18], this study focused on investigating the diagnostic yield of NBI technique for polyp detection and characterization in daily practice.

A number of studies evaluated the role of NBI colonoscopy in determining PDR and especially ADR, due to more detailed characterization of tissue and vascular pattern that is possible using NBI filters. ADR represents a direct measure of quality in colonoscopy, since the main goal in CRC screening and surveillance programs is more accurate detection of adenomas.

In pilot studies on the efficacy of NBI colonoscopy in polyp detection, a higher number of neoplastic polyps were detected with NBI compared with the standard procedure [12,14]. In the study conducted by Uraoka et al. [14], flat and right-sided adenomas were detected using NBI.

However, other studies showed contrasting results. In the study by Rex et al. [17], conducted in a medium-risk population for CRC in the USA, the same ADR was reported for NBI and standard colonoscopy procedure. In a study by Adler et al. [18], that involved 1256 patients split into two groups, an increased ADR was not observed in the group examined by high-definition NBI colonoscopy compared with the group examined by other high-definition colonoscopy procedures [18].

Two recent meta-analysis, one that included 2936 patients from 7 randomized studies [19], and the other that analyzed 3056 patients from 9 studies [20], did not find a significant difference between ADR, flat adenoma detection rate, or rate of missed adenomas between NBI and standard colonoscopy procedure in a medium-risk population for CRC.

In our study, both the PDR and ADR were significantly increased in NBI group. Interestingly, a higher number of adenomas were detected in the left-sided colon in our study, compared with previous studies that reported a higher ADR in the right-sided colon using NBI. Similar results as ours were obtained in a study by Inoue et al. [21]. The higher number of adenomas might be due to the presence of bile in the right colon, that is visualized in red color with NBI filters, and also due to a larger lumen that reduces the brightness of the NBI image.

The high proportion of patients with colon polyps (55% in NBI group and 43% in non-NBI group) observed in our study might be due to several reasons, including: experience of endoscopist, exclusion of patients with poor bowel preparation, and withdrawal time of more than 8 minutes. The high PDR, observed in our study, was not biased by the inclusion of patients with a high risk of CRC, since the percentage of patients with first-degree relatives with CRC and patients with previous adenomas or CRC, was less than 10%. The higher PDR observed in our NBI group, compared with non-NBI group, is related to the higher number of small polyps (less than 5 mm), which has also been demonstrated in previous reports. In addition, a higher number of flat adenomas and HGD were detected in our NBI group, compared with non-NBI group [12,14].

Although an increased detection rate of hyperplastic polyps was reported with NBI techniques [22], in our study this rate was only higher in the right-sided colon.
Many studies also focus on diagnostic accuracy of different techniques for colon polyp detection, such as standard colonoscopy, chromoendoscopy, and NBI. The accuracy to differentiate between neoplastic and non-neoplastic lesions is higher for standard or virtual chromoendoscopy [23], and there is no significant difference between these two techniques [8,24]. In the study conducted by Zhou et al. [25], a prediction rate for NBI in polyp detection was 93% in relation to histological analysis [25]. When NBI technique was used without magnification, the prediction rate was 80-86% [25]. In our study, the accuracy of NBI technique without magnification in polyp detection was 91.1% in relation to the results of histological analysis.

Although high accuracy rates in polyp detection were observed for NBI procedure, this technique depends on the experience of the endoscopist. Lower performance rates were reported for endoscopists who are not very familiar with NBI procedure; they showed 76-78% accuracy in the detection of polyps smaller than 1 cm [26,27]. In our study the endoscopists are experts in their field, which might explain the observed high accuracy rate for NBI. The majority of misdiagnosed hyperplastic polyps in our study, analyzed using NBI, were serrated adenomas.

In current clinical practice, all detected colon polyps are removed and histological analysis is performed. The majority of detected polyps are smaller than 5 mm without significant histological findings [28]. An adequate differentiation between neoplastic and non-neoplastic lesions is necessary during colonoscopy, for a proper management of small polyps (less than 5 mm). The American Society for Gastrointestinal Endoscopy proposed a system called Preservation and Incorporation of Valuable Endoscopic Innovations (PIVI) which includes two strategies: “resect and discard” and “do not resect.” This system is based on photo documentation of detected polyps [29] and has an accuracy of 91% [30]. Nevertheless, this strategy for small polyps also depends on the experience of an endoscopist, where the accuracy of procedure in detecting small polyps is 83%, when performed by less experienced endoscopists [31].

CONCLUSION

We found increased PDR and ADR for NBI colonoscopy without magnification. A higher number of diminutive polyps were detected in the left-sided colon; also a higher number of flat adenomas and HGD were observed using NBI technique. In addition, we documented a high accuracy rate (91%) for NBI colonoscopy without magnification, with a sensitivity of 90.9% and specificity of 95.2%.

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DECLARATION OF INTERESTS

The authors declare no conflict of interests.

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