Review

Gastro-esophageal reflux disease and Barrett’s esophagus: an overview with an histologic diagnostic approach

Luca Mastracci1,2*, Federica Grillo1,2*, Paola Parente3, Elettra Unti4, Serena Battista5, Paola Spaggiari6, Michela Campora1, Giulia Scaglione1, Matteo Fassan7, Roberto Fiocca1,2

1 Anatomic Pathology, San Martino IRCCS Hospital, Genova, Italy; 2 Anatomic Pathology, Department of Surgical Sciences and Integrated Diagnostics (DISC), University of Genova, Italy; 3 Unit of Pathology, Fondazione IRCCS Casa Sollievo della Sofferenza, San Giovanni Rotondo, (FG), Italy; 4 UOC Anatomia Patologica, ARNAS Ospedali Civico-Di Cristina-Benfratelli, Palermo, Italy; 5 SOC di Anatomia Patologica, Azienda Sanitaria Universitaria Friuli Centrale, Udine, Italy; 6 Department of Pathology, Humanitas Clinical and Research Center-IRCCS, Rozzano, Milan, Italy; 7 Surgical Pathology Unit, Department of Medicine (DIMED), University of Padua, Italy

* These authors contributed equally

Summary

The first part of this overview on non-neoplastic esophagus is focused on gastro-esophageal reflux disease (GERD) and Barrett’s esophagus. In the last 20 years much has changed in histological approach to biopsies of patients with gastro-esophageal reflux disease. In particular, elementary histologic lesions have been well defined and modality of evaluation and grade are detailed, their sensitivity and specificity has been evaluated and their use has been validated by several authors. Also if there is not a clinical indication to perform biopsies in patient with GERD, the diagnosis of microscopic esophagitis, when biopsies are provided, can be performed by following simple rules for evaluation which allow pathologists to make the diagnosis with confidence. On the other hand, biopsies are required for the diagnosis of Barrett’s esophagus. This diagnosis is the synthesis of endoscopic picture (which has to be provided with the proper description on extent and with adequate biopsies number) and histologic pattern. The current guidelines and expert opinions for the correct management of these diagnosis are detailed.

Key words: gastro-esophageal reflux disease (GERD), microscopic esophagitis, Barrett’s esophagus, intestinal metaplasia of the cardia, histology

Introduction

In the last 20 years the approach to esophageal non-neoplastic disease has dramatically changed and improved. Various reasons can explain this new interest for esophageal pathology, from the worldwide increasing incidence of esophageal adenocarcinoma, which recognizes in gastro-esophageal reflux disease (GERD) and in Barrett’s esophagus (BE) its principal carcinogenic mechanisms, to the comprehension of the pathology of conditions such eosinophilic esophagitis (EE), to the description of new rare entities such lymphocytic esophagitis (LE) which represent a challenge when approaching esophageal biopsies.

Furthermore, changes in definitions of some conditions, refinement of histologic elementary lesions and application of this knowledge in routine diagnostic practice, need to be addressed and implemented by all pathologists involved in the diagnosis of gastrointestinal diseases. This overview on non-neoplastic esophageal disease has the main aim to furnish a practical diagnostic approach to biopsy samples to the prin-
cipal illnesses affecting the esophagus tract, on the basis of recent published recommendations, guidelines and expert opinions.

**Normal Esophageal Mucosa**

The esophagus is lined by a multilayered non-keratinizing squamous epithelium. In normal individuals, the basal layer (the proliferative part of the epithelium) is limited to 2-3 layers of cells and occupies less than 15% of the total epithelial thickness. Normal papillae are shorter than 2/3 of the epithelium and inflammatory cells are sparse. Intraepithelial inflammatory cells are generally represented by T lymphocytes with a mean number of 20 in Z-lines biopsies of healthy controls and less numerous in more proximal sites. Immunophenotypically normal intraepithelial lymphocytes are predominantly CD8+ suppressor, while a minority are CD4+ helper T cells. Sparse intraepithelial Langerhans cells and very few mast cells are also present, while B lymphocytes, NK cells and macrophages are limited to the submucosal compartment. In healthy subjects, no eosinophils or neutrophils are present within the esophageal mucosa.

**Gastro-Esophageal Reflux Disease (GERD)**

**Definition**

Gastro-Esophageal Reflux Disease (GERD) is defined as damage of the squamous epithelium secondary to the pathological reflux of gastric content (comprising both gastric acidic substances and bile salts from duodenum-gastric reflux) in the esophagus, causing troublesome symptoms and/or complications.

**Clinical picture**

GERD is a very common condition with a prevalence approaching 20% in western countries, while in eastern countries, the prevalence is generally lower than 10%. The diagnosis is related to presence of typical or atypical symptoms which adversely affect the individual’s well-being. Troublesome symptoms are defined on the basis of their frequency and severity: mild symptoms occurring 2 or more days a week or moderate/severe symptoms occurring more than 1 day a week. Typical esophageal symptoms include: heartburn (retrosternal burning sensation), regurgitation (perception of flow of refluxed gastric content in the mouth or hypopharynx) and epigastric/chest pain, sometimes indistinguishable from ischemic cardiac pain. Chronic cough, laryngitis, asthma and dental erosion are the more frequently reported extra-esophageal symptoms.

