ORIGINAL ARTICLE

Narrow-band imaging and white-light endoscopy for detection of colorectal polyps: a randomized study

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KEY WORDS

missed adenomas, missed polyps, polypectomy, repeated colonoscopy

ABSTRACT

INTRODUCTION Narrow-band imaging (NBI) is a new, promising technique that might be helpful in the detection of colorectal polyps during colonoscopy.

OBJECTIVES The aim of the study was to compare the usefulness of NBI with white-light endoscopy (WLE) for the detection of polyps as well as to determine the distribution of missed polyps.

PATIENTS AND METHODS This was a randomized controlled trial. A total of 253 patients were included, in whom colonoscopy was performed twice: 126 patients underwent 2 procedures using white light, while in 127 patients NBI was used for the second procedure. The number and location of colorectal polyps identified during the second colonoscopy were recorded.

RESULTS No significant differences were observed in the rates of detected polyps, adenomas, and hyperplastic polyps between the WLE and NBI groups (38 vs. 48, $P < 0.2051$; 11 vs. 19, $P < 0.12$; 27 vs. 29, $P < 0.4647$, respectively). A half of all missed adenomas (n = 15) were found in the cecum and the ascending colon.

CONCLUSIONS WLE and NBI seem to be equally effective in identifying missed adenomas and hyperplastic polyps during colonoscopy. Repeated endoscopy of the cecum and ascending colon may significantly increase the number of detected adenomas.

INTRODUCTION Colonoscopy is the preferred technique for polyp detection and colorectal cancer prevention.[1-3] However, despite ongoing technological progress, colonoscopy still has a substantial miss rate for colon polyps, which may lead to colorectal cancer even in patients undergoing proper endoscopic surveillance.[4,5] In a meta-analysis by van Rijn et al.,[6] the miss rate for polyps of any size was as high as 22% in tandem colonoscopies. Improvement in polyp detection may be achieved by enhancing the quality of colonoscopic examinations and by developing new endoscopic imaging methods.[7-9]

The most important factor that affects quality in colonoscopy is proper colon preparation.[10] Although no preparation scale is widely accepted, examination reports often request descriptions of the quality of bowel preparation.[11]

The descriptive terminology that is commonly used makes the objective assessment and comparisons used in clinical trials almost impossible. The recently published Boston Bowel Preparation Scale (BBPS)[12] seems to be a simple and objective tool for rating the quality of bowel preparation. It has been proved that higher scores (≥5 vs. <5) were associated with a higher polyp detection rate (40% vs. 24%, $P < 0.02$).[12] It was suggested to note scores from 0 to 3 within each segment of the colon rather than only 1 score for the entire length.[13] Such modifications would provide more accurate information on the colon preparation and would enable the endoscopist to make better clinical decisions.

The adenoma detection rate (ADR), which is the fraction of patients with at least 1 adenoma, is currently the most common tool for

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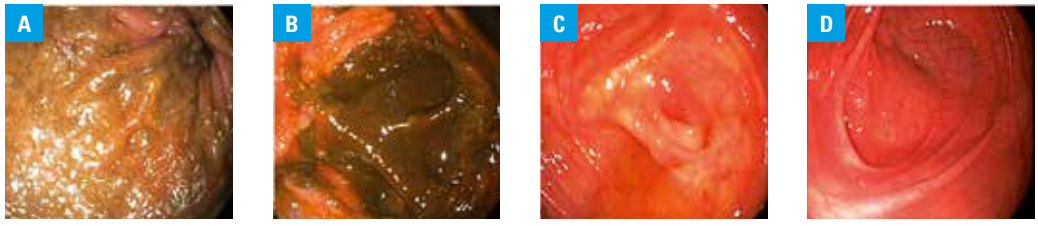

FIGURE 1 The Boston Bowel Preparation Scale; **A** – segment score, 0: unprepared colon segment with no mucosa visible; **B** – segment score, 1: only portion of the mucosa of the colon segment visible; **C** – segment score, 2: minor amount of residual stool but mucosa of the colon segment visible well; **D** – segment score, 3: the entire mucosa of the colon segment visible well

evaluating the efficiency of endoscopists.[11] Therefore, the ADR is the primary measure of outcome in the majority of studies on new endoscopic technology leading to an improvement in the quality of colonoscopies.[7] A recent study by Kaminski et al.[14] confirmed that the ADR is an independent predictor of the risk of interval colorectal cancer.

