Original Article

Use of image-enhanced endoscopy in the characterization of colorectal polyps: Still some ways to go

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Abstract

Background/Aim: Instrument-based image-enhanced endoscopy (IEE) is of benefit in detecting and characterizing lesions during colonoscopy. We aimed to study the ability of community-based gastroenterologists to differentiate between neoplastic and non-neoplastic lesions using IEE modalities and to identify predictors of correct classification and the confidence of the optical diagnosis made.

Materials and Methods: An electronic survey was sent to practicing gastroenterologists using electronic tablets during a gastroenterology meeting. Demographic and professional information was gathered and endoscopic images of various colonic lesions were shown and they were requested to classify the images based in white light, flexible spectral imaging color enhancement (FICE), iScan, and narrow band imaging (NBI).

Results: Overall, 71 gastroenterologists responded to the survey, 76% were males and the majority were aged between 36 and 45 years (44%). Most of the respondents practiced both hepatology and gastroenterology (56%) and most of them had never received any training on IEE (66%). Correct identification of lesions using regular white light endoscopy was low (range 28%–84%). None of the IEE modalities increased the percentage of correct diagnoses apart from one NBI image where it increased from 28% (95%CI: 17%–38%) to 56% (95%CI: 44%–68%) ($P < 0.01$). Those who identified themselves as practicing mainly luminal gastroenterology were more confident 72% (95%CI: 60%–84%) compared with hepatologists 36% (95%CI: 25%–48%), or those who practiced both 48% (95%CI: 39%–56%) despite no difference in the percentage in correct answers.

Conclusion: There remain areas of improvement in the performance of endoscopists in practice and would recommend more dedicated training programs, which could make use of asynchronous technological platforms.

Keywords: Colonoscopy, flexible spectral imaging color enhancement, image-enhanced endoscopy, iScan, narrow band imaging, polyps

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INTRODUCTION

Although the age-adjusted rates, distribution, and histological characteristics of polyps might vary between populations,[1,2] the majority of polyps that are encountered during colonoscopy are in the left colon,

Access this article online	
Quick Response Code:	Website: www.saudijgastro.com
	DOI: 10.4103/sjg.SJG_417_18

How to cite this article: Alharbi OR, Alballa NS, AlRajeh AS, Alturki LS, Alfuraih IM, Jamalaldeen MR, *et al*. Use of image-enhanced endoscopy in the characterization of colorectal polyps: Still some ways to go. Saudi J Gastroenterol 2019;25:89-96.

diminutive (<5 mm), and significant proportions are hyperplastic.[3] There is an effort to curtail the rising costs of health care by attempting to identify the histology of polyps *in vivo* and undertaking a "resect and discard" policy (which would decrease the cost of post polypectomy histological examination); this only is applicable to diminutive polyps in the rectosigmoid area. Although dye-based image-enhanced endoscopy (IEE) is of benefit in the detection and characterization of lesions during colonoscopy, its application and performance is considered cumbersome and has limited its widespread uptake.[4] In contrast, instrument-based IEE like iScan (Pentax, Tokyo, Japan), narrow band imaging (NBI) (Olympus Inc., Tokyo, Japan), and flexible spectral imaging color enhancement (FICE) (Fujinon Inc., Saitama, Japan) has the advantage of ease of implementation and the technology is already embedded in the instruments.

IEE is an essential instrument in the application of a "resect and discard" approach; although these technologies have been promising, they are only as good as the endoscopists interpreting the findings. In a study looking into the gastroenterologists in community practice, only 25% of gastroenterologists assessed polyps with >90% accuracy.[5] Thus, there is a need for training in the use of these IEE modalities as well as monitoring and auditing[3,6] to guarantee that the required quality benchmarks of 90% agreement between the endoscopists judgment and histopathology, and 90% negative predictive value (NPV) are achieved.[7]

The primary aim of the study was to assess the ability of community-based gastroenterologists to differentiate between neoplastic and non-neoplastic lesions using IEE modalities; the secondary aim was to identify predictors of correct classification and the confidence of the optical diagnosis made.

