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A Survey of Expert Practice and Attitudes Regarding Advanced Imaging Modalities in Surveillance of Barrett's Esophagus

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Abstract

Background—Published guidelines do not address what the minimum incremental diagnostic yield (IDY) for detection of dysplasia/cancer is required over the standard Seattle protocol for an advanced imaging modality (AIM) to be implemented in routine surveillance of Barrett's esophagus (BE) patients. We aimed to report expert practice patterns and attitudes, specifically addressing the minimum IDY in the use of AIMs in BE surveillance.

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Author's contribution Jorge D. Machicado, Samuel Han, Nicholas J. Shaheen, and Sachin B. Wani were involved in study concept and design. Jorge D. Machicado, Samuel Han, Violette C. Simon, and Sachin B. Wani were involved in acquisition of data. Jorge D. Machicado contributed to statistical analysis. Jorge D. Machicado and Sachin B. Wani drafted the manuscript. All authors were involved in data interpretation, review of manuscript for important intellectual content, final approval of the manuscript. Guarantor of the article: Sachin Wani, MD.

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Compliance with ethical standards

Conflict of interest The other authors declare no conflicts of interest.

Methods—An international group of BE experts completed an anonymous electronic survey of domains relevant to surveillance practice patterns and use of AIMs. The evaluated AIMs were conventional chromoendoscopy (CC), virtual chromoendoscopy (VC), volumetric laser endomicroscopy (VLE), confocal laser endomicroscopy (CLE), and wide-area transepithelial sampling (WATS^{3D}). Responses were recorded using five-point balanced Likert items and analyzed as continuous variables.

Results—The survey response rate was 84% (61/73)—41 US and 20 non-US. Experts were most comfortable with and routinely use VC and CC, and least comfortable with and rarely use VLE, CLE, and WATS^{3D}. Experts rated data from randomized controlled trials (1.4 ± 0.9) and guidelines (2.6 ± 1.2) as the two most influential factors for implementing AIMs in clinical practice. The minimum IDY of AIMs over standard biopsies to be considered of clinical benefit was lowest for VC (15%, IQR 10–29%) and highest for VLE (30%, IQR 20–50%). Compared to US experts, non-US experts reported higher use of CC for BE surveillance ($p < 0.001$).

Conclusion—These results should inform benchmarks that need to be met for guidelines to recommend the routine use of AIMs in the surveillance of BE patients.

Keywords

Barrett's esophagus; Surveillance; Advanced imaging modalities; Practice patterns

Introduction

Barrett's esophagus (BE) is the only identifiable premalignant condition for esophageal adenocarcinoma (EAC), a cancer with a rapidly rising incidence in the Western world and poor 5-year survival rates [1]. Progression of BE to EAC involves a series of pathologic changes from non-dysplastic BE (NDBE) to low-grade dysplasia (LGD), high-grade dysplasia (HGD), and finally invasive EAC [2]. Current practice guidelines recommend endoscopic surveillance of BE with acquisition of tissue samples by the Seattle protocol (4-quadrant random biopsies every 1–2 cm and targeted biopsies of visible lesions), with the objective of detecting dysplasia/ EAC at an early and potentially curable stage [3–9]. However, this strategy is limited by its high significant risk for sampling error, as dysplasia/EAC may be highly focal and only less than 5% of the surface area of the BE segment is sampled, resulting in an expensive, time-consuming, and relatively low-yield process [10, 11]. Furthermore, there is variability among endoscopists with respect to adherence to the recommended intervals for surveillance and compliance with obtaining biopsies using the Seattle protocol [12].