Another variable related to the quality of colonoscopy is the endoscope withdrawal time.[11] The US Multi-Society Task Force on Colorectal Cancer, the American Society for Gastrointestinal Endoscopy, and the American College of Gastroenterology Task Force on Quality in Endoscopy recommend 6 minutes as the minimum withdrawal time to ensure high-quality colonoscopy.[15]

Although it has recently been proved that chromoendoscopy can detect more polyps than standard colonoscopy,[16] this method has not been widely accepted in routine practice because it is inconvenient in use.[17-19] Panchromocolonoscopy takes longer to perform than standard colonoscopy, which is unacceptable in screening colonoscopy.[16-19] New image enhancement techniques, known as electronic chromoendoscopy, have been developed to eliminate the disadvantages of chromoendoscopy.

Narrow-band imaging (NBI) is an optical image-enhancement technology that enhances vessels and their patterns in the mucosa by employing narrow spectra of blue and green light.[20] Consequently, we may observe the mucosa in an unnatural brownish color, with the vessels appearing as dark dots and stripes. The unquestionable advantage of this method is that it only requires 1 second to change the picture to NBI mode by pressing the button on the head of the endoscope. Although the visual result of NBI is similar to chromoendoscopy, the effectiveness of NBI in colon polyp detection has not been confirmed, and the available studies yielded conflicting results.[21-29] Proving the superiority of NBI over white light in polyp detection would thus provide significant benefits for everyday endoscopic practice.

PATIENTS AND METHODS From October 2009 to August 2010, all of the patients who were referred for a diagnostic or a screening colonoscopy to NZOZ Endoterapia (Warsaw, Poland) and who met the inclusion criteria were enrolled to the study. The exclusion criteria were as follows: colon surgery in the past, macroscopic features of advanced cancer, endoscopic suspicion or previously diagnosed inflammatory bowel disease, lack of patient consent for polypectomy or contraindications for polypectomy, incomplete colonoscopy, melanosis coli, BBPS score of 0 or 1 for any of the 3 colon segments and known history of an unresected polyp in the previous examination.

All examinations were conducted by the same endoscopist, who had performed over 7000 colonoscopies over his lifetime and had used NBI in everyday practice for over 1 year before the start of the study. The study was approved by the ethical committee of the Warsaw Medical University.

After reaching the cecum with the colonoscope, patients were randomly assigned to the NBI group or the white-light endoscopy (WLE) group. Then, the cecum and ascending colon were examined in white light, and all polyps were removed and retrieved for histology. Afterwards the colonoscope was introduced to the cecum again, and a second examination of the cecum and ascending colon was conducted using either white light (WLE group) or NBI (NBI group). All polyps were retrieved for histology in separate bottles. The entire colon was examined as the instrument was withdrawn in 5- to 20-centimeter intervals. The length of the colon fragments was determined by a number of morphological signs such as flexures, polypectomy sites, characteristic vessel patterns, and, if no such signs could be found, tissue scarring from biopsy forceps. Consequently, all patients underwent 2 colonoscopies. In the WLE group, both examinations were conducted in white light. In the NBI group, the first examination was in white light and the second with NBI.

The bowels were prepared using polyethylene glycol lavage with 4-liter solution until rectal effluent was clear. The bowel preparation was evaluated after additional cleaning with a water jet using the Boston Bowel Preparation Scale. Three regions of the colon (i.e., the right colon [cecum and ascending colon], transverse colon [with hepatic and splenic flexures], and left colon [descending colon, sigmoid colon and rectum]) were each scored from 0–3 points (FIGURE 1). Only patients with at least 2 points for each part were randomized for the study.

Each patient's record contained the following parameters: age, sex, withdrawal time, polyp size and location, histology findings after polyp removal, and BBPS score.

The main outcome measure was the number of missed polyps (adenomas and hyperplastic polyps) in the 2 groups. The secondary outcome measures were the location of missed adenomas, the ADR change after the second examination,

TABLE 1 Detection of polyps in the study groups

	NBI group	WLE group
all polyps		
first colonoscopy, n	224	182
second colonoscopy, n	48	38
adenomas		
first colonoscopy, n	100	89
second colonoscopy, n	19	11
hyperplastic polyps		
first colonoscopy, n	124	93
second colonoscopy, n	29	27

Abbreviations: NBI – narrow-band imaging, WLE – white-light endoscopy

the effect of the colon preparation on polyp detection, and the miss rate.