MATERIALS AND METHODS

This is a cross-sectional study where an electronic survey was sent to practicing gastroenterologists who are members of the Saudi Gastroenterology Association (SGA) through emails. Also, the survey was conducted using electronic tablets during the SGA annual meeting which was held on the 11th and 12th of February 2017.

The questionnaire was comprised of two segments. The first collected demographic and professional information of the participants: age, sex, level of training (fellow in training, specialist, or independent consultant), practice setting (government hospital, private hospital, or both settings), main practice (gastroenterology, hepatology, or both), the number of years in practice, the annual number of endoscopies they would perform if they had received training in IEE (iScan, NBI, FICE), and whether they thought it was important.

The second section showed a series of thirty endoscopic images, of various adenomas, lesions with cancer and hyperplasia.[8-10] The participants were requested to classify the images based in white light endoscopy into a hyperplastic polyp, adenoma, or cancer. At a later time in the survey, they were shown the same image using an IEE modality and asked again to classify the images based in white light endoscopy into a hyperplastic polyp, adenoma, or cancer.

Statistical analysis

Descriptive statistics were computed for continuous variables, including means, standard deviations, minimum and maximum values, frequencies for categorical variables and 95% confidence intervals (CIs). When hypothesis testing was conducted, the paired *t*-test and Fisher's exact test, where appropriate, were used. In comparing more than one group, a one-way analysis of variance was used to test for differences among the groups. A statistical significance threshold of $P = 0.05$ was adopted. No attempt at imputation was made for missing data. A sample size calculation was performed to detect a 50% difference in the success interpreting images with a power of 80% and type I error of 5%; a sample size of 62 gastroenterologists was required.[11-13]

STATA 11.2 (Stata Corp., College Station, TX, USA) was used for all analyses.

RESULTS

Demographics

In total, 71 gastroenterologists responded to the survey, 76% were males and the majority were aged between 36 and 45 years (44%). Independent consultants comprised 58% of the participants, whereas 21% were specialists and 21% fellows in training. The majority of the gastroenterologists practiced in the government sector (76%) and 10% in both private and government sectors. Most of the respondents practiced both hepatology and gastroenterology (56%) and 73% were practicing for <10 years [Table 1].

The respondents believed that knowledge and training is mandatory for the use of IEE (91%). When asked if they required training on IEE, the majority (80%) thought they did require training, whereas the remainder did not think so.

Table 1: Demographics of physicians who participated in the study

Variable	Frequency (%)	95%CI
Sex		
Male	54 (76)	65%-86%*
Female	17 (24)	13%-34%
Age (years)		
25-35	18 (25)	14%-35%
36-45	31 (44)	31%-55%
46-55	14 (20)	10%-29%
55-65	6 (8)	1%-18%
>65	2 (3)	1%-7%
Training level		
GI fellow	15 (21)	11%-31%
GI specialist	15 (21)	11%-31%
GI consultant	41 (58)	45%-69%*
Area of practice		
Government hospital	54 (76)	65%-86%*
Private hospital	10 (14)	5%-22%
Both	7 (10)	3%-17%
Main clinical expertise		
Mainly gastroenterology	20 (28%)	17%-38%
Mainly hepatology	11 (16)	6%-24%
Both	40 (56)	44%-68%*
Experience years		
<5	27 (38)	26%-49%
5-10	25 (35)	23%-46%
11-15	5 (7)	1%-13%
>15	14 (20)	10%-29%
Number of endoscopy procedures performed annually		
<100	14 (20)	10%-29%
100-150	8 (11)	3.73%-19%
151-200	9 (13)	5%-21%
201-250	7 (10)	3%-17%
251-350	7 (10)	3%-17%
>350	26 (37)	25%-48%

*Statistically significant

NBI was used by 44%, 8.5% used iScan, 14% used both NBI and iScan, 4% used FICE, and 1% used both FICE and NBI, whereas 28% used only white light without any IEE [Figure 1].