These limitations have provided the impetus for the development and evaluation of several advanced imaging modalities (AIMs) [e.g., conventional chromoendoscopy (CC), virtual chromoendoscopy (VC), confocal laser endomicroscopy (CLE), volumetric laser endomicroscopy (VLE)] and enhanced sampling techniques [e.g., wide-area transepithelial sampling with 3D analysis (WATS^{3D})]; in order to improve the yield of dysplasia/early EAC detection, eliminate the need for random biopsies, and guide endoscopic eradication therapy (EET) [13]. While current guidelines recommend against the routine use of AIMs in BE surveillance [3, 4], the American Society of Gastrointestinal Endoscopy (ASGE)

Preservation and Incorporation of Valuable Endoscopic Innovations (PIVI) document has recently established performance thresholds for an AIM with targeted biopsies to eliminate the need for random biopsies during endoscopic surveillance of BE [14]. These thresholds include: (1) per-patient sensitivity of 90% and a negative predictive value of 98% for detecting HGD/EAC, compared with the current standard protocol and (2) the imaging modality should demonstrate a specificity 80% to allow a reduction in the number of biopsies compared with biopsies obtained using the Seattle protocol.

While substituting the Seattle protocol biopsies with AIM directed target biopsies is a lofty goal, the more conservative and pragmatic approach is to use both in conjunction. However, the ASGE PIVI document does not address the issue of a threshold or minimum incremental diagnostic yield (IDY) of an AIM over standard 4-quadrant biopsies to support the use and implementation of an AIM in clinical practice. Practically, the IDY is clinically meaningful, as it is a direct measure of the proportion of patients who benefit from the application of an AIM. Thus, establishment of IDY thresholds is critical for driving decision-making and informing clinical guidelines. In addition, the current use and regional variations of AIMs among expert endoscopists have not been previously explored. An improved understanding of salient research questions in the area of AIMs will be essential to delivering high-quality and value-based care to this patient population. With this background, the aims of this survey of international experts were: (1) to report current practice patterns in the use of AIMs; (2) to define clinical thresholds for the establishment of minimum IDYs in the use of AIMs in the surveillance of BE; and (3) to compare surveillance practices and beliefs in the use of AIMs in BE among US and non-US experts.

Methods

Study Design

This was a prospective two-phase survey instrument development and distribution study performed between August, 2017 and December, 2017. This study was approved by the University of Colorado Institutional Review Board.

Survey Instrument Development

First, a comprehensive literature review identified potentially relevant questions of interest. Next, a mixed-methods approach was used to create the survey instrument. Content validity was established after survey review by three international experts in AIMs and BE. Face validity was assessed by detailed qualitative interviews with five experts in BE, and pilot testing was performed by five BE experts.

The final 17-item survey (Supplementary Appendix A) was designed to address five clinical domains: (A) surveillance patterns (endoscopy intervals and use of Seattle protocol in BE); (B) factors that determine surveillance intervals in order of importance; (C) availability, comfort level, and utilization of AIMs; (D) factors that determine practice patterns in use of AIMs; and (E) minimum IDY of dysplasia/ EAC for implementation of an AIM in clinical practice over 4-quadrant biopsies. The evaluated AIMs were CC, VC, VLE, and CLE. WATS^{3D} was the only enhanced sampling technique evaluated but was considered as an

AIM in this study. IDY was defined as the proportional increase in dysplasia/EAC diagnostic yield in addition to 4-quadrant biopsies

$$\left(\frac{\text{number of patients with dysplasia detected by AIM but missed by random biopsies}}{\text{total number of patients with dysplasia detected by any method}} \right).$$

Responses to domains B-D were recorded using five-point balanced Likert items (e.g., 1 = completely agree, 2 = agree, 3=neutral, 4 = disagree, 5=completely disagree; 1 = always, 2 = often, 3 = sometimes, 4 = rarely, 5 = never). In domain B, respondents were asked to rate from 1 (very important) to 8 (least important) the following factors determining BE surveillance intervals: length of BE, family history of EAC, gender, family history of BE, obesity, race, advancing age, and tobacco use. With regard to domain D, respondents were asked to rate from 1 (most influential) to 5 (least influential) the following factors determining the use of AIMs: data from randomized controlled trials, society guideline documents, data from observational studies, costs associated with AIMs, and time added to the procedure. Demographic questions on practice location, monthly endoscopy volume for BE, and years of practice were also included in the survey.