All colonoscopies in both studies were performed using Olympus endoscopes with NBI (CF-H180) without optical magnification and standard monitors (OEV203), which did not include a high-definition mode. Histological examinations were conducted in the NZOZ Consilio (Łódź, Poland).

The number of detected polyps was modeled by generalized linear models with Poisson or negative binomial errors. The coefficients of the models (i.e., slopes and intercepts) were estimated with the bootstrap approach. If possible, bias-corrected, accelerated intervals on the confidence levels of 1-α = 0.95 were computed. Additionally, permutation tests were used to estimate the *P* values of the statistics. The Cohen's kappa coefficient was used for interrater agreement, and the Cochrane test was used to verify identical effects. The statistical significance for all tests was α = 0.05. All calculations and simulations were conducted using the R Project for Statistical Computing v. 2.11.0.

RESULTS A total of 253 patients were included in the study, 127 (40 men) in the NBI group and 126 (43 men) in the WLE group. The mean age in the NBI and in the WLE groups was 58.5 years and 55.8 years, respectively.

The first examination for both groups was performed in white light, and a total of 406 polyps were found (189 adenomas and 217 hyperplastic polyps). In the second examination, 76 polyps were found. The details are presented in TABLE 1.

There was no difference between the NBI and WLE groups in the total number of missed polyps, missed adenomas, or missed hyperplastic polyps found in the second endoscopy (P <0.2051; P <0.12; P <0.4647, respectively).

Among the 253 patients in both groups, 101 had at least 1 adenoma in the first colonoscopy, and the ADR for the first examination was 39.92%. The second colonoscopy in the NBI group revealed adenomas in 6 patients who did not have adenoma in the first examination; in the WLE group, adenomas were found in 5 patients who had no adenomas after the first colonoscopy. No difference in the ADR was found between the groups after the second examination (χ^2 value = 0.087; P = 0.7681). The number of adenomas per subject after the first colonoscopy was 0.747 (95% confidence interval, 0.6008–0.951). In the second examination, 19 missed adenomas were found in the NBI group and 11 in the WLE group. The number of adenomas per subject after both colonoscopies was 0.897 for the NBI group and 0.834 for the WLE group, but the difference was not significant (P = 0.1205).

The miss rates for adenomas and hyperplastic polyps for the NBI group and the WLE group were the highest in the cecum and ascending colon (17% and 30%, respectively). In both groups, 15 of 30 missed adenomas (50%) were in the cecum and ascending colon (TABLE 2).

In 253 patients, the mean BBPS score was 2.67. The preparation of the colon segments and the overall polyp miss rates in these segments are presented in TABLE 3.

There was a significant difference in the BBPS score of 3 between the right colon and the 2 other colon segments (Q = 168.4; P <0.000 001). There was a correlation between the polyp miss rate and the colon preparation quality, which was measured as a percentage of patients with a BBPS of 3.

The mean withdrawal time for colonoscopies without polyps was 14.4 min in both examinations. The number of polyps found during the examination was the only variable that affected the withdrawal time, which increased by 7% for each additional polyp (TABLE 4).

TABLE 2 Distribution of colorectal polyps in the study groups

	Right colon	Transverse colon	Left colon	Total
adenomas				
first colonoscopy, n	70	48	71	189
second colonoscopy, n	15	8	7	30
missed polyps, %	17	14	9	40
hyperplastic polyps				
first colonoscopy, n	34	43	140	217
second colonoscopy, n	15	14	27	56
missed polyps, %	30	24	16	70

TABLE 3 Preparation of the colon segments and overall rate of missed polyps

	Right colon	Transverse colon	Left colon
mean BBPS	2.4	2.77	2.84
patients with BBPS = 2, n	152	59	40
patients with BBPS = 3, n	101	194	213
patients with BBPS = 3, %	39.9	76.7	84.2
missed polyps, %	22.4	19.5	13.8

