Endoscopic diagnosis and screening of Barrett’s esophagus: Inconsistency of diagnostic criteria between Japan and Western countries

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Abstract
Barrett’s esophagus (BE) is an endoscopically identifiable premalignant condition for esophageal adenocarcinoma (EAC). To diagnose BE precisely, careful inspection of the anatomic landmarks, including the esophagogastric junction and the squamocolumnar junction is important. The distal end of the palisade vessels and the proximal end of the gastric folds are used as the landmark of the esophagogastric junction in endoscopic diagnosis, with the latter solely used internationally, except in some Asian countries, including Japan. In addition, the diagnostic criteria adopted internationally for BE are inconsistent, particularly between Japan and Western countries. Recently updated guidelines in Western countries have included length criteria, with a 1-cm threshold of columnar epithelium by endoscopic observation and/or histologic confirmation of the presence of specialized intestinal metaplasia. Since BE is endoscopically diagnosed at any length without histologic assessment in Japan, the reported prevalence of short-segment BE is very high in Japan compared with that in Western countries. Although guidelines on screening exist for BE, the current strategies based on the presence of chronic gastroesophageal reflux disease with multiple risk factors may miss the opportunity for early detection of EAC. Indeed, up to 40% of patients with EAC have no history of chronic gastroesophageal reflux disease. To discuss BE on the same footing worldwide, standardization of diagnostic criteria, screening indication, and establishment of effective techniques for detecting dysplastic lesions are eagerly awaited. Japanese guidelines for BE should be revised regarding the length criteria, including the minimum length and long-segment BE, in line with the recently updated Western guidelines.

KEYWORDS
Barrett’s esophagus, esophageal adenocarcinoma, endoscopic diagnosis, guidelines, intestinal metaplasia

INTRODUCTION
The geographic variation in esophageal cancer incidence differs substantially between the 2 main histologic subtypes, esophageal squamous cell carcinoma (ESCC) and esophageal adenocarcinoma (EAC).1–3 ESCC is the predominant subtype in Asia, including Japan, while EAC is the predominant subtype in many Western regions, including Europe, North America, and Australia, with a rapidly increasing incidence noted in the...
Although the incidence of ESCC remains high, accounting for approximately 90% of all esophageal cancer cases in Japan, the incidence of EAC was reported to have increased steadily, more than threefold, for the past two decades according to the comprehensive registry of esophageal cancer in Japan.\textsuperscript{5–7} Barrett’s esophagus (BE) is the only known premalignant condition for EAC, characterized by the replacement of normal stratified squamous epithelium with columnar metaplasia in response to chronic gastroesophageal reflux.\textsuperscript{5–10} Early detection of precancerous or neoplastic changes in Barrett’s mucosa is of utmost importance because of the high mortality rate of EAC, which has a 5-year overall survival rate of less than 25%.\textsuperscript{11–13} Therefore, sensitive and accurate diagnosis of BE is an important issue in clinical practice. For detection of BE, endoscopy is the best diagnostic tool, with histopathological confirmation used in an adjunctive manner. To standardize and improve clinical practice, multiple guidelines have been published, though the definition of BE and the strategy of BE management have yet to be standardized universally and internationally.\textsuperscript{14} Here, we present a review of the endoscopic diagnosis and screening of BE, focusing on the inconsistency of diagnostic criteria, especially between Japan and Western countries.

**MULTIPLE GUIDELINES ON BE**

In Japan, the Japanese Esophageal Society (JES) definition of BE is well accepted and broadly used in the clinical setting.\textsuperscript{15} The Japanese Society of Gastroenterology briefly addressed BE in their recommendations for gastroesophageal reflux disease (GERD) published in 2015.\textsuperscript{16} The Asian Pacific Association of Gastroenterology updated its consensus statement on proton pump inhibitor-refractory GERD and BE based on Asia-Pacific data.\textsuperscript{17} In Europe, the European Society of Gastrointestinal Endoscopy (ESGE) published a position statement in 2017 that resulted from the consensus of four recent national guidelines.\textsuperscript{18} However, the British Society of Gastroenterology guidelines still differ from the ESGE guidelines on several domains of BE definition and management.\textsuperscript{19,20} In the USA, three gastrointestinal societies have contributed recommendations on the diagnosis and management of BE. The American Society of Gastrointestinal Endoscopy (ASGE) published recommendations in 2012 and recently updated those on BE screening, surveillance, and treatment (2017, 2018, and 2019).\textsuperscript{21–23} The American Gastroenterological Association has recently (2020) revised its previously published guidelines (2011 and 2016).\textsuperscript{24–26} In addition, the American College of Gastroenterology updated its guidelines in 2015.\textsuperscript{27} All of the current guidelines agree that BE should be diagnosed upon extension of the columnar epithelium into the distal esophagus. However, some controversy remains regarding the length and histologic criteria for BE diagnosis.\textsuperscript{14,28}

**DIAGNOSIS OF BE**

A diagnostic algorithm for BE is shown in Figure 1. Three major issues remain to be resolved in terms of the endoscopic and histologic diagnosis of BE as follows: Q1) What is the optimal landmark for the esophagogastric junction (EGJ)? Q2) What are the optimal length criteria for BE? Q3) What is the optimal histologic diagnosis of BE? Each of these issues is discussed in greater detail below.