Study Population

To maximize the validity of the results, the a priori plan was to conduct the survey only if 50 or more expert participants were identified. The sampling frame was international BE experts. Three independent reviewers (JDM, SH, SW) utilized a non-random purposeful sampling strategy to generate a list of survey recipients. The recruitment sample of experts was based on a comprehensive literature search of human studies in MEDLINE from January, 2007, to June, 2017, using the following MeSH and keyword terms: “Barrett’s esophagus,” “advanced imaging modalities,” “chromoendoscopy,” “narrow-band imaging,” “chromoendoscopy,” “confocal laser endomicroscopy,” and “volumetric laser endomicroscopy.” The corresponding authors were noted and authors with multiple and/or influential publications made up the list of experts. The final sample included a total of 73 BE experts from 56 centers and 10 countries. Participants practiced in Australia (2), Belgium (1), Canada (1), France (2), Germany (5), Italy (1), Japan (3), Netherlands (6), the UK (8), and the USA (44).

Survey Distribution, Data Collection, and Data Management

The survey was designed using the University of Colorado REDCap (Research Electronic Data Capture), a secure, web-based application designed to support data capture for research studies [15]. The survey was first distributed with an e-mail explanation of the purpose of the study to participants in October 2017. Non-responders and partial responders were contacted weekly for a total of five reminders until December 2017. To ensure confidentiality, each subject’s information was deidentified and assigned a study code before entry into REDCap.

Statistical Analysis

The primary analysis was a descriptive assessment of individual survey response items in the five domains (A–E). The secondary analysis evaluated differences in survey responses

according to the following categorical outcomes: practice location (US vs. non-US), monthly endoscopy volume for BE (low volume: 10/month; medium volume: 11–20/month; high volume: > 20/month), and years of practice (early-career stage: 10 years; mid-career stage: 11–20 years; late-career stage: > 20 years) [16] via univariate analysis using Chi-square or Fischer's exact test for categorical data and student's *t* test or Mann–Whitney *U* test for continuous data. In order to reduce the potential for a type I error, and based on Bonferroni correction, statistical significance was defined as $p \leq 0.01$. All statistical analyses were performed using Stata/IC version 12.1 (College Station, TX), and missing data were not imputed.

Results

Demographic Characteristics

The survey response rate was 84% (61/73)—41 US and 20 non-US (15 Europe, 3 Asia, 2 Australia). Demographic characteristics of respondents are shown in Table 1. The majority practiced in an academic hospital (89%), had > 10 years in practice (83%) and performed > 10 monthly endoscopies in BE patients (62%).

Surveillance Practice Patterns

The surveillance practice patterns among experts are highlighted in Table 2. The vast majority followed a 3-year surveillance interval for NDBE (79%) but also considered additional factors to individualize this surveillance interval (84%). When ranking importance of clinical factors in a 1–8 order, experts placed highest importance on BE length (mean score 1.9 ± 0.9) and family history of EAC (1.9 ± 1.5) in determining surveillance intervals. The majority of experts reported consistently using the Seattle biopsy protocol for surveillance of NDBE (78%) and BE with LGD (88%).

Attitudes and Practice Patterns in the Use of AIMS

Data regarding availability, comfort level and utilization of AIMS are highlighted in Table 3. With regard to availability, HDWLE (98%), VC (92%) and CC (62%) were available to most experts. On the other hand, only a minority of experts had CLE (31%), VLE (34%) or WATS^{3D} (26%) available in their clinical practice. Experts reported they were comfortable (1—completely agree to 5—completely disagree) using VC (1.1 ± 0.4) and CC (1.7 ± 0.9), but not with CLE (3.2 ± 1.6), VLE (3.3 ± 1.5) or WATS^{3D} (3.1 ± 1.5). During surveillance of NDBE and BE with LGD, experts reported to “always” use (1—always to 5—never) HDWLE (NDBE: 1 ± 0 ; LGD: 1 ± 0) and VC (NDBE: 1.1 ± 0.5 ; LGD: 1.1 ± 0.4); “sometimes” use CC (NDBE: 3.5 ± 1.3 ; LGD: 3.2 ± 1.5); and “rarely” use CLE (NDBE: 4.5 ± 0.9 ; LGD: 4.4 ± 1.0), VLE (NDBE: 4.5 ± 0.9 ; LGD: 4.3 ± 1.1) or WATS^{3D} (NDBE: 4.4 ± 1.1 ; LGD: 4.4 ± 1.1). Experts rated data from randomized controlled trials (1.4 ± 0.9) and GI society guidelines (2.6 ± 1.2) as the two most influential factors in the implementation of AIMS in clinical practice, while costs (3.5 ± 1.0) and time associated with the use of AIMS (4.1 ± 1.1) were the least influential factors.