Abbreviations: BBPS – Boston Bowel Preparation Scale

TABLE 4 Colonoscope withdrawal time and number of resected polyps

		Withdrawal time, min					Patients, n
		10–15	16–20	21–25	26–30	>30	
resected polyps, n	0	68	10	0	0	0	78
	1	29	25	2	0	0	56
	2	14	28	2	3	0	47
	3	0	20	6	0	0	26
	4	1	9	6	0	0	16
	≥5	0	11	11	5	3	30
patients, n		112	103	27	8	3	253

DISCUSSION The present study did not indicate significant differences in the detection of missed adenomas and hyperplastic polyps between WLE and NBI without optical magnification. The data on polyp detection using NBI and WLE for tandem colonoscopies are limited. Studies that reported no benefits of using NBI for polyp detection were large (211 to 1256 patients), prospective, randomized studies with control groups, and all were performed using endoscopes without optical magnification.[25-29] These findings are supported by a meta-analysis which showed that, compared with high-definition WLE, high-definition NBI does not increase the yield of colon polyps, adenomas, or flat adenomas, nor does it decrease the miss rate of colon polyps or adenomas in patients undergoing screening or surveillance colonoscopy.[30] All reports confirming a higher polyp detection rate in NBI,[22-24] excluding 1,[21] were performed using endoscopes with sequential NBI and optical magnification. Only 1 study[24] had a white-light control group, and although the pan-colonic NBI system improved the total number of adenomas detected in that study, the ADR and the number of patients with multiple adenomas were not significantly different between the groups. That study, conducted without optical magnification,[21] used methods similar to ours and detected 41% more polyps that were missed in the first white-light colonoscopy in the second colonoscopy with NBI. However, that study included only 40 patients (all male) and had no control group.

It is widely accepted that, in screening colonoscopy, adenomas should be detected in at least 25% of men and at least 15% of women.[11] In the present study, the ADR after the first colonoscopy was 39.9%, and there was no difference between the groups after the second colonoscopy. This result confirmed the high skill of the endoscopist.

An alternative method to determine the effectiveness of colonoscopy is the number of adenomas detected per colonoscopy, but the power of that parameter is not yet known.[7] In our study, the number of adenomas per patient was 0.747 after the first colonoscopy and 0.897 after the second colonoscopy in NBI and 0.834 in WLE. No significant difference was found. The only study on adenoma detection with NBI that reported also the number of adenomas per patient was the report of Rastogi et al.[21] In the first white-light colonoscopy, 1.08 adenomas per patient were found, and after the second colonoscopy performed in NBI, the number increased to 1.8 per subject. The substantial differences between the results of the 2 studies may be explained by the differences in the studied populations. That study examined only men with a mean age of 62 ±9.5 years. In our study, the majority of patients were women with a lower mean age. Although the rise in the number of adenomas per patient after the second colonoscopy was significant and may indicate the effectiveness of NBI in adenoma detection, it must be noted that the study by Rastogi et al.[21] did not have a white-light control group.

There is an established association between missed adenomas and interval colon cancer, that is, cancer diagnosed during properly conducted post-polypectomy surveillance.[4,31,32] One of the most interesting results of our study was the distribution of missed adenomas. Fifty percent (15/30) of all missed adenomas were located in the cecum and ascending colon. This result corresponds with observations that interval cancer is more frequently localized in the right colon.[33,34] In a previous study, it was suggested that a repeated examination of the proximal colon

with a second inspection in NBI could improve the ADR and help reduce interval cancer rates.[22] That study included only patients with hereditary non-polyposis colorectal cancer, and the proximal colon was defined as the colon from the cecum to the descending-sigmoid colon junction. Therefore, it is difficult to apply these results to the general population. A double examination of the colon from the cecum to sigmoid colon, either in NBI or white light, would be unfavorable to both endoscopists and patients. However, our results suggest that half of the missed adenomas are found in the short colon segment of the cecum and the ascending colon. A double examination of that segment would take only little additional time, and the anatomy of that segment allows a painless examination that is more acceptable to patients and may result in substantial improvement in adenoma detection. However, this issue requires further study.

One of the most important causes of missed colon polyps is inadequate bowel preparation.[35] The assessment of the bowel preparation quality in our study was performed using the BBPS.[12] The authors of the scale demonstrated a significant difference between polyp detection in colons with a total BBPS score of less than 5 and equal to 5 and higher (40% vs. 24%, P <0.02). Another study suggested that instead of totaling the segmental BBPS score, it would be more accurate to note separate scores from 0 to 3 for each colon segment.[13] Patients included in our study had a BBPS score of at least 2 in each colon segment. The right colon (cecum and ascending colon) was prepared significantly worse than the 2 other segments, the transverse colon and the left colon. Although all patients had good or excellent colon preparation, the polyp miss rate in the 3 segments correlated with the colon preparation for colonoscopy. The highest polyp miss rate was noted in the worst-prepared right colon segment, and the lowest was noted in the left colon segment, which had the highest preparation score.