On the basis of symptoms and endoscopic appearance the following conditions can be distinguished:

- **Erosive reflux disease (ERD):** presence of symptoms and mucosal breaks at endoscopy;
- **Non-erosive reflux disease (NERD):** presence of symptoms in the absence of mucosal breaks at endoscopy. NERD patients are reported to be 50-60% of patients with GERD;
- **Esophageal Disorders of Gut-Brain Interaction (EDGBI, previously named functional disorders):** these are a group of disorders with symptoms related to motility disturbances, visceral hypersensitivity, altered mucosal and immune functions, gut microbiota, and/or central nervous system processing. This category includes functional esophageal chest pain, functional heartburn and reflux hypersensitivity (esophagus sensitive to the normal reflux of acidic or non-acidic material), globus (sensation of foreign body in the throat) and functional dysphagia (sensation of abnormal bolus transit through the esophageal body).

**Endoscopy picture**

ERD is diagnosed by endoscopy when visible breaks are seen in the esophageal mucosa near to or at the GE junction. The Los Angeles classification is the validated and most reliable and diffuse system for grading esophageal mucosal breaks (scoring based on the number and extension). The term esophagitis, grades A to D, is used to define endoscopically detectable erosive lesions. NERD and EDGBI, by definition, do not show any endoscopic abnormalities.

**Biopsy site**

Patients with GERD are usually diagnosed on the basis of symptoms and endoscopic assessment with/without pHmetry and impedance, in the absence of any indications for routine esophageal biopsies. This is mainly due to the fact that histology does not provide additional information for patient management. Despite this, esophageal biopsies can be performed by gastroenterologists in patients with suspected GERD complications or in patients with atypical symptoms or functional disease in the absence of endoscopic alterations. For these reasons, an accurate evaluation of histological lesions in order to provide a correct diagnosis, may be important. As histologic lesions in GERD are usually limited to the distal esophagus, sampling should include the last 2 cm above the Z line (2 biopsies at 2 cm and 2 biopsies on the esophageal side of the Z line). More proximal biopsies are less informative.
**Histologic Elementary Lesions**

The term microscopic esophagitis refers to a group of histologic lesions, observed in patients with GERD and NERD reflux disease and also in some ‘functional disorders’. Histologic lesions are unspecific and can also be observed in other types of esophagites and in physiological reflux. In the last 15 years, numerous studies have focused on the definition of histologic elementary lesions, sensitivity and specificity of histology, reproducibility and validation of diagnosis and demonstration of improvement of esophageal mucosal repair after surgical or medical therapy 9-20.

The most informative histological lesions are the following:

- **Basal cell hyperplasia (BCH)** is defined as the thickness of the squamous epithelium basal layer ≥ 15% of the total thickness. The upper limit of the basal layer is defined as the level where the nuclei of epithelial cells are separated by a distance greater than their diameter. Basal cell hyperplasia is graded as mild (< 30%) or marked (≥ 30%) (Fig. 1) and assessment requires well oriented samples 11,14.

- **Papillae elongation (PE)** is defined as an elongation of papillae ≥ 66% of total epithelial thickness. The upper limit of the papilla is defined as the upper limit of the vessel along its axis. It is graded as mild (< 75%) or marked (≥ 75%) (Fig. 2) and assessment requires well oriented samples 11,14.

- **Dilated intercellular spaces (DIS)** are irregular dilations of intercellular spaces, detectable as optically empty bubbles or ladders. DIS are more prevalent in the lower half of the epithelium and around the papillae and must be differentiated from “stretching” artefacts and from intracytoplasmic vacuoles 11,14. DIS can be graded as small or large (in relation to the diameter of a small lymphocyte) (Fig. 3).

- **Inflammatory cells**: intraepithelial eosinophils are present in about 50% of patients with GERD; intraepithelial neutrophils are a rare finding (< 5%) in patients with NERD and their presence is usually associated with erosive disease. Both are highly specific but suffer from low sensitivity. Intraepithelial lymphocytes do not play a significant role in the diagnosis of microscopic esophagitis, nor other types of inflammatory cells (mast cells, Langerhans cells, macrophages), rarely seen in esophageal biopsies 10.

- **Erosions** are characterized by the presence of necrosis with granulation tissue and/or fibrin with neutrophils; **healed erosions** show fibrosis/granulation tissue covered by thin regenerative epithelium in the absence of necrosis 11-14. These lesions are mainly seen in erosive esophagitis, with a high specificity but a low sensitivity, and, together with intraepithelial neutrophils represent the most severe lesions in the spectrum of microscopic eso-
Figure 2. Elementary lesion - increasing grades of severity in papillae elongation: A) normal papillae occupy less than 2/3 of the total epithelial thickness; B) mild papillae elongation does not exceed 75% of total epithelial thickness; C) marked papillae elongation with the upper limit of papillae approaching the epithelial surface. Magnification 20x. Reprinted from ref. 10 with permission from Virchows Archiv, Springer Nature.