Minimum IDY for Implementation of AIMs in Clinical Practice

The median minimum IDY of AIMs over standard random biopsies to be considered of clinical benefit is shown in Fig. 1. Experts believe that a minimum IDY of 15% (IQR, 10–29%) is required with VC, 20% (10–35%) with CC, 24% (15–45%) with WATS^{3D}, 27% (20–50%) with CLE, and 30% (18–50%) with VLE, before implementation in clinical practice can be recommended (Fig. 1).

Effect of Geographic Location

Comparisons between US and non-US experts with regard to the five clinical domains are highlighted in Table 4. Non-US experts were more likely to recommend surveillance at 1–2 years for patients with NDBE (30 vs. 0%, $p < 0.01$). In addition, non-US experts placed greater importance on BE length (mean score 1.4 vs. 2.1, $p < 0.01$) and less importance on family history of EAC (2.5 vs. 1.8, $p < 0.01$) to determine surveillance intervals compared to US experts. Non-US experts reported a higher availability of CC with acetic acid (80 vs. 27%, $p < 0.001$) and indigo carmine (45 vs. 15%, $p < 0.01$), but less availability of CLE (10 vs. 42%, $p = 0.01$) and VLE (5 vs. 49%, $p < 0.001$). Non-US experts reported higher utilization of CC for surveillance of NDBE (2.1 vs. 4.2, $p < 0.001$) and BE with LGD (1.7 vs. 3.9, $p < 0.001$) than US experts. There was no difference between the 2 groups in the comfort level to utilize AIMs in surveillance of BE, importance of factors for implementing AIMs in practice, and in the minimum IDY for implementation of AIMs in clinical practice.

Effect of Endoscopy Volume and Years of Experience

Compared with low and medium volume endoscopists, high volume experts had a trend toward higher availability ($p = 0.03$), comfort level ($p = 0.02$) and utilization ($p = 0.03$) of WATS^{3D} for surveillance of BE, though this did not reach statistical significance. Experts early in their career reported that costs of technologies had a higher impact on their decisions regarding the use of AIMs in clinical practice compared with late-career experts ($p = 0.01$). There was no impact of endoscopy volume or years of experience in any other of the survey domains (Supplementary Tables 1 and 2).

Discussion

The availability of AIMs offers the potential to target biopsies in BE and to potentially increase diagnostic yield for neoplasia over the current standard of four-quadrant random biopsies. However, most of these modalities are not yet routinely implemented in general clinical practice. Our study provides a snapshot of current BE surveillance practices as well as addresses gaps in provider attitudes, preferences, and behavior in the use of AIMs by a panel with extensive experience in the field. This international expert survey also provides critical information to inform the setting of thresholds for clinical decision-making in the context of clinical guideline development by better defining the minimum incremental diagnostic yield of dysplasia/early EAC required for an AIM. In a sense, these data represent the “best guess” as to rational utilization of these modalities, which the endoscopy community may elect to adopt while more robust evidence base is awaited.