**What is the optimal landmark for the EGJ?**

BE is usually diagnosed by endoscopy to detect salmon-colored columnar mucosa in the distal esophagus and confirmed by pathology. Therefore, the endoscopic recognition of the key anatomic landmarks of the EGJ is the first step in the diagnosis of BE. For identification of the EGJ, the distal end of the esophageal palisade vessels and the proximal end of the gastric mucosal folds are used as a landmark, with the latter widely adopted in most countries. In contrast, the distal end of the palisade vessels is mainly used as a landmark of the EGJ in some Asian countries, including Japan, and the proximal end of the gastric folds is used as the EGJ if the palisade vessels cannot be clearly identified.\textsuperscript{15,29,30}
Palisade vessels, defined histologically as veins greater than 100 µm in size, run longitudinally in the mucosal layer within the lower esophageal sphincter, descending the submucosa once entering the cardia. Therefore, the distal end of the palisade vessels coincides anatomically with the boundary between the esophagus and the stomach. Palisade vessels can be found easily on endoscopy when the lower esophagus is adequately distended by air through endoscopy with cooperated deep breathing (Figure 2a). However, they are sometimes difficult to identify owing to several factors, including insufficient extension under conscious sedation, mucosal inflammation, dysplastic changes, and the presence of a thick double muscularis mucosa (Figure 2b). Although some studies showed that the palisade vessels were visible to Western endoscopists in Western patients with BE, current Western guidelines do not include the palisade vessels as a landmark of the EGJ.

The definition of the EGJ adopted in Western countries is the most proximal border of the gastric longitudinal fold. This definition also has potential drawbacks, as the position of the proximal end of the gastric fold can easily change with gut motility, respiration, and the degree of air insufflation with endoscopy (Figure 3). In addition, the proximal end of the gastric fold is difficult to identify in the presence of atrophic gastritis with Helicobacter pylori infection, which is more commonly observed in Japan. It is because of the difficulty of accurate identification of the EGJ even with the use of these landmarks, that the inter-observer variability in the diagnosis of BE has been reported to be unacceptably high, especially in cases with BE length less than 1 cm. In a comparative study of the two landmarks, the proximal extent of the gastric folds was more accurate compared with the palisade vessels after a complete presentation of C&M criteria (C=circumferential length, M=maximal length) to endoscopists. Accordingly, the proximal extent of the gastric folds is still used as the EGJ in the most recent Western guidelines, despite poor concordance.

Virtual chromoendoscopy (VC), including narrow-band imaging (NBI), linked color imaging (LCI), and blue laser imaging, can accentuate surface mucosal patterns.
and vascular features without the use of stains or dyes, which is now available on many endoscopes and is useful for detecting gastrointestinal neoplastic lesions. In 2004, Hamamoto et al. reported the usefulness of NBI for visualization of the EGJ. More recently, endoscopic observation with LCI has been reported to improve the visibility of the palisade vessels as well as the area of Barrett’s segment compared with that using white light imaging, suggesting that VC may improve the diagnostic consistency to detect palisade vessels, especially for short-segment BE (SSBE). Consequently, the distal end of the palisade vessels is thought to be more suitable to the anatomic criteria of the EGJ than the proximal end of the gastric folds.

What are the optimal length criteria for BE?

The squamocolumnar junction or Z-line is an endoscopically visible demarcation separating the esophageal squamous epithelium from the red-colored columnar gastric epithelium. In BE, the salmon-colored columnar epithelium extends proximally from the EGJ to the esophagus in a continuous manner. In Japan, BE is defined as any length of columnar mucosa in the distal esophagus (Table 1). However, recently updated guidelines in Western and Asia-Pacific regions have included length criteria with a 1-cm threshold of the columnar-lined esophagus (CLE), because a CLE of less than 1 cm has high interobserver variability as well as a low risk of EAC. If the length of the CLE is less than 1 cm, it is called an irregular Z-line or specialized intestinal metaplasia (IM) of the EGJ in those guidelines, although the older American Gastroenterological Association and ASGE guidelines do not provide a length threshold.

Accordingly, the reported prevalence of BE based on endoscopy findings in Japan varies widely, with results ranging from 15% to 85.9%, in contrast to the range in Western countries of 5% to 20%. Adachi et al. reported that the prevalence of BE with a length of less than 1 cm was 56.2%, while that with a length of ≥1 cm was 26.2% when LCI was used to determine the area of BE, as the distal end of the palisade vessels was easily visualized. We investigated the inter-institutional variability in the diagnosis of BE at four different hospitals. Because of cases of over- and under-diagnosis, we demonstrated that the variance was unacceptably large (17.2%–96.8%), and the diagnostic accuracy was inadequate, especially in cases with a BE length of less than 1 cm, suggesting that the minimum length of CLE should be defined in future criteria in Japan. Although most studies show that the incidence of EAC in BE of less than 1 cm in length is very low, Barrie et al. recently reported that almost 20% of all dysplasia in BE and EAC occurs within a centimeter of the EGJ, suggesting that all lengths of CLE above the EGJ should be recognized as BE and subjected to a thorough biopsy protocol.

