Published in final edited form as:

Gastroenterol Clin North Am. 2013 March ; 42(1): . doi:10.1016/j.gtc.2012.11.010.

Endoscopic Therapy of Barrett's Esophagus and Early Esophageal Adenocarcinoma

Cadman L. Leggett, MD, Emmanuel C. Gorospe, MD, MPH, and Kenneth K. Wang, MD, FASGE, FACC

Barrett's Esophagus Unit, Division of Gastroenterology and Hepatology, Mayo Clinic, Rochester, Minnesota, USA

Summary

Endoscopic therapy of Barrett's esophagus is feasible and likely to decrease the future risk of development of esophageal adenocarcinoma. The most commonly utilized therapy is radiofrequency ablation that has been shown to produce reproducible superficial injury in the esophagus. Other thermal therapies have been performed including multipolar coagulation, argon plasma coagulation, and thermal laser therapy. The other end of the ablative spectrum includes cryotherapy which involves freezing tissue to produce mucosal necrosis. Finally, photodynamic therapy has been used to photochemically eliminate abnormal mucosa. Endoscopic therapy has been demonstrated to be effective in high-risk situations such as Barrett's esophagus with high-grade dysplasia. Even after the development of early esophageal carcinoma, endoscopic therapy is feasible so long as there are no risk factors for potential metastasis. Although the biological principles of re-epithelialization have not been well elucidated, it appears that adequate control of gastroesophageal reflux is necessary. There is a substantial risk of recurrence even after complete ablation that necessitates continued surveillance after ablation.

Keywords

Barrett's esophagus; argon plasma coagulation; radiofrequency ablation; multipolar electrocoagulation; photodynamic therapy; cryoablation; radiofrequency ablation; endoscopic mucosal resection

BACKGROUND

Endoscopic ablation therapy has evolved from as a possibility in patients who could not undergo esophagectomy to a standard of care for the treatment of early esophageal neoplasia (EAC). Its increasing efficacy and decreasing morbidity through the years have made this approach the preferred treatment for Barrett's esophagus (BE) with high-grade dysplasia (HGD) and early EAC.¹⁸ Several treatment modalities are currently available and can be broadly classified as mucosal resection and ablative techniques. These modalities usually

© 2012 Elsevier Inc. All rights reserved.

Corresponding author: Kenneth K. Wang, MD, FACC, AGAF, FASGE, Barrett's Esophagus Unit, Division of Gastroenterology & Hepatology, Mayo Clinic, 200 First Street SW, Rochester MN 55905, Phone: 507-284-2174, Fax: 507-255-7612, wang.kenneth@mayo.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

used in combination and as part of a treatment program that requires endoscopic surveillance.

RISK-STRATIFICATION OF BARRETT'S ESOPHAGUS

Risk stratification begins with a detailed examination of the Barrett's mucosa under white light endoscopy. Irregularities in the mucosa are targeted with biopsies or endoscopic mucosal resection (EMR) as these sites are more likely to contain neoplasia. Tissue sampling is also performed at four-quadrant intervals over the entire BE segment to detect dysplasia that may not be apparent under endoscopic evaluation. Advanced imaging technologies such as narrow band imaging, confocal endomicroscopy and optical coherence tomography can be used to enhance detection of dysplasia but are currently not a substitute thorough examination under high-resolution white-light endoscopy.

Endoscopic eradication therapy should be considered in patients with the highest risk of progression to invasive EAC in which metastatic lymphadenopathy has been excluded.²⁵ Risk stratification is currently based on histopathological evaluation for grade of dysplasia which is unreliable due to the lack of agreement among pathologists regarding the exact degree of dysplasia. One indicator of low-grade dysplasia more likely to progress is agreement between two or more pathologists.¹⁹ The risk with non-dysplastic Barrett's is about 0.18% per year that is less than half the risk estimated only 5 years ago. The decrease in cancer risk appears to be related to more reports from large population based databases. The absolute risk of EAC increases in proportion to the grade of dysplasia with HGD carrying a 30% 5-year cancer risk.²⁰ The risk of metastatic lymphadenopathy is proportional to the depth of invasion and is low (<5%) for neoplasia confined to the mucosa (intramucosal adenocarcinoma, stage T1a).²⁵ Other risk factors for potential metastatic disease with early T1a cancer is evidence of lymphovascular invasion and high grade malignancy. The most reliable technique to obtain this information is with the use of endoscopic mucosal resection which can be used to diagnose, stage and treat early cancer.