Figure 3. Elementary lesion - increasing grades of severity in dilated intercellular spaces (DIS): (A) in normal squamous epithelium, cells are sealed one with the other; (B) small, irregular DIS are shown close to a papilla; (C) large DIS with bubbles and ladders larger than the diameter of a small lymphocyte. Magnification 40x. Reprinted from ref. 10 with permission from Virchows Archiv, Springer Nature.
phagitis. Whenever they are found, microscopic esophagitis can be diagnosed regardless of the presence of other lesions. Histologic lesions in microscopic esophagitis are irregularly distributed and may be focal. Consequently, assessment should be made in the most affected areas. A scoring system including multiple histologic lesions could help to increase both sensitivity and specificity of histologic findings.\(^\text{10}\)

**Diagnosis**

For a practical approach to esophageal biopsies, the diagnosis of microscopic esophagitis should be made when any of the following are seen: a) at least two mild histologic lesions; b) at least one severe lesion; c) any one of erosions/healed erosions/intraepithelial neutrophils.\(^\text{10,21}\)

**Barrett’s esophagus**

**Definition**

Barrett’s esophagus (BE) is defined as the replacement of any portion of the esophageal normal distal squamous epithelium by metaplastic columnar epithelium, which is clearly visible endoscopically (≥ 1 cm) above the gastro-esophageal junction (GEJ). This definition requires histological confirmation on esophageal biopsies. This definition is common to international guidelines as well as Italian guidelines and expert statements.\(^\text{21,27}\)

**Clinical picture**

BE represents a complication of gastro-esophageal reflux disease, with which it shares symptoms. The prevalence of BE in the population at large remains uncertain. Two studies have attempted to assess the prevalence via endoscopy screening of an unselected adult population, reporting respectively a prevalence of 1.6% in the Swedish\(^\text{28}\) and of 1.3% in the Italian population.\(^\text{29}\) However, the limited participation rate remained a concern in both these studies, since it introduced a risk of selection bias resulting in a possible overestimate of the prevalence. On the other hand, in symptomatic patients with chronic GERD, BE prevalence is as high as 15%.\(^\text{30}\)

**Endoscopy picture**

The importance of measuring the length and shape of the columnar-lined segment using a standardized methodology is recognized worldwide. This aids communication between endoscopists and pathologists so improving the level of diagnostic confidence. To obtain this goal, it is necessary to comply with recognized and standardized terminology and to precisely describe endoscopic landmarks.

**Terminology**

**GEJ.** The term anatomic gastro-esophageal junction (GEJ) identifies the proximal border of the gastric folds when endoscopy is performed with minimal air-insufflation.\(^\text{31}\) GEJ is identified exclusively by endoscopists and this term should not be used by pathologists in their diagnostic report.

**SCJ or Z-line.** The term histologic squamo-columnar junction (SCJ) or Z-line refers to the transition between esophageal stratified squamous epithelium and columnar epithelium. It can be identified both by endoscopists (due to the white color of the squamous epithelium compared to the pinkish color of columnar epithelium) and by pathologists who easily identify the histologic transition between squamous and columnar epithelium.\(^\text{32}\) As a rule, GEJ and SCJ coincide in normal subjects but a dis-alignment of the SCJ up to 1 cm proximally to GEJ is also seen.

**ESEM.** The term Endoscopically Suspected Esophageal Metaplasia, according to the Montreal definition defines the presence of salmon pink mucosa in the distal esophagus at endoscopy; it describes endoscopically suspected columnar metaplasia related to the proximal dislocation of SCJ with respect to the GEJ.

**Landmarks (Fig. 4)**

1. By visualizing two landmarks, namely the distal end of the palisade vessels and the proximal end of the gastric folds at endoscopy, it is possible to accurately delineate the GEJ and identify whether there is a columnar-lined segment in the lower esophagus. The two landmarks should coincide at the GEJ, however different factors (peristaltic or respiratory movements, esophagitis, and degree of air insufflation) can lead to inconsistencies between these two landmarks. In a comparative study of the two methods, investigators found that the proximal extent of the gastric folds was more accurate compared to the palisade vessels (due to frequent lower position of these compared to the GEJ).\(^\text{35}\)

2. The diaphragmatic hiatus is identified as an indentation of the gastric folds that is apparent during upper endoscopy with inspiration.

3. The SCJ, as mentioned above, can be recognized by endoscopists by the color changing from white to salmon pink. It is recommended that all three landmarks (or at least GEJ and SCJ), are mentioned in every endoscopic report.
REPORT ENDOSCOPICAL METHODOLOGY

The Prague C&M system for ESEM length is widely used by major academic societies such as the American Gastroenterological Association, American College of Gastroenterology, the British Society of Gastroenterology, and it is also recommended by the Asia-Pacific consensus and Australian Guidelines. The Prague C&M classification is based on validated, explicit, consensus-driven criteria and includes assessment of the circumferential (C) and maximal (M) extent of ESEM. The overall reliability coefficients for endoscopic recognition of ESEM ≥ 1 cm was 0.72. These findings have been reproduced in different patient populations and have also been validated in a multicenter study. A subtext in the Prague classification, records non-continuous ESEM islands (which may be found after endoscopic therapy); these last findings should also be recorded according to the Paris classification.