In this survey, the vast majority of experts were comfortable with using VC, and reported having VC available in their practice. Experts reported always using VC (predominantly NBI, the most frequent type of VC available in practice) for surveillance of BE (NDBE and LGD). Although experts were also comfortable performing CC, availability was limited and was used sometimes in clinical practice. These differences in attitudes and practice patterns regarding use of VC and CC for BE surveillance may be driven by the obvious advantages of VC which include easy activation (a simple push of a button using standard endoscopes), lack of dye spraying, shorter procedural time, and reduced costs. In addition, comparable detection rates of HGD/early EAC have been reported in studies comparing CC with VC [17, 18]. Finally, standardized consensus driven classification systems have been described for the use of NBI in BE surveillance while no standardized classification criteria exist for CC [19–22]. Availability, comfort level and utilization of other imaging and sampling modalities such as CLE, VLE, and WATS^{3D} were low among expert endoscopists. Interestingly, use of AIMS among experts was driven by data from randomized controlled trials and GI society guideline documents much more so than by costs and time associated with the use of AIMS in clinical practice.

Experts believe that AIMS should increase the diagnostic yield of dysplasia/early EAC by at least 15–30% (VC: 15%, CC: 20%, WATS^{3D}: 24%, CLE: 27%, VLE: 30%) over standard biopsies to be considered of clinical benefit and for implementation in clinical practice. In the absence of any data from consensus or guideline documents that define the minimum IDY for an AIM to be introduced into clinical practice, results of this study provide acceptable benchmarks by experts that may be used in future guidelines addressing the use of AIMS in BE surveillance. Experts report lower minimum IDY thresholds for VC and CC compared to other AIMS such as CLE and VLE. These clinical thresholds likely take into account factors such test performance, provider training, time, and cost, and provides a contextualized threshold to help develop evidence-based recommendations [23]. There is currently available data to support the use of VC and CC compared with other AIMS [24, 25]. In a systematic review and meta-analysis that included 14 studies, both VC and CC increased the diagnostic yield of dysplasia/early EAC compared with random biopsies by 34% (95% CI 20–56) exceeding the minimum thresholds proposed for VC and CC in our study [26]. Limited data exist regarding the IDY of VLE, CLE and WATS^{3D} compared to standard biopsies, and it is unclear if the published results surpass the thresholds reported above [27–29]. It is clear that several issues need to be addressed before widespread adoption of AIMS can be recommended in routine clinical practice. Prospective trials that address IDY using AIMS from community practices and non-experts among non-enriched BE populations are required. Additionally, further research in AIMS is needed to address issues around lack of a uniform grading systems, limited cost-effectiveness data, and issues related to training and maintaining quality standards.

There is a paucity of data comparing the utilization of AIMS between US and non-US expert endoscopists [30, 31]. Results of this study demonstrate that non-US experts are more likely to use CC during surveillance of BE (NDBE and LGD) compared to US experts. This may be explained by the higher availability of acetic acid and indigo carmine among non-US experts. Interestingly, non-US experts were also more likely to recommend 1–2 year surveillance intervals in NDBE patients and more likely to use BE length to determine

surveillance intervals. The reasons for these differences in practice patterns are unclear and need to be addressed in future studies [32, 33]. Despite the higher utilization of CC in the non-US group, VC was still the most widely used AIM during BE surveillance regardless of endoscopist location. There is agreement among US and non-US experts regarding benchmarks that need to be met for AIMs to be uniformly adopted in clinical practice and recommended by guidelines. Additional studies with a larger sample size and real-patient data will be helpful to further assess the differences in practice patterns between US and non-US experts.

These results should be interpreted in the context of several important limitations. The selection of experts was based primarily on scientific publications, and we acknowledge that this is only one aspect that defines an “expert.” The overall number of experts from Asia, Australia and South America was limited. This under-representation may limit the generalizability of our results and hence not account for all regional experiences, resources, practice patterns and attitudes toward the use of AIMs in BE surveillance. Our survey included a nonprobability sample, which limited our ability to determine the characteristics of non-responders and could have carried non-response bias. Familiarity with specific AIMs may have affected the responses of minimal IDY thresholds, but subgroup analysis by availability of modalities was not possible given our small sample size. Strengths of this study include the inclusion of a large panel of international experts from 10 different countries and a high overall response rate (84%), and addressing an important aspect in the management of patients with BE. This document is not intended to be a consensus statement or to be a substitute for primary research in the field of AIMs in BE. However, these data provide guidance and set the stage for future consensus statements in this field using a modified Delphi process such as the RAND/University of California, Los Angeles Appropriateness Methodology (RAM); a process we used to develop quality indicators in EET [34, 35]. The impact of the length of BE, grade of dysplasia, and risk factors associated with progression of BE, should be taken into consideration when defining thresholds for AIMs in future studies and consensus statements.