Traditionally, BE is divided into long-segment BE (LSBE, ≥3 cm) and SSBE (<3 cm) based on the length of columnar mucosa in the distal esophagus as assessed by endoscopy. Although not clearly defined in all guidelines, BE less than 1 cm in length is termed ultrashort-segment BE (USSBE). Since it is well understood that the risk of EAC increases with the length of BE, endoscopic inspections should receive more attention in patients with LSBE than in those with SSBE and USSBE. In Japan, LSBE is defined as the presence of circular Barrett’s mucosa extending longitudinally for 3 cm or more, while SSBE is defined as the presence of circular Barrett’s mucosa less than 3 cm in length or the presence of non-circular Barrett’s mucosa. In contrast, in other countries, LSBE is generally defined as Barrett’s mucosa with a maximal length greater than 3 cm (Figure 4). To date, the risk of EAC arising from LSBE with and without circular Barrett’s mucosa extending over 3 cm remains to be elucidated. Recently, a Japanese multicenter prospective cohort study showed that the incidence of EAC in patients with LSBE defined as Barrett’s mucosa with

### TABLE 1 Diagnostic criteria for Barrett’s esophagus

| Guideline (Area, published year) | EGJ landmark | Length | Histology |
|----------------------------------|--------------|--------|-----------|
| JES (Japan, 2015)                | 1) Lower end of palisade vessels  
2) Proximal end of gastric folds (when palisade vessels are not clear) | Any length | Columnar epithelium |
| APAGE (Asia-Pacific, 2016)       | Proximal end of gastric folds | ≥1 cm | Columnar epithelium |
| BSG (UK, 2014)                   | Proximal end of gastric folds | ≥1 cm² | Columnar epithelium |
| ESGE (Europe, 2017)             | Proximal end of gastric folds | ≥1 cm² | Intestinal metaplasia |
| ACG (USA, 2016)                 | Proximal end of gastric folds | ≥1 cm² | Intestinal metaplasia |
| AGA (USA, 2011)                 | Proximal end of gastric folds | any length | Intestinal metaplasia |
| ASGE (USA, 2012)                | Proximal end of gastric folds | none | Intestinal metaplasia |

1 Endoscopists should utilize the Prague classification to describe what is seen in Barrett’s segment. Abbreviations: ACG, American College of Gastroenterology; AGA, American Gastroenterological Association; APAGE, Asian Pacific Association of Gastroenterology; ASGE, American Society of Gastrointestinal Endoscopy; BSG, British Society of Gastroenterology; ESGE, European Society of Gastrointestinal Endoscopy; JES, Japanese Esophageal Society.
FIGURE 4 Diagnosis of Barrett’s esophagus based on length. (a) In Japan, Barrett’s esophagus (BE) is defined as any length of the columnar-lined esophagus (CLE), while in recently updated Western guidelines, BE is defined as CLE with length $\geq 1$ cm. In Japan, long-segment BE (LSBE) is defined as the presence of circular CLE extending 3 cm or more, while in Western countries, LSBE is generally defined as CLE with maximal length greater than 3 cm. *CLE with length $<1$ cm is also termed as ultrashort-segment BE (USSBE). **An irregular Z-line or specialized intestinal metaplasia of the esophagogastric junction. (b) Endoscopic view of CLE with length $<1$ cm ($M < 1$). (c) Endoscopic view of CLE with maximal length greater than 3 cm ($C < 3$, $M \geq 3$).

FIGURE 5 Endoscopic diagnosis based on Prague C&M criteria. (a) Endoscopic criteria for a diagnosis of Barrett’s esophagus are described in the Prague classification. The distance from the esophagogastric junction (EGJ), defined as the proximal end of the gastric fold to the top of the circumferential columnar mucosa, is the C-extent in centimeters, and the distance from the EGJ to the maximal extent of the columnar mucosa is the M-extent in centimeters. (b) In this case, the Prague classification is C1M4.

maximal length greater than 3 cm was 1.2%/year, similar to the values in reports from Western countries. This suggests that the term LSBE should be used for Barrett’s mucosa with maximal length greater than 3 cm for risk stratification based on length.

Further assessment and documentation of the BE segment should include the Prague C&M criteria, describing the circumferential (C) and maximal (M) extent of BE (Figure 5). This system classifies BE based on both the length of circumferential involvement and the maximal proximal extent of endoscopically visible columnar mucosa in the esophagus to simplify and standardize endoscopic characterization of the length and shape of BE. Because the increasing length of...
the BE segment is a known risk factor for the development of EAC, most recent guidelines recommend recording the length of BE in centimeters using these criteria.10,57–59

What is the optimal histologic diagnosis of BE?

The large number of studies demonstrating an oncogenic link between IM and EAC has led to the inclusion of the histologic confirmation of specialized IM, characterized by the presence of goblet cells for diagnosis of BE in most guidelines (Table 1).26,60,61 However, several studies showed that EAC may arise in the columnar mucosa without specialized IM.62,63 In addition, specialized IM may be missed due to insufficient biopsy sampling, suggesting that specialized IM may not be essential for a BE diagnosis.

In contrast, the JES defines BE as any type of columnar epithelium continuous from the stomach, regardless of the presence of specialized IM.15 Histologically, at least one of the following findings must be observed: 1) proper esophageal gland ducts, 2) squamous island, and 3) double-layer muscularis mucosa. Among these findings, squamous islands can be detected by endoscopy, and more effectively by NBI.64 Similar to the Japanese criteria, the Asian Pacific Association of Gastroenterology and British Society of Gastroenterology guidelines suggest that the presence of IM is not a prerequisite for the definition of BE,20 but should be taken into account when deciding the surveillance strategy.