BIOPSY SITE

Intestinal metaplasia (IM – which in some countries is necessary for a diagnosis of BE – see paragraph below) can be patchy and multiple biopsies are required in order to characterize ESEM, their number being correlated to ESEM length. The Seattle biopsy protocol, which entails four-quadrant random biopsies every 2 cm in addition to targeted biopsies on macroscopically visible lesions, is recommended at the time of diagnosis and at subsequent surveillance. Unfortunately, this sampling protocol is not frequently performed in routine practice because it is lengthy and poorly tolerated by patients. Targeted biopsy samples from visible lesions should be taken before random biopsies and distal areas should be biopsied first starting 1-2 cm above the GEJ and advancing proximally. In patients with ESEM without confirmation of IM despite adequate number of biopsies, a repeat examination could be considered in 1-2 years based on a longitudinal cohort study demonstrating that around 30% of these patients can be expected to demonstrate IM on a repeat examination. Advances in chromoendoscopy (methylene blue, indigo carmine, and acetic acid), endoscope digital enhancements (narrow-band imaging, i-SCAN, Fujinon intelligent chromo endoscopy), and enhanced magnification have not been shown to be superior to the currently accepted practice of random four-quadrant biopsies at 2-cm intervals. Biopsies of a normal or irregular z-line are not recommended. If biopsies are sampled from an irregular

Figure 4. Landmarks (GEJ and Z-line) and the Prague C&M system for reporting ESEM length: on the left side GEJ and Z-line coincide in normal case; on the right side Z-line is proximally dislocated with respect to GEJ and a C2M4 ESEM is represented. Artwork by Federica Grillo.
Z-line, with no clear endoscopic evidence of Barrett’s, they should then be sent to the pathologist as z-line biopsies and not as endoscopically suspected Barrett esophagus (ESEM) biopsy samples.

**Histologic elementary lesions**

Two types of columnar epithelium may replace esophageal stratified squamous epithelium: cardiac/oxyntic atrophic type and intestinal type epithelium. IM in BE is most commonly of an incomplete (type II or III) subtype comprising mucous cells and goblet cells, although a complete type (type I with absorptive cells) may also be seen. Finding mature oxyntic epithelium on distal esophageal biopsies is generally a sign of hiatus hernia whereas it represents gastric ectopia (inlet patches) when found in the mild-proximal esophagus.

What defines the histologic diagnosis of BE still remains a contentious issue. Indeed the type of columnar mucosa necessary for BE diagnosis varies between different countries. While the American College of Gastroenterology - ACG and Australian guidelines require IM as a necessary diagnostic criterium to diagnose BE, the British Society of Gastroenterology guidelines and the Asia-Pacific consensus on the management of GERD both suggest that in the context of visible columnar epithelium, IM is not a requisite, and hence gastric cardiac/oxyntic atrophic type metaplasia is also regarded as BE. Both points of view have some merit:

a. **the emphasis on IM as a defining feature of BE** is based on an increasing body of evidence which has demonstrated an increased risk of neoplastic progression for ESEM with IM compared to ESEM without IM. Among various studies, one of the largest population-based cohort investigations demonstrated a substantially higher EAC risk in subjects with columnar metaplasia with IM compared with those without IM (0.38%/year vs 0.07%/year, p < 0.01). Furthermore, a detailed genomic analysis comparing IM and non-IM epithelium in 45 patients with BE reported a higher frequency of mutations in cancer-associated genes such as CDKN2A, WWOX, c-MYC and GATA6 in IM. However, other studies have not corroborated such findings.

b. **IM is not necessary for BE definition** as sampling may impact on IM detection. Within the length of ESEM, IM has been shown to be patchy and generally found with greater frequency on the squamo-columnar junction leading edge. This may lead to sampling error with misclassification of ESEM with IM as ESEM without IM. The yield for IM correlates directly with the number of endoscopic biopsies obtained. In a large retrospective study, the yield for IM was 35% if 4 biopsies were obtained and up to 68% after 8 biopsies were performed. Biopsy site is also relevant for IM detection, with a 94% detection rate of IM when biopsies are performed close to the squamo-columnar junction, even if fewer samples are taken. Finally, recognition of IM was shown to increase cumulatively with follow-up: over 50% of patients who originally did not have IM were found to have IM at 5 years and over 90% at 10 years follow-up.