In conclusion, experts are most comfortable with and routinely use VC and CC, and least comfortable with and rarely use other AIMs in clinical practice despite publishing in this field. The minimum incremental diagnostic yield for detection of dysplasia/EAC of AIMs over standard biopsies to be considered of clinical benefit was lowest for VC (15%) and highest for VLE (30%). Compared to US experts, non-US experts reported higher use of CC with acetic acid and indigo carmine for surveillance of BE and were more likely to factor BE length to determine surveillance intervals. The results of this survey should inform benchmarks that need to be met for guidelines to recommend AIMs in routine surveillance of BE patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1.

Attitudes on the minimum incremental diagnostic yield (IDY) of individual advanced endoscopic imaging technologies for detection of dysplasia/cancer to be considered of clinical benefit and be implemented in clinical practice. NBI: narrow band imaging or related technology; CC: conventional chromoendoscopy; CLE: confocal laser endomicroscopy; VLE: volumetric laser endomicroscopy; WATS^{3D}: wide-area transepithelial sample with 3D analysis

Table 1

Demographics of study participants

Variable (<i>n</i> = 61)	<i>N</i> (%)
Geographic location	
USA	41 (67.2)
Europe	15 (24.6)
Asia	3 (4.9)
Australia	2 (3.3)
Type of practice	
Academic hospital	54 (88.5)
Veteran administration hospital	3 (4.9)
Community hospital	4 (6.6)
Private practice	5 (8.2)
Years in practice (<i>n</i> = 60)	
< 5	2 (3.3)
5–10	8 (13.3)
11–15	11 (18.3)
16–20	11 (18.3)
> 20	28 (46.8)
Monthly number of endoscopies in BE	
< 5	7 (11.5)
5–10	16 (26.2)
11–15	9 (14.7)
16–20	7 (11.5)
> 20	22 (36.1)

Surveillance patterns and consideration of other factors for determining surveillance intervals in Barrett's esophagus among international experts

Table 2

Characteristics	Overall (n = 61)
Frequency of surveillance of NDBE, n (%)	
1 year	3 (4.9)
2 years	3 (4.9)
3 years	48 (78.7)
4 years	2 (3.3)
5 years	4 (6.6)
> 5 years	1 (1.6)
Consideration of other factors to determine surveillance interval of NDBE, n (%)	
Yes	51 (83.6)
No	10 (16.4)
Factors associated to surveillance intervals (n = 51), mean (Sd) *	
Length of BE	1.9 (0.9)
Family history of EAC	1.9 (1.5)
Gender	4.1 (1.5)
Family history of BE	4.7 (2.3)
Obesity	4.8 (1.6)
Race	5.4 (1.9)
Advancing age	5.5 (2.0)
Tobacco use	5.5 (1.7)
Use of Seattle protocol for surveillance of NDBE (n = 59), n (%)	
Always	46 (77.9)
Often	7 (11.9)
Sometimes	3 (5.1)
Rarely	1 (1.7)
Never	2 (3.4)
Use of Seattle protocol for surveillance of BE with history of indefinite or low-grade dysplasia but with-out prior ET (n = 60), n (%)	
Always	53 (88.3)
Often	4 (6.7)

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Characteristics	Overall (n = 61)
Sometimes	0 (0)
Rarely	1 (1.7)
Never	2 (3.3)