At the initial diagnosis, the Seattle biopsy protocol, which entails four-quadrant biopsies every 2 cm in addition to targeted biopsies of macroscopically visible lesions, is recommended if the columnar lining is greater than 1 cm above the EGJ in most Western guidelines.49,65 However, the protocol is time-consuming, practicing endoscopists have poor adherence to it, and there is an increased risk associated with the large number of biopsy samples required.66 Since the majority of BE is SSBE, targeted biopsies are the standard protocol for endoscopic observation in Japan.30

SCREENING OF BE BY ENDOSCOPY

Most guidelines recommend against BE screening in the general population, but state that endoscopic screening can be considered in high-risk individuals. The common risk factors include chronic GERD symptoms, age older than 50 years, white race, male sex, obesity, smoking history, and a first-degree relative with BE or EAC.67 Consistently, Rubenstein et al. created a prediction tool incorporating GERD frequency, age, waist-to-hip ratio, and pack-years of cigarette use, and the tool showed substantially improved prediction of the presence of BE compared with a model using GERD symptoms alone.67,68 Although the threshold for the number of risk factors considered for screening varies among societies, all of those guidelines recommend endoscopy as the method for BE screening for high-risk individuals (Table 2). In contrast, there is no recommendation for BE screening in Japanese guidelines, likely due to the low prevalence of EAC. However, due to the higher prevalence of gastric cancer, screening endoscopy has been widely executed with low cost for asymptomatic healthy subjects as a part of the comprehensive health check-up to detect gastric cancer at the early stages. Therefore, most cases of BE are diagnosed incidentally on endoscopy findings obtained during a health check-up, and most EACs are detected at an early stage.5

Screening of BE based on the presence of multiple risk factors, as described above, may miss the opportunity for early detection of EAC in a large number of asymptomatic patients. Although chronic GERD is thought to be the principal causal risk factor for EAC based on previous studies,69,70 previous studies showed that up to 40% of patients with EAC had no history of chronic GERD.71,72 Furthermore, sampling and diagnostic errors with inter-variable pathological discrepancies result in reduced effectiveness of screening. According to the recent meta-analysis by Tan et al., only 11.8% of patients with EAC had a prior BE diagnosis, though concurrent BE was found in up to 60% at the time of EAC diagnosis. In particular, up to 91% of all newly diagnosed patients with early-stage EAC had BE on histopathology at the time of cancer diagnosis, and these findings raise the question of whether the population at risk of EAC is correctly identified and managed.73

ENDOSCOPIC DETECTION OF DYSPLASTIC LESIONS

When BE is suspected on endoscopy, careful inspection should be conducted prior to obtaining biopsies to look for subtle visible abnormalities. Indeed, longer inspection time has been associated with a higher likelihood of diagnosing dysplastic lesions.74 Recently, the ESGE endorsed examination of the BE segment at a rate of 1 min per cm as a quality measure.75 Compared with standard-definition white light, high-definition white light improved dysplasia detection with an odds ratio of 3.27 (95% confidence interval, 1.27–8.40)76 and is recommended in current guidelines. To increase yield in the detection of dysplasia or early cancer, the ASGE recommends chromoendoscopy or VC in addition to white-light endoscopy and biopsy specimens obtained using the Seattle protocol compared with white-light endoscopy and biopsy specimens obtained using the Seattle protocol alone.21 Several advanced imaging modalities have been investigated to improve the detection and identification of early neoplastic lesions during surveillance...
endoscopy. Based on the ASGE meta-analysis in 2016, only chromoendoscopy using acetic acid and VC using NBI met the ASGE Preservation and Incorporation of Valuable Endoscopic Innovations thresholds (sensitivity ≥90%, negative predictive value ≥98%, and specificity ≥80%). Indeed, NBI has been shown to increase the detection of dysplasia as well as to reduce the number of biopsies needed per patient.77,78

During the endoscopic examination, particular attention should be paid to the right side of the esophagus extending from 12- to 6-o’clock position, especially for SSBE, because EAC arising from SSBE is reported to be mainly located in the right side of the esophageal lumen likely due to potential inflammatory mechanisms for the circumferential predilection of EAC.80–83 In contrast, the distribution of EAC arising from LSBE remains to be clearly elucidated.84 We previously showed that EAC at the EGJ in LSBE was frequently located on the right anterior wall, while EAC distant from the EGJ showed no characteristic circumferential distribution, suggesting that development of this type of lesion may be less affected by gastroesophageal reflux.85

To aid in the ability to identify dysplasia and cancer on NBI, the Barrett’s International NBI Group has developed and validated an NBI classification system in patients with BE. The system, which includes the assessment under NBI with near-focus imaging of the mucosal pattern and the vascular pattern as either regular or irregular, has greater than 85% accuracy and a high level of interobserver agreement.86 More recently, the JES classification of BE using magnification NBI was developed. This classification very simply categorizes most mucosal or vascular descriptions as regular for non-dysplastic and irregular for dysplastic BE.87,88

To reduce rates of underdiagnosed or undiagnosed neoplasia in the upper gastrointestinal tract, artificial intelligence (AI) has recently been introduced to assist endoscopists in the detection and diagnosis of upper gastrointestinal neoplasia, including esophageal cancer.89 To date, several reports have been published regarding the detection of neoplasia in BE using AI technology.90–94 A recent meta-analysis by Arribas et al. showed that AI-aided endoscopy can detect BE-related neoplasia with high sensitivity (89%) and specificity (88%), indicating that the AI system is a promising tool to avoid missing neoplasia during endoscopy.95

CONCLUSIONS

The incidence of EAC arising from BE has been increasing worldwide, and better strategies must be developed for the early detection and prevention of EAC. However, the definition of BE remains to be standardized universally and current strategies for BE screening are far from being satisfactory. Although endoscopy with biopsy continues to be the gold standard in a clinical setting, minimally invasive, non-endoscopic technologies for BE have shown promise in recent clinical trials.96,97 To discuss BE on the same footing, international standardization of diagnostic criteria, screening indications, and techniques, as well as a more personalized approach to surveillance, are eagerly awaited. Unfortunately, current Japanese guidelines for BE do not use the GRADE system and should be revised regarding the length criteria, in line with recently updated Western guidelines.