Few studies focus on **inter-observer variability in the diagnosis of BE**. In particular, one study reported an inter-observer agreement of 88.3% (kappa value of 0.41) in distinguishing columnar epithelium types. An Italian study, evaluated both the inter-observer agreement in type of epithelium recognition (oxyntic/cardia versus intestinal) and more importantly on diagnostic category assignment. While agreement for diagnosis of BE had a moderate-substantial agreement rate among participants (overall K = 0.60, CI 0.58-0.62) major problems arose when interpreting columnar epithelium in an irregular z-line. This perfectly describes the frequent and diffuse problems faced by practicing pathologists in esophageal biopsy assessment, and therefore in BE diagnosis. In our opinion this point needs to be addressed further, as clear, reproducible and accurate BE diagnoses are the first, indispensable step for access to surveillance programs.

**Ancillary techniques**. There is an undeniable need for novel diagnostic approaches to the evaluation and risk stratification of patients with BE. Unfortunately, currently available ancillary techniques, including histochemical and immunohistochemical markers, have little to offer over routine H&E assessment, because they lack sufficient specificity for detection of BE and dysplasia classification. Some such biomarkers have been investigated and are here briefly described. Alcian Blue-PAS helps distinguish cardia from intestinal epithelium. Unfortunately, the specificity of Alcian blue for goblet cells is generally low, particularly with respect to distinguishing goblet cells from their morphologic mimics. Johnson and colleagues found that Alcian blue detects goblet cells with similar sensitivity (100%), but lower specificity (90%), compared with H&E, owing to false-positive staining of esophageal mucus glands and columnar non-goblet cells. There is insufficient evidence to justify the reflexive use of Alcian blue and/or PAS on all esophageal biopsies because goblet cells are almost always identifiable on routine H&E-stained sections. The value of immunohistochemical markers in establishing a diagnosis of BE has been diffusely investigated applying numerous markers of intestinal
phenotype (CDX2, MUC2, MUC1, Villin, SOX9 and DAS1). Although these stains may be markers of an earlier phase of intestinal differentiation, there is insufficient evidence to suggest that they predict the development of IM. Furthermore, their use to distinguish between IM in BE from IM of the cardiac has been largely unsuccessful.

**DIAGNOSIS**

According to the previous terminology suggested for BE diagnosis in the histology report by SIAPEC-IAP, we suggest the use of the following terminology (Fig. 5):
- Barrett’s esophagus with Intestinal Metaplasia (when IM is histologically proven in an ESEM ≥ 1 cm at index biopsies);
- Barrett’s esophagus without Intestinal Metaplasia (when IM is not demonstrated in an ESEM ≥ 1 cm at index biopsies).

These two different diagnoses will lead to different management and follow-up.

No diagnosis of BE can be made on biopsies taken from < 1 cm z-line irregularities; the type of columnar epithelium in GEJ biopsies should be described differentiating between oxyntic/cardial epithelium suggestive of site-appropriate gastric mucosa and intestinal epithelium suggestive of intestinal metaplasia of the cardia.

**Conclusions**

The role of histology in diagnosing microscopic esophagitis related to GERD is still debated, however, in
the last 20 years or so, histologic elementary lesions have been more precisely described and defined. Though biopsies are currently not part of the routine work up in diagnosing GERD, it is important to recognize and properly evaluate histologic elementary lesions, in order to make this diagnosis only when clear damage of the squamous mucosa is seen. The identification of true lesions will hopefully contribute in maintaining the high sensitivity and specificity that histology has demonstrated to have in this setting. On the other hand, biopsies are mandatory in diagnosing GERD-related complications, and in particular BE. The diagnosis of BE suffers from a low inter-observer reproducibility related to different reasons (ie different BE definition in different countries, availability of precise endoscopic description and sampling). This diagnosis has however a major impact both in deciding which patients need to be included in surveillance programs and in making these programs cost-effective. For these reasons it seems to be very important to precisely describe the type of columnar epithelium present in esophageal biopsies, to apply the algorithm (histology plus endoscopy) for diagnosis, and to refer to the adopted current guidelines (whichever are chosen and referenced) in order to make this diagnosis as clear as possible for the clinician.

References

1. Mastracci L, Bruzzone M, Pacella E et al. The contribution of intraepithelial inflammatory cells to the histological diagnosis of microscopic esophagitis. Esophagus. 2016;13:80-7. https://doi.org/10.1007/s10388-015-0501-9

2. Lucendo AJ, Navarro M, Comas C, et al. Immunophenotypic characterization and quantification of the epithelial inflammatory infiltrate in eosinophilic esophagitis through stereology: an analysis of the cellular mechanisms of the disease and the immunologic capacity of the esophagus. Am J Surg Pathol 2007;31:598-606. https://doi.org/10.1097/01.pas.0000213392.49698.8c

3. Eusebi LH, Ratnakumaran R, Yuan Y, et al. Global prevalence of, and risk factors for, gastro-oesophageal reflux symptoms: a meta-analysis. Gut. 2018;67:430-40. https://doi.org/10.1136/gutjnl-2016-313589

4. Vakil N, van Zanten SV, Kahrilas P, et al. The Montreal definition and classification of gastroesophageal reflux disease: a global evidence-based consensus. Am J Gastroenterol. 2006;101:1900-20. https://doi.org/10.1111/j.1572-0241.2006.00630.x