The mean withdrawal time in colonoscopy with no polyps was 14.4 minutes. Because the colonoscope withdrawal for standard colonoscopy without polypectomy or biopsy should take at least 6 minutes,[15] the obtained results confirm the good quality of the study regarding withdrawal time. No difference in withdrawal time was found between the NBI and WLE groups, and the only variable that affected the withdrawal time was the number of polyps detected during examination. There was no correlation between the withdrawal time and the preparation for colonoscopy, although such a relationship was proven by previous reports.[12] This result is likely due to the inclusion criteria (BBPS score of 2 and 3), which limited the patients only to those with well and very well-prepared colons, each requiring a similar time for the cleansing maneuvers.

Our study has a number of limitations, which may have affected the results, one of which was the endoscopic equipment. Although only Olympus colonoscopes (CF-180H, high definition) were used, the picture was displayed on standard-definition monitors, Olympus OEV 203. According to the Olympus expert opinion, the pictures obtained with such equipment were better than those obtained with a standard-definition endoscope, but they were worse than those produced by a high-definition endoscope displayed on a high-definition monitor.

Another limitation was that all of the examinations were performed by a single endoscopist with experience in both WLE and NBI. It has been reported that experienced endoscopists did not benefit from NBI in polyp detection and that polyp detection in white-light improved with growing experience using NBI.[29]

In summary, the use of NBI without optical magnification for the detection of missed polyps did not improve the number of identified polyps compared with WLE in the outpatient population referred for screening and diagnostic colonoscopy. The BBPS seems to be a useful tool, not only in colonoscopy-related research but also for practitioners, especially when separate colon segment scores are included in the examination reports. The difference in preparation between a BBPS score of 2 and that of 3 may affect the polyp miss rate. Repeated endoscopy for a short segment of the colon (cecum and ascending colon only), which is time-effective and painless for the patient, may yield substantial improvement in the ADR, but that issue requires further study.

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ARTYKUŁ ORYGINALNY

Wykrywanie polipów jelita grubego w świetle białym i w obrazowaniu wąskopasmowym – badanie z randomizacją

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SŁOWA KLUCZOWE

niewykryte gruczolaki, niewykryte polipy, podwójna kolonoskopia, polipektomia

STRESZCZENIE

WPROWADZENIE Obrazowanie wąskopasmowe (*narrow-band imaging* – NBI) jest nową, obiecującą techniką, która może być pomocna w wykrywaniu polipów jelita grubego w czasie kolonoskopii.

CELE Celem badania była ocena skuteczności NBI z badaniem w świetle białym (*white-light endoscopy* – WLE) w wykrywaniu polipów jelita grubego oraz określenie rozmieszczenia pominiętych polipów.

PACJENCI I METODY Przeprowadzono badanie z randomizacją, z grupą kontrolną. Do badania włączono 253 pacjentów, u których dwukrotnie przeprowadzono kolonoskopię: u 126 pacjentów obydwie kolonoskopie wykonano używając światła białego, u 127 – używając obrazowania wąskopasmowego podczas drugiej kolonoskopii. Odnotowywano polipy jelita grubego znalezione podczas drugiej kolonoskopii wraz z ich lokalizacją.

WYNIKI Nie stwierdzono statystycznie istotnych różnic w wykryciu polipów, gruczolaków i polipów hiperplastycznych między grupą WLE a grupą NBI (odpowiednio: 38 *vs* 48, p <0,2051; 11 *vs* 19, p <0,12; 27 *vs* 29, p <0,647). Połowa pominiętych gruczolaków (n = 15) została znaleziona w kątnicy i zstępnicy.

WNIOSKI Skuteczność NBI i WBE w wykrywaniu polipów jelita grubego pominiętych w czasie kolonoskopii jest porównywalna. Dwukrotne oglądanie kątnicy i zstępnicy może znacząco zwiększyć liczbę wykrytych gruczolaków jelita grubego.

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