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CONFLICT OF INTEREST

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REFERENCES

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2021; 71: 209–49.

2. Rummey H, Arnold M, Laversanne M, et al. International trends in esophageal squamous cell carcinoma and adenocarcinoma incidence. Am J Gastroenterol 2021; 116: 1072–6.

3. Uhlenhopp DJ, Then EO, Sunkara T, Gaduputi V. Epidemiology of esophageal cancer: Update in global trends, etiology and risk factors. Clin J Gastroenterol 2020; 13: 1010–21.

4. Thrift AP. Global burden and epidemiology of Barrett oesophagus and oesophageal cancer. Nat Rev Gastroenterol Hepatol 2021; 18: 432–43.

5. Nishi T, Makuuchi H, Ozawa S, Shimada H, Chino O. The present status and future of Barrett’s esophageal adenocarcinoma in Japan. Digestion 2019; 99: 185–90.

6. Watanabe M, Tachimori Y, Oyama T, et al. The present status and future of Barrett’s esophageal adenocarcinoma in Japan. Jpn J Clin Oncol 2017; 47: 179–212.

7. Scholvinck D, Goto O, Seldenrijk CA, et al. Endoscopic eradication therapy for patients with Barrett’s esophagus-associated dysplasia and intramucosal cancer. Gastrointest Endosc 2018; 87: 907–31.e9.

8. Thapa S, Qin X, Kato C, et al. Westernized Barrett’s esophagus in East Asian countries. Digestion 2018; 96: 166–73.

9. Shinagawa H, Takahashi A, Onoda K, et al. Westernized Barrett’s esophagus and other premalignant conditions of the esophagus. J Gastroenterol Hepatol 2019; 34: 50–60.

10. Amano Y, Ishimura N, Ishihara S. Is malignant potential of Barrett’s esophagus predictable by endoscopy findings? Life 2020; 10: 244. DOI: 10.3390/life10100244

11. Launoy G, Bossard N, Castro C, Manfredi S. Trends in net survival of esophageal cancer in Japan, 2013. Esophagus 2021; 18: 1–24.

12. Chen Z, Ren Y, Du XL, et al. Diagnostic value of endoscopic detection of palisade vessels as a landmark of esophagogastric junction. J Gastroenterol Hepatol 2015; 30: 50–60.

13. Njei B, McCarty TR, Birk JW. Trends in esophageal cancer survival in United States adults from 1973 to 2009: A SEER database analysis. J Gastroenterol Hepatol 2016; 31: 1141–6.

14. Marques De Sá I, Pereira AD, Sharma P, Dinis-Ribeiro M. Systematic review of the published guidelines on Barrett’s esophagus: Should we stress the consensus or the differences? Dis Esophagus Published online: 30 Nov 2020; DOI: 10.1093/dote/doaa115.

15. Asian Esophageal Society. Japanese classification of esophageal cancer, 11th edition: Part I. Esophagus 2017; 14: 1–36.

16. Iwakiri K, Kinoshita Y, Habu Y, et al. Evidence-based clinical practice guidelines for gastroesophageal reflux disease 2015. J Gastroenterol 2016; 51: 751–67.

17. Fock KM, Talley N, Goh KL, et al. Asia-Pacific consensus on the management of gastro-esophageal reflux disease: An update focusing on refractory reflux disease and Barrett’s oesophagus. Gut 2016; 65: 1402–15.

18. Warshaw AL, Armstrong D, et al. Endoscopic management of Barrett’s esophagus: European Society of Gastrointestinal Endoscopy (ESGE) position statement. Endoscopy 2017; 49: 191–8.

19. Di Pietro M, Fitzgerald RC. Revised British Society of Gastroenterology recommendation on the diagnosis and management of Barrett’s oesophagus with low-grade dysplasia. Gut 2018; 67: 392–3.

20. Marques De Sá I, Pereira AD, Dinis-Ribeiro M. Systematic review of the published guidelines on Barrett’s esophagus: Should we stress the consensus or the differences? Dis Esophagus Published online: 30 Nov 2020; DOI: 10.1093/dote/doaa115.

21. Wani S, Qumseya B, Sultan S, et al. Endoscopic eradication therapy for patients with Barrett’s esophagus-associated dysplasia and intramucosal cancer. Gastrointest Endosc 2018; 87: 907–31.e9.

22. Evans JA, Early DS, Fukami N, Ben-Menachem T, Chandrasekhar V, Chathadi KV, et al. The role of endoscopy in Barrett’s esophagus and other premalignant conditions of the esophagus. Gastrointest Endosc 2012; 76: 1087–94.

23. Sharma P, Shaheen NJ, Katzka D, Bergman J, JGHM. AGA clinical practice update on endoscopic treatment of Barrett’s esophagus with dysplasia and/or early cancer: Expert review. Gastroenterology 2020; 158: 760–9.

24. Wani S, Rubenstein JH, Vieth M, Bergman J. Diagnosis and management of low-grade dysplasia in Barrett’s esophagus: Expert review from the clinical practice updates committee of the American Gastroenterological Association. Gastroenterology 2016; 151: 822–35.

25. Mcdonald SAC, Lavery D, Wright NA, Jansen M. Barrett oesophagus predictable by endoscopy findings? Life 2020; 10: 244. DOI: 10.3390/life10100244

26. American Gastroenterological Association; Spechler SJ, Sharma P, Souza RF, Inadomi JM, Shaheen NJ, American Gastroenterological Association medical position statement on the management of Barrett’s esophagus. Gastroenterology 2011; 140: 1084–91.