5. Pace F, Bazzoli F, Fiocca R, et al. The Italian validation of the Montreal Global definition and classification of gastroesophageal reflux disease. Eur J Gastroenterol Hepatol 2009;21:394-408. https://doi.org/10.1097/MEG.0b013e3283a70e2

6. Drossman DA. Functional gastrointestinal disorders: history, pathophysiology, clinical features and Rome IV. Gastroenterology 2016;150:1262-79. https://doi.org/10.1053/j.gastro.2016.02.032

7. Schmulson M. How to use Rome IV criteria in the evaluation of esophageal disorders. Curr Opin Gastroenterol 2016;34:258-65. https://doi.org/10.1097/MOG.0000000000000443

8. Lundell LR, Dent J, Bennett JR, et al. Endoscopic assessment of oesophagitis: clinical and functional correlates and further validation of the Los Angeles classification. Gut. 1999;45:172-80. https://doi.org/10.1136/gut.45.2.172

9. Zentilin P, Savarino V, Mastracci L, et al. Reassessment of the diagnostic value of histology in patients with GERD, using multiple biopsy sites and an appropriate control group. Am J Gastroenterol 2005;100:2299-306. https://doi.org/10.1111/j.1572-0241.2005.50209.x

10. Mastracci L, Spaggiari P, Grillo F, et al. Microscopic esophagitis in gastro-esophageal reflux disease: individual lesions, biopsy sampling, and clinical correlations. Virchows Arch 2009;454:31-9. https://doi.org/10.1007/s00428-008-0704-8

11. Fiocca R, Mastracci L, Riddell R, et al. Development of consensus guidelines for the histologic recognition of microscopic esophagitis in patients with gastroesophageal reflux disease: the Esohisto project. Hum Pathol 2010;41:223-31. https://doi.org/10.1016/j.humpath.2009.07.016

12. Mastracci L, Grillo F, Zentilin P, et al. Cell proliferation of squamous epithelium in gastro-oesophageal reflux disease: correlations with clinical, endoscopic and morphological data. Aliment Pharmacol Ther 2007;25:637-45. https://doi.org/10.1111/j.1365-2036.2006.03243.x

13. Savarino E, Zentilin P, Mastracci L, et al. Microscopic esophagitis distinguishes patients with non-erosive reflux disease from those with functional heartburn. J Gastroenterol 2013;48:473-82. https://doi.org/10.1038/s00535-012-0672-2

14. Yerian L, Fiocca R, Mastracci L, et al. Refinement and reproducibility of histologic criteria for the assessment of microscopic lesions in patients with gastroesophageal reflux disease: the Esohisto Project. Dig Dis Sci 2011;56:2656-65. https://doi.org/10.1007/s10620-011-1624-z

15. Fiocca R, Mastracci L, Engström C, et al. Long-term outcome of microscopic esophagitis in chronic GERD patients treated with esomeprazole or laparoscopic antireflux surgery in the LOTUS trial. Am J Gastroenterol 2010;105:1015-23. https://doi.org/10.1038/ajg.2009.631

16. Furnari M, Zentilin P, Mastracci L, et al. Esophageal biopsies in the management of GERD: complementary tool for many but not for all. Hum Pathol 2011;45:2512-3. https://doi.org/10.1016/j.humpath.2011.06.029

17. Savarino E, Zentilin P, Mastracci L, et al. Light microscopy is useful to better define NERD and functional heartburn. Gut 2014;63:368. https://doi.org/10.1136/gutjnl-2013-305955

18. Mastracci L, Fiocca R, Engström C, et al. The dynamics of the oesophageal squamous epithelium ‘normalisation’ process in patients with gastro-oesophageal reflux disease treated with long-term acid suppression or anti-reflux surgery. Aliment Pharmacol Ther 2017;45:1339-49. https://doi.org/10.1111/apt.14038

19. Vieth M, Mastracci L, Vakil N, et al. Epithelial Thickness is a Marker of Gastroesophageal Reflux Disease. Clin Gastroenterol Hepatol 2016;14:1544-51 https://doi.org/10.1016/j.cgh.2016.06.018

20. Schneider NI, Plieschnegger W, Geppert M, et al. Validation study of the Esophisto consensus guidelines for the recognition of microscopic esophagitis (histoGERD Trial). Hum Pathol 2014;45:994-1002. https://doi.org/10.1016/j.humpath.2013.