THEORY OF ABLATION

It is important to realize that it is unclear why ablation therapy results in squamous regeneration. The current belief is that intestinal metaplasia occurs because of chronic injury to the esophageal mucosa with the production of cytokines such as IL-1B, IL6, and IL8 that increase expression of transcription factors that promote intestinalization such as CDX2 and BMP4 (See Figure 1). These factors have been shown in animal models to act on gastric glandular stem cells to produce an intestinal phenotype that migrates proximally into the esophagus. These cytokines are also produced by adipocytes and can be a partial biological explanation of how obesity promotes Barrett's esophagus.

The elimination of Barrett's esophagus due to endoscopic injury and secondary production of squamous mucosa is unclear. Studies have found that the squamous mucosa that regenerates does not contain genetic abnormalities similar to the intestinal mucosa indicating that there may well be a different cell of origin of these squamous stem cells. It is believed, that similar to keratinocytes in the cutaneous skin, that the stem cell of origin of these squamous cells is the interpapillary basal cells. This would imply that squamous regeneration should occur from neighboring squamous mucosa and confirms early observations in ablation therapy that if 3 areas of squamous mucosa surrounded the area of treated columnar tissue, squamous regeneration was more likely than if not in contact with any squamous mucosa. However, it has been observed that squamous islands appear to form if deep injury to the mucosa has occurred as is seen with mucosal resection. It has also been found that bone marrow stem cells migrate to areas of deep tissue wounds throughout the body and it is possible that these isolated patches of squamous mucosa are the result of bone

marrow derived squamous stem cells. There is little clinical evidence that substantiates this hypothesis and would require a very unusual situation where a male patient undergoes ablation after a bone marrow transplant from a female to permit lineage tracing of the bone marrow donor.

ENDOSCOPIC MUCOSAL RESECTION

Endoscopic mucosal resection (EMR) refers to the use of standard polypectomy technique in flat mucosa for the purposes of resecting suspicious and dysplastic lesions. In spite of its name as a “mucosal” resection technique, EMR actually extends into the submucosa. Hence, it is not uncommon that EMR is sometimes referred to as “endoscopic resection” (ER). (See Figures 2 and 3)

In the setting of appropriate risk stratification, patients with HGD and early EAC may be offered to undergo EMR instead of esophagectomy. The risk of advanced malignancy is dependent on the depth of neoplastic luminal involvement. As such, EMR should only be attempted in patients with low risk of locally-advanced EAC or metastatic lymphadenopathy.^{15,26} EMR has emerged as an indispensable tool in the endoluminal therapy of dysplastic BE and early EAC. Its use has increased because it accomplishes the basic prerequisites of surgical therapy for malignancy in a minimally-invasive manner. EMR also offers a dual advantage for tissue diagnosis aside from its therapeutic use. Studies have demonstrated that pathologists achieve improved inter-rater agreement and accuracy for detecting HGD and early EAC, as compared to traditional biopsies.^{14,26}

In the United States, there are two commercially-available devices for esophageal EMR, either as a cap-type or multiband device. The cap technique utilizes a hard or soft plastic cap and snare for ligation of the target mucosa.²⁷ The cap also comes in flat and oblique configurations with the oblique cap capable of removing more tissue. The cap technique requires a snare to be fitted on the end of the cap that requires experience to place correctly. On the other hand, the multi-band technique evolved as a modification of the variceal banding device. The banding device is available with 6 pre-fitted bands. With this kit, the dysplastic mucosa is suctioned deep into the plastic cap at which time the band is deployed. (Figure 2) This band creates a pseudopolyp of tissue to prevent luminal perforation. Once the tissue of interest has been captured, a snare is used to resect the tissue.

The initial step of EMR is lifting the target mucosa with the use of a dilute epinephrine injection (1: 200,000). The mucosal lift facilitates separation of the mucosa from the submucosa. This is crucial in preventing perforation during resection especially with the use of the cap technique.⁹ Once the resection is completed with use of the snare, the EMR tissue should be retrieved for histopathological evaluation to determine the grade of dysplasia and involvement of the margins.