27. Shaheen NJ, Falk GW, Iyer PG, Gerson LB. AGC clinical guideline: Diagnosis and management of Barrett’s esophagus. Am J Gastroenterol 2016; 111: 30–60.

28. Clermont M, Falk GW. Clinical guidelines update on the diagnosis and management of Barrett’s esophagus. Dig Dis Sci 2018; 63: 2122–8.

29. Choi DoW, Oh SN, Baek SJ, et al. Endoscopically observed lower esophageal capillary patterns. Korean J Intern Med 2002; 17: 245–8.

30. Ishimura N, Amano Y, Sollano JD, et al. Questionnaire-based survey conducted in 2011 concerning endoscopic management of Barrett’s esophagus in East Asian countries. Digestion 2012; 86: 136–46.

31. Aida J, Vieth M, Ell C, et al. Palisade vessels as a new histologic marker of esophageal origin in ER specimens from columnar-lined esophagus. Am J Surg Pathol 2011; 35: 1140–5.

32. Noda T. Angloarchitectural study of esophageal varices. With special reference to variceal rupture. Virchows Arch A Pathol Anat Histopathol 1984; 404: 381–92.

33. An A, Zhang Y, Li X, et al. Detection of palisade vessels as a landmark for Barrett’s esophagus in a Western population. J Gastroenterol 2016; 51: 682–90.

34. Usami K, Kishimoto H, Nanri H, et al. Westernized Barrett’s esophagus in East Asian countries. Digestion 2018; 96: 166–73.

35. Ishimura N, Amano Y, Kinoshita Y. Endoscopic definition of esophagogastric junction for diagnosis of Barrett’s esophagus: Importance of systematic education and training. Dig Endosc 2009; 21: 213–8.

36. Sharma P, Dent J, Armstrong D, et al. The development and validation of an endoscopic grading system for Barrett’s esophagus: The Prague C & M criteria. Gastroenterology 2006; 131: 1392–9.
37. Amano Y, Ishimura N, Furuta K, et al. Which landmark results in a more consistent diagnosis of Barrett’s esophagus, the gastric folds or the palisade vessels? *Gastrointest Endosc* 2006; **64**: 206–11.

38. Hajlesseidig OE, Zorron Cheng Tao Pu L, Thompson JY, et al. Diagnostic accuracy of narrow-band imaging endoscopy with targeted biopsies compared with standard endoscopy with random biopsies in patients with Barrett’s esophagus: A systematic review and meta-analysis. *J Gastroenterol Hepatol* Published online: 13 Jun 2021; DOI:10.1111/jgh.15577.

39. Shinozaki S, Osawa H, Hayashi Y, Lefor AK, Yamamoto H. Linked color imaging for the detection of early gastrointestinal neoplasms. *Therap Adv Gastroenterol* 2019; 12: 17562841988524.

40. Diao W, Huang Xu, Shen L, Zeng Z. Diagnostic ability of blue laser imaging combined with magnifying endoscopy for early esophageal cancer. *Dig Liver Dis* 2018; **50**: 1035–040.

41. Hamamoto Y, Endo T, Nosho K, Arimura Y, Sato M, Imai K. Usefulness of narrow-band imaging endoscopy for diagnosis of Barrett’s esophagus. *J Gastroenterol* 2004; **39**: 14–20.

42. Adachi K, Ishimura N, Kishi K, et al. Prevalence of Barrett’s epithelium shown by endoscopic observations with linked color imaging in subjects with different H. pylori infection statuses. *Intern Med* 2021; **60**: 667–74.

43. Takeda T, Nagahara A, Ishizuka K, et al. Improved visibility of Barrett’s esophagus with linked color imaging: Inter- and intra-rater reliability and quantitative analysis. *Digestion* 2018; **97**: 183–94.

44. Marques De Sá I, Marcos P, Sharma P, Dinis-Ribeiro M. The global prevalence of Barrett’s esophagus: A systematic review of the published literature. *United European Gastroenterol J* 2020; **8**: 1086–105.

45. Sugimoto H, Kawai T, Naito S, et al. Surveillance of short-segment Barrett’s esophagus using ultrathin transnasal endoscopy. *J Gastroenterol Hepatol* 2015; **30**(Suppl 1): 41–5.

46. Shiotra S, Singh S, Anshasi A, El-Serag HB. Prevalence of Barrett’s esophagus in Asian countries: A systematic review and meta-analysis. *Clin Gastroenterol Hepatol* 2015; **13**: 1907–18.

47. Ho KY. From GERD to Barrett’s esophagus: Is the pattern in Asia mirroring that in the West? *J Gastroenterol Hepatol* 2011; **26**: 816–24.

48. Ishimura N, Yuki M, Yuki T, et al. Inter-institutional variations regarding Barrett’s esophagus diagnosis. *Esophagus* 2019; **16**: 71–6.

49. Fukuda S, Watanabe K, Yoshida T, et al. Low risk of esophageal adenocarcinoma among patients with ultrashort-segment Barrett’s esophagus in Japan. *Dig Endosc* Published online: 26 Aug 2021; DOI:10.1111/den.14118.

50. Barrie J, Yanni F, Sheriff M, Dubé AK, Tamhankar AP. Length of Barrett’s esophagus in the presence of low-grade dysplasia, high-grade dysplasia, and adenocarcinoma. *Surg Endosc* 2021; **35**: 4756–62.

51. Matsuaki J, Suzuki H, Asakura K, et al. Etiological difference between ultrashort- and short-segment Barrett’s esophagus. *J Gastroenterol* 2011; **46**: 332–8.