21. Fiocca R, Mastracci L, Milione M, et al. Microscopic esophagitis and Barrett’s esophagus: the histology report. Dig Liver Dis 2011;43:319-30. https://doi.org/10.1016/S1590-8658(11)60588-4

22. Spechler SJ, Sharma P, Souza RF, et al. American Gastroenterological Association technical review on the management of Barrett’s esophagus. Gastroenterology 2011;140:e18-52. https://doi.org/10.1053/j.gastro.2011.01.031
Lee YC, Cook MB, Bhatia S, et al. Interobserver reliability in the diagnosis, surveillance and therapy of Barrett's esophagus. Am J Gastroenterol 2008;103:789-97. https://doi.org/10.1111/j.1572-0241.2008.01835.x

Fitzgerald RC, di Pietro M, Ragunath K, et al. British Society of Gastroenterology guidelines on the diagnosis and management of Barrett's oesophagus. Gut 2014;63:7-42. https://doi.org/10.1136/gutjnl-2013-305372

Fock KM, Talley N, Goh K, et al. Asia-Pacific consensus on the management of gastro-oesophageal reflux disease: an update focusing on refractory reflux disease and Barrett's oesophagus. Gut 2016;65:1402-15. https://doi.org/10.1136/gutjnl-2016-311715

Whiteman DC, Appleyard M, Bahin FF, et al. Australian clinical practice guidelines for the diagnosis and management of Barrett's esophagus and early esophageal adenocarcinoma. J Gastroenterol Hepatol 2015;30:804-20. https://doi.org/10.1111/jgh.12913

Costamagna G, Battaglia G, Repici A, et al. Diagnosis and endoscopic management of Barrett's esophagus: an Italian experts’ opinion based document. Dig Liver Dis 2017;49:1306-13. https://doi.org/10.1016/j.dld.2017.08.034

Ronkainen J, Aro P, Storskrubb T, et al. Prevalence of Barrett’s esophagus in the general population: an endoscopic study. Gastroenterology 2005;129:1825-51. https://doi.org/10.1053/j.gastro.2005.08.053

Zagari RM, Fuccio L, Wallander MA, et al. Gastro-oesophageal reflux symptoms, oesophagitis and Barrett’s oesophagus in the general population: the Loiano-Monghidoro study. Gut 2008;57:1354-9. https://doi.org/10.1136/gut.2007.145177

Johansson J, Hakansson HO, Melblom L, et al. Prevalence of precancerous and other metaplasia in the distal oesophagus and gastro-oesophageal junction. Scand J Gastroenterol 2005;40:893-902. https://doi.org/10.1080/003655205101515692

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. https://doi.org/10.1053/j.gastro.2006.08.032

Mastracci L, Piot N, Molinaro L, et al. Interobserver reproducibility in pathologist interpretation of columnar-lined esophagus. Virchows Arch 2016;468:159-67. https://doi.org/10.1007/s00428-015-1878-5

Ogiya K, Kawano T, Ito E, et al. Lower esophageal palisade vessels and the definition of Barrett’s esophagus. Dis Esophagus 2008;21:645-9. https://doi.org/10.1111/j.1442-2050.2008.00825.x

Sharma P, Morales TG, Sampliner RE. Short segment Barrett’s esophagus - the need for standardization of the definition and of endoscopic criteria. Am J Gastroenterol 1998;93:1033-6. https://doi.org/10.1111/j.1572-0241.1998.00324.x

Amano Y, Ishimura N, Furuta K, et al. Which landmark results in the diagnosis of Barrett’s esophagus by gastroenterology trainees: a multicenter study. Gastrointest Endosc 2012;75:236-41. https://doi.org/10.1016/j.gie.2011.09.017

Endoscopic Classification Review Group. Update on the Paris classification of superficial neoplastic lesions in the digestive tract. Endoscopy 2005;37:570-8. https://doi.org/10.1055/s-2005-861352

Endlicher E, Rummele P, Beer S, et al. Barrett’s esophagus: a discrepancy between macroscopic and histological diagnosis. Endoscopy 2005;37:1131-5. https://doi.org/10.1055/s-2005-870409

Yantiss RK, Odze RD. Optimal approach to obtaining mucosal biopsies for assessment of inflammatory disorders of the gastro-intestinal tract. Am J Gastroenterol 2009;104:774-83. https://doi.org/10.1038/ajg.2008.108

Levine DS, Blount PL, Rudolph RE, et al. Safety of a systematic endoscopic biopsy protocol in patients with Barrett's esophagus. Am J Gastroenterol 2000;95:1152-7. https://doi.org/10.1111/j.1572-0241.2000.02002.x

Abela JE, Going JJ, Mackenzie JF, et al. Systematic four-quadrant biopsy detects Barrett's dysplasia in more patients than nonsystematic biopsy. Am J Gastroenterol 2008;103:850-5.

Reid BJ, Blount PL, Feng Z, et al. Optimizing endoscopic biopsy detection of early cancers in Barrett’s high-grade dysplasia. Am J Gastroenterol 2000;95:3089-96.

Khandwalla HE, Graham DY, Kramer JR, et al. Barrett’s Esophagus suspected at endoscopy but no specialized intestinal metaplasia on biopsy, what’s next. Am J Gastroenterol 2014;109:178-82. https://doi.org/10.1038/ajg.2013.408

Ferguson DD, DeVault KR, Krishna M, et al. Enhanced magnification-directed biopsies do not increase the detection of intestinal metaplasia in patients with GERD. Am J Gastroenterol 2006;101:1611-6. https://doi.org/10.1111/j.1572-0241.2006.00622.x

Ngamruengphong S, Sharma VK, Das A. Diagnostic yield of methylene blue chromoendoscopy for detecting specialized intestinal metaplasia and dysplasia in Barrett’s esophagus: a meta-analysis. Gastrointest Endosc 2009;69:1021-8. https://doi.org/10.1016/j.gie.2008.06.056

Horwhat JD, Maydonovitch CL, Ramos F, et al. A randomized comparison of methylene blue-directed biopsy versus conventional four-quadrant biopsy for the detection of intestinal metaplasia and dysplasia in patients with long-segment Barrett’s esophagus. Am J Gastroenterol 2008;103:546-54.