The majority of physicians responded that they had never received any training on IEE (66%), whereas 20% were trained with NBI, 8% trained with NBI and iScan, 3% had training with all three modalities (NBI, FICE, and iScan), 2% trained with iScan only, and 1% trained with FICE only.

Correct identification of lesions

When comparing the correct identification of lesions using regular white light endoscopy, it was observed that the scores were overall low, ranging from 28% to 84%. Table 2 demonstrates a paired comparison on the total correct answers on the images taken using IEE modalities (NBI, FICE, iScan) when compared with the same image taken by white light endoscopy.

None of the IEE modalities that were used increased the percentage of physicians who made a correct diagnosis apart from one of the images of NBI, where the percentage

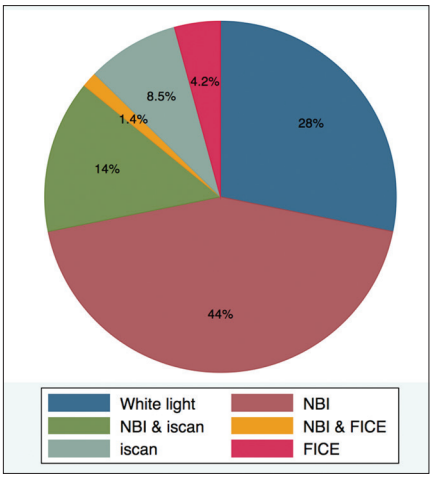


Figure 1: Different image enhancement modalities used by the participants in the study

increased from 28% (95% CI: 17%–38%) to 56% (95% CI: 44%–68%; $P < 0.01$).

Relationship between correct identification of lesions and the confidence of the endoscopist

In general, the level of confidence by which the study participants made their diagnosis was low (range 32% to 72%). There was no correlation between the percentage of correct identification of lesions and the confidence of the endoscopist when making that diagnosis. This was also the case when stratified by sex, age, practice setting, number of years in practice, or level of training.

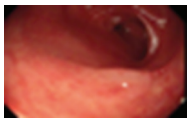
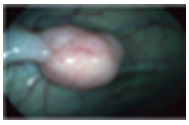
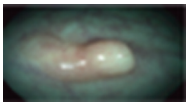
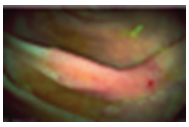
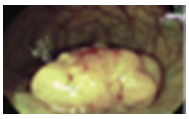
It was noted that those who identified themselves as practicing mainly luminal gastroenterology were more confident 72% (95% CI: 60%–84%) compared with hepatologists 36% (95% CI: 25%–48%), or those who practice both 48% (95% CI: 39%–56%) despite no difference in the percentage in correct answers in identifying lesions [Table 3].

Also, those who thought that training in IEE was not necessary tended to have a lower confidence in their diagnoses 26% (95% CI: 3%–48%) compared with those who thought it was 55% (95% CI: 48%–62%), again despite no difference in the percentage in correct answers in identifying lesions [Table 4]. There was no effect of the annual number of procedures performed, the type of IEE used, or the training received [Table 4].

DISCUSSION

Real-time optic diagnosis using IEE modalities can prevent unnecessary polypectomy to decrease the cost related to the histopathological examinations of polyps. However, before applying this strategy in routine clinical

Table 2: Paired sample comparison on total correct answers on images taken using various enhance imaging modalities

IEE	White light	Correct identification	CI 95%	Enhanced imaging	Correct identification	CI 95%	*P*
NBI		45%	33%-57%		42%	30% to 54%	0.36
		28%	17%-38%		56%	44%-68%	<0.01
FICE		73%	62%-83%		66%	54%-77%	0.08
		51%	38%-62%		61%	49%-72%	0.94
		67%	54%-79%		67%	54%-79%	0.50
		37%	26%-48%		39%	26%-50%	0.58
iScan		84%	76%-93%		77%	67%-87%	0.10
		61%	49%-73%		70%	58%-81%	0.90
		53%	41%-64%		56%	44%-67%	0.65

CI: Confidence interval, FICE: Flexible spectral imaging color enhancement, IEE: Image-enhanced endoscopy, NBI: Narrow band imaging

practice, a gastroenterologist must achieve a certain diagnostic threshold in differentiating adenomas from non-adenomas.