NDBE non-dysplastic Barrett's esophagus, *BE* Barrett's esophagus, *EAC* esophageal adenocarcinoma, *ET* eradication therapy

* Scores ranged from 1 for the most important to 8 for the least important

Table 3

Practice patterns regarding use of advanced imaging modalities (AIMs) among international experts in Barrett's esophagus

Advanced imaging modalities (n = 61)	N (%) or mean (SD)
Availability of AIMs, n (%)	
HDWLE	60 (98.4)
Virtual chromoendoscopy	56 (91.8)
NBI	55 (90.2)
BLI	8 (13.1)
i-Scan	6 (9.8)
FICE	1 (1.6)
Conventional chromoendoscopy	38 (62.3)
Acetic acid	27 (44.2)
Methylene blue	26 (42.6)
Indigo carmine	15 (24.6)
CLE	19 (31.1)
VLE	21 (34.4)
WATS ^{3D}	16 (26.2)
Comfort level, mean (SD) *	
Virtual chromoendoscopy (NBI or related technology)	1.1 (0.4)
Conventional chromoendoscopy	1.7 (0.9)
CLE	3.2 (1.6)
VLE	3.3 (1.5)
WATS ^{3D}	3.1 (1.5)
Use of AIMs for surveillance of NDBE, mean (SD) **	
HDWLE	1 (0)
Virtual chromoendoscopy (NBI or related technology)	1.1 (0.5)
Conventional chromoendoscopy	3.5 (1.3)
CLE	4.5 (0.9)
VLE	4.5 (0.9)
WATS ^{3D}	4.4 (1.1)

Advanced imaging modalities (n = 61)	N (%) or mean (SD)
Use of AIMs for surveillance of LGD, mean (SD) **	
HDWLE	1 (0)
Virtual chromoendoscopy (NBI or related technology)	1.1 (0.4)
Conventional chromoendoscopy	3.2 (1.5)
CLE	4.4 (1.0)
VLE	4.3 (1.1)
WATS ^{3D}	4.4 (1.1)
Importance of factors in determining use of AIMs, mean (SD) ***	
Data from randomized controlled trials	1.4 (0.9)
Society guidelines documents	2.6 (1.2)
Data from observational studies	3.2 (1.2)
Costs associated with technologies	3.5 (1.0)
Time added to the procedure	4.1 (1.1)

HDWLE high-definition white light endoscopy, NBI narrow-band imaging, BLI blue laser imaging, FICE Fujii intelligent chromoendoscopy, CLE confocal laser endomicroscopy, VLE volumetric laser endomicroscopy, WATS^{3D} wide-area transepithelial sampling with 3D analysis

* In response to whether they are comfortable using the technology, 1 = completely agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = completely disagree

** When screening/surveying for NDBE or LGD, they use the modality: 1 = always, 2 = often, 3 = some-times, 4 = rarely, 5 = never

*** Scores ranged from 1 for the, most influential to 5 for the, least influential

Surveillance patterns and use of advanced imaging modalities (AIMs) among international experts in Barrett's esophagus based on geographic location

Table 4

Characteristics	US (n = 41)	Non-US (n = 20)	p value
Frequency of NDBE surveillance, n (%)			
1 year	0 (0)	3 (15)	0.007
2 year	0 (0)	3 (15)	
3–5 years	40 (97.6)	14 (70)	
>5 years	1 (2.4)	0 (0)	
Reported importance of factors in determining surveillance intervals (mean, SD) ^{1*}			
Length of BE	2.1 (0.9)	1.4 (0.7)	0.005
Family history of EAC	1.8 (1.6)	2.5 (1.1)	0.002
Gender	4.3 (1.6)	3.3 (1.0)	0.1
Family history of BE	4.4 (2.3)	5.9 (2.1)	0.1
Obesity	5.0 (1.5)	4 (1.7)	0.2
Race	5.4 (1.8)	5.8 (2.2)	0.5
Advancing age	6.1 (1.6)	4.2 (2.3)	0.03
Tobacco use	5.3 (1.7)	6 (1.6)	0.3
Availability of AIMs, n (%)			
HDWLE	41 (100)	19 (95)	0.1
VC	37 (90.2)	19 (95)	0.5
NBI	37 (90.2)	18 (90)	0.9
BLI	0 (0)	8 (40)	<0.001
i-Scan	1 (2.4)	5 (25)	0.006
FICE	0 (0)	1 (5)	0.1
CC	21 (51.2)	17 (85)	0.01
Acetic acid	11 (26.8)	16 (80)	<0.001
Methylene blue	16 (39)	10 (50)	0.4
Indigo carmine	6 (14.6)	9 (45)	0.009
CLE	17 (41.5)	2 (10)	0.01
VLE	20 (48.8)	1 (5)	<0.001
WATS ^{3D}	12 (29.3)	4 (20)	0.4