Gottfried MR, McClave SA, Boyle HW. Incomplete intestinal metaplasia in the diagnosis of columnar lined esophagus (Barrett’s esophagus). Am J Clin Pathol 1989;92:741-6. https://doi.org/10.1093/ajcp/92.6.741

Shaheen NJ, Falk GW, Iyer PG, et al. ACG clinical guideline: diagnosis and management of Barrett's esophagus. Am J Gastroenterol 2016;111:30-50. https://doi.org/10.1038/ajg.2015.322

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. https://doi.org/10.1093/jnci/djr203.

Bandia S, Peters JH, Ruff D, et al. Comparison of cancer-associated genetic abnormalities in columnar-lined esophagus tissues with and without goblet cells. Ann Surg 2014;260:72-80. https://doi.org/10.1097/SLA.0000000000000424

Kelty CJ, Gough MD, Van Wyk Q, et al. Barrett’s oesophagus: intestinal metaplasia is not essential for cancer risk. Scand J Gastroenterol 2007;42:1271-4. https://doi.org/10.1080/00365520701420735
54 Siddiki HA, Lam-Himlin DM, Kahn A, et al. Intestinal metaplasia of the gastric cardia: findings in patients with versus without Barrett’s esophagus. Gastrointest Endosc 2019;89:759-68. https://doi.org/10.1016/j.gie.2018.10.048

55 Chandrasoma PT, Der R, Dalton P, et al. Distribution and significance of epithelial types in columnar lined esophagus. Am J Surg Pathol. 2001;25:1188-1193. https://doi.org/10.1097/00000478-200109000-00010

56 Harrison R, Perry I, Haddadin W, et al. Detection of intestinal metaplasia in Barrett’s esophagus: an observational comparator study suggests the need for a minimum of eight biopsies. Am J Gastroenterol 2007;102:1154-61. https://doi.org/10.1111/j.1572-0241.2007.01230.x

57 Gatenby PA, Ramus JR, Caygill CP, et al. Relevance of the detection of intestinal metaplasia in non-dysplastic columnar-lined oesophagus. Scand J Gastroenterol 2008;43:524-30. https://doi.org/10.1080/00365520701879831

58 Corley DA, Kubo A, DeBoer J, et al. Diagnosing Barrett’s esophagus: reliability of clinical and pathologic diagnoses. Gastrointest Endosc 2009;69:1004-10. https://doi.org/10.1016/j.gie.2008.07.035

59 Panarelli NC, Yantiss RK. Do Ancillary Studies Aid Detection and Classification of Barrett Esophagus? Am J Surg Pathol 2016;40:e83-e93. https://doi.org/10.1097/PAS.0000000000000654

60 Johnson DR, Abdelbaqi M, Tahmasbi M, et al. CDX2 protein expression compared to alcian blue staining in the evaluation of esophageal intestinal metaplasia. World J Gastroenterol 2015;21:2770-6. https://doi.org/10.3748/wjg.v21.i9.2770

61 Srivastava A, Appelman H, Goldsmith JD, et al. The use of ancillary stains in the diagnosis of Barrett Esophagus and Barrett Esophagus-associated dysplasia: recommendations from the Rodger C. Haggitt Gastrointestinal Pathology Society. Am J Surg Pathol 2017;41:e8-e21. https://doi.org/10.1097/PAS.0000000000000819

62 Groisman GM, Amar M, Meir A. Expression of the intestinal marker Cdx2 in the columnar-lined esophagus with and without intestinal (Barrett’s) metaplasia. Mod Pathol 2004;17:1282-8. https://doi.org/10.1038/modpathol.3800182

63 McIntire MG, Soucy G, Vaughan TL, et al. MUC2 is a highly specific marker of goblet cell metaplasia in the distal esophagus and gastroesophageal junction. Am J Surg Pathol 2011;35:1007-13. https://doi.org/10.1097/PAS.0b013e318218940d

64 Shearer C, Going J, Neilson L, et al. Cytokeratin 7 and 20 expression in intestinal metaplasia of the distal oesophagus: relationship to gastro-oesophageal reflux disease. Histopathology 2005;47:268-75. https://doi.org/10.1111/j.1365-2559.2005.02219.x

65 Zhang X, Westerhoff M, Hart J. Expression of SOX9 and CDX2 in nongoblet columnar-lined esophagus predicts the detection of Barrett’s esophagus during follow-up. Mod Pathol 2015;28:654-61. https://doi.org/10.1038/modpathol.2014.157