Although current IEE technologies have advanced compared with earlier versions of scopes and their performance of IEE has been very encouraging in clinical trials, there remains some caution when it comes to the *in vivo* diagnosis of diminutive polyps to the degree that the European Society of Gastrointestinal Endoscopy (ESGE) has suggested that these technologies (NBI, FICE, and iScan) could be used, under strictly controlled conditions, for the diagnosis of diminutive polyps.[14] They also required that the diagnosis be reported using validated scales, photodocumented, and only performed by endoscopists who are adequately trained, experienced, and audited periodically.[14] This stems from the fact that the performance of IEE outside of clinical trials and academic/specialized centers has been inconsistent.[3,15]

We included in our study standard IEE modalities that are widely available, but the advances in the field of IEE have been relatively fast where even newer technologies, such as blue laser imaging (BLI) (Fujifilm Co, Tokyo, Japan) and linked color imaging (LCI)[16-18] (Lasereo system, Fujifilm, Tokyo, Japan), iScan optical enhancement,[19] and second-generation (2G) NBI[4] are being rolled out. We still do not have a clear sense of the performance of the older technologies and their impact in real clinical practice let alone these newer IEE modalities. Thus, we felt a need to assess the ability of community practicing gastroenterologists in identifying lesions correctly with the use of IEE compared with regular white light endoscopy as well as trying to identify factors that would affect this competency.

Table 3: Relationship of correctly identifying lesions and the confidence with which that judgment was made

Variable	Correct diagnosis with IEE (%)		Confidence about the diagnosis (%)	
	Mean (SD)	95%CI	Mean (SD)	95% CI
Sex				
Male	49 (16)	45-54	51 (26)	44-58
Female	48 (14)	39-57	57 (34)	40-75
Age (year)				
25-35	47 (17)	37-56	57 (36)	39-74
36-45	51 (15)	45-57	54 (25)	44-64
46-55	47 (18)	35-59	55 (22)	44-68
55-65	56 (14)	21-90	32 (22)	9-55
>65	34 (9)	0-128	32 (26)	0-265
Level of training				
Fellow in training	42 (14)	33-56	44 (39)	23-66
Specialist	55 (20)	41-68	64 (24)	51-78
Consultant	50 (14)	45-55	51 (23)	44-59
Years of experience				
<5	47 (16)	40-54	54 (32)	42-67
5-10	50 (15)	43-56	53 (27)	42-65
11-15	37 (17)	0-78	46 (25)	15-77
>15	57 (14)	47-86	50 (23)	37-64
Area of practice				
Government hospital	49 (17)	44-55	52 (29)	44-60
Private hospital	50 (12)	40-61	57 (33)	40-74
Both	46 (13)	34-75	51 (22)	31-72
Main clinical expertise				
Gastroenterologist	44 (13)	37-52	72 (25)	60-84*
Hepatologist	47 (17)	33-61	36 (18)	25-48
Both	52 (16)	46-75	48 (27)	39-56

CI: Confidence interval, IEE: Image-enhanced endoscopy, SD: Standard deviation. *Statistically significant

Table 4: Relationship of correctly identifying lesions and the confidence with which that judgment was made based on receiving training, perception for the need of training and annual procedure volume