52. Pohl H, Pech O, Arash H, et al. Length of Barrett’s oesophagus and cancer risk: Implications from a large sample of patients with early oesophageal adenocarcinoma. *Gut* 2016; **65**: 196–201.

53. Hamade N, Vennelaganti S, Parasa S, et al. Lower annual rate of progression of short-segment vs long-segment Barrett’s esophagus to esophageal adenocarcinoma. *Clin Gastroenterol Hepatol* 2019; **17**: 864–8.

54. Chang J, Fasanella K, Chennat J, Davison J, Mcgrath K. Prevalence of esophageal neoplasia in short-segment versus long-segment Barrett’s esophagus. *Esophagus* 2016; **13**: 151–5.

55. Matsushashi N, Sakai E, Ohata K, et al. Surveillance of patients with long-segment Barrett’s esophagus: A multicenter prospective cohort study in Japan. *J Gastroenterol Hepatol* 2017; **32**: 409–14.

56. Armstrong D. Review article: Towards consistency in the endoscopic diagnosis of Barrett’s oesophagus and columnar metaplasia. *Aliment Pharmacol Ther* 2004; **20**(Suppl 5): 40–7.

57. Alvarez Herrero L, Curvers WL, van Vlisteren FG, et al. Validation of the Prague C&M classification of Barrett’s esophagus in clinical practice. *Endoscopy* 2013; **45**: 876–82.

58. Vahabzadeh B, Seetharam AB, Cook MB, et al. Validation of the Prague C & M criteria for the endoscopic grading of Barrett’s esophagus by gastroenterology trainees: A multicenter study. *Gastrointest Endosc* 2012; **75**: 236–41.

59. Lee Y, Cook M, Bhatia S, et al. Interobserver reliability in the endoscopic diagnosis and grading of Barrett’s esophagus: An Asian multinational study. *Endoscopy* 2010; **42**: 699–704.

60. Bhat S, Coleman HG, Yousef F, et al. Risk of malignant progression in Barrett’s esophagus patients: Results from a large population-based study. *J Natl Cancer Inst* 2011; **103**: 1049–57.

61. Westerhoff M, Hovan L, Lee C, Hart J. Effects of dropping the requirement for goblet cells from the diagnosis of Barrett’s esophagus. *Clin Gastroenterol Hepatol* 2012; **10**: 1232–6.

62. Takubo K, Aida J, Naomoto Y, et al. Cardiac rather than intestinal-type background in endoscopic resection specimens of minute Barrett adenocarcinoma. *Hum Pathol* 2009; **40**: 65–74.

63. Kelty CJ, Gough MD, Van Wyk Q, Stephenson TJ, Ackroyd R. Barrett’s oesophagus: Intestinal metaplasia is not essential for cancer risk. *Scand J Gastroenterol* 2007; **42**: 1271–4.

64. Ishimura N, Amano Y, Uno G, Yuki T, Ishihara S, Kinoshita Y. Endoscopic characteristics of short-segment Barrett’s esophagus, focusing on squamous islands and mucosal folds. *J Gastroenterol Hepatol* 2012; **27**(Suppl 3): 62–7.

65. Thota PN, Vennelaganti P, Vennelaganti S, et al. Low risk of high-grade dysplasia or esophageal adenocarcinoma among patients with Barrett’s esophagus less than 1 cm (irregular z line) within 5 years of index endoscopy. *Gastroenterology* 2017; **152**: 987–92.

66. Wani S, Williams JL, Komanduri S, Muthusamy VR, Shaheen NJ. Endoscopists systematically undersample patients with long-segment Barrett’s esophagus: An analysis of biopsy sampling practices from a quality improvement registry. *Gastrointest Endosc* 2019; **90**: 732–41.e3.

67. Rubenstein JH, Morgenstern H, Appelman H, et al. Prediction of Barrett’s esophagus among men. *Am J Gastroenterol* 2013; **108**: 353–62.

68. Thrift AP, Vaughan TL, Anderson LA, Whiteman DC, El-Serag HB. External validation of the Michigan Barrett’s esophagus prediction tool. *Clin Gastroenterol Hepatol* 2017; **15**: 1124–6.

69. Cook MB, Corley DA, Murray LJ, et al. Gastroesophageal reflux in relation to adenocarcinomas of the esophagus: A pooled analysis from the Barrett’s and esophageal adenocarcinoma consortium (BEACON). *PLoS One* 2014; **9**: e103508.

70. Lagergren J, Bergström R, Lindgren A, Nyren O. Symptomatic gastroesophageal reflux as a risk factor for esophageal adenocarcinoma. *N Engl J Med* 1999; **340**: 825–31.

71. Shaheen N, Ransohoff DF. Gastroesophageal reflux, Barrett esophagus, and esophageal cancer: Scientific review. *JAMA* 2002; **287**: 1972–81.

72. Holmes RS, Vaughan TL. Epidemiology and pathogenesis of esophageal cancer. *Semin Radiat Oncol* 2007; **17**: 2–9.

73. Tan MC, Mansour N, White DL, Sisson A, El-Serag HB, Thrift AP. Systematic review with meta-analysis: Prevalence of prior and concurrent Barrett’s oesophagus in oesophageal adenocarcinoma patients. *Aliment Pharmacol Ther* 2020; **52**: 20–36.

74. Gupta N, Gaddam S, Wani SB, Bansal A, Rastogi A, Sharma P. Longer inspection time is associated with increased detection of high-grade dysplasia and esophageal adenocarcinoma in Barrett’s esophagus. *Gastrointest Endosc* 2012; **76**: 531–38.