Characteristics	US (n = 41)	Non-US (n = 20)	p value
Comfort level in using AIMs, mean (SD) **			
VC	1.1 (0.3)	1.1 (0.5)	0.9
CC	1.8 (1.1)	1.4 (0.7)	0.2
CLE	2.9 (1.6)	3.8 (1.3)	0.08
VLE	3.1 (1.6)	4 (1.2)	0.05
WATS ^{3D}	2.9 (1.5)	3.4 (1.5)	0.3
Use of AIMs for surveillance of NDBE, mean (SD) ***			
VC	1.1 (0.3)	1.2 (0.7)	0.9
CC	4.2 (0.8)	2.1 (1.2)	<0.001
CLE	4.4 (0.9)	4.7 (1.0)	0.1
VLE	4.4 (0.9)	4.8 (0.6)	0.2
WATS ^{3D}	4.3 (1.2)	4.6 (0.7)	0.7
Use of AIMs for surveillance of LGD, mean (SD) ***			
VC	1.0 (0.1)	1.2 (0.7)	0.2
CC	3.9 (1.0)	1.7 (1.2)	<0.001
CLE	4.3 (1.0)	4.7 (1.0)	0.06
VLE	4.1 (1.2)	4.8 (0.6)	0.05
WATS ^{3D}	4.2 (1.2)	4.6 (0.7)	0.7
Importance of factors in determining use of AIMs, mean (SD) ****			
Data from randomized controlled trials	1.3 (0.7)	1.6 (1.1)	0.2
Society guidelines documents	2.7 (1.2)	2.4 (1.3)	0.3
Data from observational studies	3.3 (1.2)	3.1 (1.3)	0.7
Costs associated with technologies	3.5 (1.1)	3.4 (0.8)	0.5
Time added to the procedure	4.2 (1.0)	3.9 (1.2)	0.4
IDY, median percent (IQR)			
VC	10 (10–25)	24 (10–80)	0.07
CC	23 (15–32)	20 (10–59)	0.9
CLE	26 (20–40)	34 (20–74)	0.4
VLE	30 (15–50)	36 (20–50)	0.7
WATS ^{3D}	25 (15–50)	20 (10–36)	0.4

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NDBE non-dysplastic Barrett's esophagus, *BE* Barrett's esophagus, *EAC* esophageal adenocarcinoma, *AIMs* advanced imaging modalities, *HDWLE* high-definition white light endoscopy, *VC* virtual chromoendoscopy, *CC* conventional chromoendoscopy, *NBI* narrow-band imaging, *BLI* blue laser imaging, *FICE* Fujii intelligent chromoendoscopy, *CLE* confocal laser endomicroscopy, *VLE* volumetric laser endomicroscopy, *WATS^{3D}* wide-area transepithelial sampling with 3D analysis, *IDY* incremental diagnostic yield

* Scores ranged from 1 for the most important to 8 for the least importance

** In response to whether they are comfortable using the technology, 1 = completely agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = completely disagree

*** When screening/surveying for NDBE or LGD, they use the modality: 1 = always, 2 = often, 3 = some-times, 4=rarely, 5 = never

**** Scores ranged from 1 for the most influential to 5 for the least influential