Variable	Correct diagnosis with IEE (%)		Confidence about the diagnosis (%)	
	Mean (SD)	95%CI	Mean (SD)	95%CI
Training on image enhancement is important to characterize polyps				
Yes	49 (16)	45-54	55 (27)	48-62
No	46 (11)	35-58	26 (22)	3-48
Do you need training on image enhancement?				
Yes	49 (16)	45-54	55 (28)	47-62
No	48 (14)	39-57	45 (28)	28-61
Number of procedures annually				
<100	51 (15)	41-61	47 (28)	31-63
100-150	50 (20)	33-66	60 (32)	33-88
>151-200	50 (17)	34-65	42 (25)	23-61
201-250	45 (11)	31-59	66 (34)	34-98
251-350	33 (15)	17-49	38 (25)	15-62
>350	54 (12)	48-60	57 (25)	47-68
Types of IEE used				
White light	44 (12)	37-50	49 (29)	35-62
FICE	48 (12)	0-154	53 (13)	20-87
iScan	48 (17)	27-69	59 (35)	22-97
NBI	50 (17)	43-57	51 (26)	41-60
NBI and iScan	59 (16)	44-73	64 (33)	39-90
NBI and FICE	53 (NA)	NA	43 (NA)	NA
Training received				
None	47 (15)	42-52	47 (27)	39-55
FICE	27 (NA)	NA	73 (NA)	NA
iScan	33 (NA)	NA	97 (NA)	NA
NBI	53 (14)	45-62	59 (22)	46-72
NBI and iScan	64 (14)	31-98	77 (26)	51-104
NBI and FICE and iScan	60 (NA)	NA	13 (NA)	NA

CI: Confidence interval, FICE: Flexible spectral imaging color enhancement, IEE: Image-enhanced endoscopy, NA: Not applicable, NBI: Narrow band imaging. *Statistically significant

When applied properly, NBI could differentiate between neoplastic and non-neoplastic colorectal polyps in real time with a sensitivity of 91.0% (95%CI: 87.6%–93.5%), a specificity of 82.6% (95%CI: 79.0%–85.7%), and an area under the receiver-operating characteristics curve of 92% (95%CI: 90%–94%),[20] with similar figures also being reported for iScan and FICE.[21] With these test characteristics, a correct surveillance interval for the follow-up procedure using IEE correlated with that derived from pathological assessment in 92% of patients.[20] Unfortunately, these figures were far from what we had found in our survey, which stress the need to be cautious when generalizing these results into community practice.[5] Even for white light endoscopy, the correct identification of polyps was relatively low, which emphasizes the need for improving basic skills prior to any IEE.

Even today, there remains some ambiguity in the amount and type of training required, and earlier studies indicating that it might be taxing (up to 100 video recordings between training and assessment) to achieve competence[22] in IEE, whereas others gave a notion that it could be done with minimal effort (20 min).[23] Most probably the reality lies in between these extremes, but what seems to be for sure is that this learning requires constant practice and "relearning"[22] to maintain these skills.

Not receiving training (whatever that training form maybe) is a hindrance to any gain that would be anticipated for this technology. Although 66% of the respondents did not receive any form of training in IEE, a significant proportion had the technology available and were using it in practice, which indicates that there is a will to use these tools in clinical practice.

Part of learning is the knowledge of what one knows and what is required to reach a desired or needed knowledge or skill to be attained, this self-awareness will aid in this process, while overconfidence will hinder this process. In our study, it was interesting that those who identified as mainly gastroenterologists were more confident about their diagnoses compared with their counterparts, while they were not different in correctly identifying lesions. It is not clear what the driving factor for the overconfidence in this group was, but it is a cognitive bias that might be linked to certain personality traits; other cognitive bias that have been found in physicians include a lower

tolerance to risk, the anchoring effect, and information and availability biases.[24] Also, it has been known that relatively incompetent people consistently overestimate their abilities.[25] It has been demonstrated that physicians have a lack of perception of the difficulty of tasks at hand and this is reflected in a stable level of confidence despite a change in the difficulty of the task that was requested from them to achieve.[26] The knowledge of one's gaps and acquisition of that knowledge is at the core of the value of "Life Long Learning," which is instilled in healthcare practitioners during their training, and thus knowing the unknown is an essential aspect.[27]

In a meta-analysis, factors associated with a better performance when using digital IEE included being at an academic medical center (NPV 91.8%; 95% CI: 89%–94%), being an expert (NPV 93%; 95% CI: 91%–96%), and when the assessment was made with high confidence (NPV 93%; 95% CI: 90%–96%),[28] thus, pinning the importance of confidence which is a natural byproduct of learning and practice.