75. Bisschops R, Areia M, Coren E, Dobru D, Kaskas B, Kuvaev R, et al. Performance measures for upper gastrointestinal
endoscopy: A European Society of Gastrointestinal Endoscopy quality improvement initiative. United European Gastroenterol J 2016;4: 629–56.
76. Sami SS, Subramanian V, Butt WM, et al. High definition versus standard definition white light endoscopy for detecting dysplasia in patients with Barrett’s esophagus. Dis Esophagus 2015; 28: 742–9.
77. Thosani N, Abu Dayyeh BK, Sharma P, et al. ASGE Technology Committee systematic review and meta-analysis assessing the ASGE Preservation and Incorporation of Valuable Endoscopic Innovations thresholds for adopting real-time imaging-assisted endoscopic targeted biopsy during endoscopic surveillance of Barrett’s esophagus. Gastrointest Endosc 2016; 83: 684–98.
78. Sharma P, Hawes RH, Bansal A, et al. Standard endoscopy with random biopsies versus narrow band imaging targeted biopsies in Barrett’s esophagus: A prospective, international, randomised controlled trial. Gut 2013; 62: 15–21.
79. Wolfsemi HC, Crook JE, Krishna M, et al. Prospective, controlled tandem endoscopy study of narrow band imaging for dysplasia detection in Barrett’s Esophagus. Gastroenterology 2008; 135: 24–31.
80. Ishimura N, Okada M, Mikami H, et al. Pathophysiology of Barrett’s esophagus-associated neoplasia: Circumferential spatial predilection. Digestion 2014; 89: 291–8.
81. Kariyawasam VC, Bourke MJ, Hourigan LF, et al. Circumferential location predicts the risk of high-grade dysplasia and early adenocarcinoma in short-segment Barrett’s esophagus. Gastrointest Endosc 2012; 75: 938–44.
82. Omae M, Fujisaki J, Shimizu T, et al. Correlation of the location of superficial Barrett’s esophageal adenocarcinoma (s-BEA) with the direction of gastroesophageal reflux. Endosc Int Open 2016; 4: E515–20.
83. Ohara S, Furuta K, Adachi K, et al. Radially asymmetric gastroesophageal acid reflux in the distal esophagus: Examinations with novel pH sensor catheter equipped with 8 pH sensors. J Gastroenterol 2012; 47: 1221–7.
84. Cassani L, Sumner E, Slaughter JC, Yachimski P. Directional distribution of neoplasia in Barrett’s esophagus is not influenced by distance from the gastroesophageal junction. Gastrointest Endosc 2013; 77: 877–82.
85. Okada M, Ishimura N, Mikami H, et al. Circumferential distribution and clinical characteristics of esophageal cancer in lower esophagus: Differences related to histological subtype. Esophagus 2019; 16: 98–106.
86. Sharma P, Bergman JG, Goda K, et al. Development and validation of a classification system to identify high-grade dysplasia and esophageal adenocarcinoma in Barrett’s esophagus using narrow-band imaging. Gastroenterology 2016; 150: 591–8.
87. Goda K, Fujisaki J, Ishihara R, et al. Newly developed magnifying endoscopic classification of the Japan Esophageal Society to identify superficial Barrett’s esophagus-related neoplasms. Esophagus 2018; 15: 153–9.
88. Goda K, Takeuchi M, Ishihara R, et al. Diagnostic utility of a novel magnifying endoscopic classification system for superficial Barrett’s esophagus-related neoplasms: A nationwide multicenter study. Esophagus 2021; 18: 713–23.
89. Oka A, Ishimura N, Ishihara S. A new dawn for the use of artificial intelligence in gastroenterology, hepatology and pancreatology. Diagnostics 2021; 11: 1719. DOI:10.3390/diagnostics11091719.
90. Ebibgo A, Palm C, Messmann H. Barrett esophagus: What to expect from artificial intelligence? Best Pract Res Clin Gastroenterol 2021; 52–53: 101726.
91. De Groof AJ, Struyvenberg MR, Fockens KN, et al. Deep learning algorithm detection of Barrett’s neoplasia with high accuracy during live endoscopic procedures: A pilot study (with video). Gastrointest Endosc 2020; 91: 1242–50.
92. De Groof AJ, Struyvenberg MR, Van Der Putten J, et al. Deep-learning system detects neoplasia in patients with Barrett’s Esophagus with higher accuracy than endoscopists in a multistep training and validation study with benchmarking. Gastroenterology 2020; 158: 915–29.e4.
93. Groof J, Sommen F, Putten J, et al. The Argos project: The development of a computer-aided detection system to improve detection of Barrett’s neoplasia on white light endoscopy. United European Gastroenterol J 2019; 7: 538–47.
94. Hashimoto R, Requa J, Dao T, et al. Artificial intelligence using convolutional neural networks for real-time detection of early esophageal neoplasia in Barrett’s esophagus (with video). Gastrointest Endosc 2020; 91: 1264–71.e1.
95. Arribas J, Antonelli G, Frazzoni L, et al. Standalone performance of artificial intelligence for upper GI neoplasia: A meta-analysis. Gut Published online: 30 Oct 2020; DOI:10.1136/gutjnl-2020-321922.
96. Krishna Chandar A, Sharma A, Chak A. Novel screening alternatives for barrett esophagus. Gastroenterol Hepatol 2020; 16: 238–45.
97. Peters Y, Al-Kaabi A, Shaheen NJ, Chak A, et al. Barrett oesophagus. Nat Rev Dis Primers 2019; 5: 35.