Educational programs have been conducted in the field of dye-based IEE for the surveillance colonoscopies in patients with inflammatory bowel disease and had impact on trainees' practices,[29] and the plateau is reached after 15 cases,[30] and has been found to be reproducible even outside of clinical trials.[31] Programs for the detection of diminutive polyps have been performed with encouraging results as demonstrated with a NPV of 94.7% (95% CI: 92.6%–96.8%) achieved by 26 endoscopists after a period of training in NBI,[6] but the need for continuous auditing appears to be required to maintain that level of competency.[6] Such programs would need to be given on a larger scale, if the use of these IEE technologies were to be widespread.

A study on 10 gastroenterologists found that with some training in NBI, and no prior experience with IEE, they achieved a NPV of 95% for adenomas and a 93% agreement with histology but could not find any factors that could affect the quality of the optical diagnosis made.[32] Of note, the study had a small number of participants and they were enrolled from two academic centers and 2 of 10 had been involved in clinical studies in IEE technologies.[32] All these factors limit the generalizability of that study to a community-based practice. A second study of five gastroenterologists, who were already involved in an endoscopy-related randomized trial,[33] achieved the quality threshold of a 90% NPV and maintained that when they were trained on the initiation of the study as well as getting a mid-study refresher.[15]

To overcome the human element of variation in the differentiation between hyperplastic polyps and neoplastic lesions, the use of computer-aided diagnosis with a deep neural network is being developed, and has produced results that are promising where this system was able to differentiate between hyperplastic and neoplastic lesions with a sensitivity of 96.3%, specificity of 78.1%, a positive predictive value of 89.6%, and a NPV of 91.5%,[34] which was similar to expert endoscopists but better than novices.[34] How these new computer-aided detection and diagnosis systems will function in the future is unclear[35] but might act as "a second reader" for the endoscopist.[36]

An interesting advancement in the technology for IEE is in LCI where it was found in a small study that trainees had better scores in characterizing lesions compared with the white light or BLI-bright, which is interesting as these modalities usually require a level of expertise,[37,38] whether this would be sustained when adapted at a community level remains to be seen.

Although the interpretation of still images does not translate to the performance of IEE in real-time endoscopy, where other variables such as the preparation quality, patient comfort and scope position, all might affect the real-time performance of IEE. The use of electronic surveys to investigate the ability of endoscopists in correctly identifying lesions is well established. A study involving 60 Japanese gastroenterologists using IEE demonstrated that they achieved a diagnostic accuracy of 88% for superficial colorectal neoplasms using still images.[39]

Limitations in our study include the fact that this was a self-administered questionnaire and is limited by the relatively small number of respondents and also is susceptible to recall bias in terms of annual volume of endoscopies. Also, the definition of receiving training on IEE is not standardized, but nonetheless, the self-perception of being trained is an important aspect when realizing the need for proper initial training and maintenance of these skills[15] as well as self-audit which has been demonstrated to be important if one is to achieve and maintain the quality thresholds needed[7] and whether these variables should be taken into credentialing of endoscopists by their institutions, as a matter of debate.

In conclusion, there remain areas of improvement in the performance of endoscopists in practice and would recommend more dedicated training programs, which could make use of asynchronous technological platforms, with frequent feedback and well-validated scales and classification to familiarize the gastroenterologists about

IEE modalities, if we are to maximize these technological advances. This study does stress that a tool is as good as its user in akin to "beauty is in the eye of the beholder."

Ethical approval statement

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and within the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the Institutional Review Board (IRB) No. E-17-2257.

Informed consent statement

Informed consent was obtained from all individual participants included in the study.

Acknowledgements

The authors extend their sincere appreciation to the Deanship of Scientific Research at King Saud University for funding this research through the Research Group Project number RGP-279.

Financial support and sponsorship

The authors extend their sincere appreciation to the Deanship of Scientific Research at King Saud University for funding this research through the Research Group Project number RGP-279.

Conflicts of interest

There are no conflicts of interest.

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