Retrospective studies have shown that the efficacy of EMR is comparable to esophagectomy in the treatment of localized EAC. Complete eradication of dysplasia (CR-D) has been reported to be over 90% with or without subsequent ablation therapy.^{5,13} EMR is well tolerated and has a low risk of complications under the hands of experienced endoscopists. Complications such as bleeding or perforation occur in <4% of cases and these can be controlled with the use of hemoclips or stents.^{12,24}

MUCOSAL ABLATIVE TECHNIQUES

Mucosal ablation refers to the induction of superficial tissue necrosis by either thermal energy, freezing, mechanical debridement or photochemical injury. The injured mucosa is replaced by normal squamous mucosa in the absence of acid reflux. A goal of mucosal

ablation is to achieve complete elimination of all dysplasia (CR-D) as well as eradication of intestinal metaplasia (CR-IM) over the entire BE segment. CR-IM is felt to be necessary to further lower risk of cancer development as genetic abnormalities have been shown to persist after ablation.

Radiofrequency ablation

Radiofrequency ablation (RFA) uses a bipolar electrode array to generate thermal energy (12 J/cm²). Commercially available RFA devices include the HALO360, HALO90, HALO60, and HALO90Ultra (Covidien, Mansfield MA, USA). The HALO360 is used for circumferential ablation of BE and consists of a 3-cm electrode array that encircles a 4-cm long balloon. A sizing balloon is used to preselect the treatment balloon size that can range in diameter from 18 mm to 34 mm depending on the size of the esophagus (See Figure 4). The HALO90 consists of a flat array (20 by 13-mm) fitted on the tip the endoscope and used for focal ablation. The HALO60 device is 60% smaller than the HALO90 and is meant for individuals with smaller islands after circumferential treatment. The HALO90Flex is a HALO90 device with a 4 centimeter long treatment surface rather than the original two centimeter device. Direct contact of the electrode array with the esophageal mucosa is necessary for successful ablation.

The treatment consists of first carefully delineating the length of Barrett's segment to be treated followed by cleansing the surface with 1% N-acetyl cysteine prior to RFA. The treatment device is then applied to the surface at a dose of 12 J/cm² for the initial application. The surface of the mucosa is then cleaned and all the debris removed. Finally, the treatment is repeated at the same dose to the mucosa to complete the ablation. If low-grade dysplasia is treated, only 10 J/cm² is needed for the treatment energy.

RFA is an effective treatment modality for the eradication of dysplasia in BE. A randomized, multicenter, sham-controlled trial showed a rate of CR-D in 81% of participants with HGD compared to 19% in the sham arm.²³ The rate of development of EAC was reduced from 16% in the RFA group compared to 4% in the sham arm. A 6% rate of stricture formation was reported. The rate of CR-D at two-year follow-up remained high at 95%.²² Failure to achieve CR-D with RFA can be due to the length of the segment of Barrett's treated, the presence of genetic defects such as p16 loss, the presence of a large diaphragmatic hernia which could produce poor reflux control.¹¹

Although RFA may be effective for non-nodular Barrett's lesions, it is recommended that patients with nodular Barrett's dysplasia have mucosal resection before RFA as the treatment depth is fairly limited. As with other ablative devices, RFA does not allow tissue confirmation and leaves the patient and clinician the uncertainty of knowing the precise depth of invasion of any neoplastic lesion within the mucosa.

Argon Plasma Coagulation

Before RFA became widely available, argon plasma coagulation (APC) was the most widely available ablative therapy for BE. APC consists of a monopolar high frequency probe that delivers thermal energy through ionized argon plasma which can cause thermal injury to the mucosa. Its degree of injury is modulated by voltage, gas flow, and pressure from the probe (See Figure 5).

The application of APC in BE with HGD has been demonstrated in several open-labeled studies with reported high rates of CR-D (80%) after an average of 3 sessions.¹ Adverse events such as stricture formation may occur if applied over a wide area of thermal injury. APC is limited by its non-uniform, narrow field of application as compared to radiofrequency ablation. Buried intestinal metaplasia in the post-APC neosquamous

epithelium can occur in 20–30% of cases.^{3,8} Previous studies have shown that APC is effective in patients with flat dysplastic BE lesions. The presence of mucosal thickening and nodules will result in less effective outcomes. In these cases, EMR would be more appropriate. As such, APC can be an adjunct to EMR with special application to the edges of the EMR lesion.

Multipolar Electrocoagulation

Multipolar electrocoagulation (MPEC) is another form of thermal ablative therapy. Similar to APC, it is widely available for hemostatic interventions in gastrointestinal endoscopy. In addition, it can be used for ablative therapy in BE complicated by dysplasia but its application is mostly limited to non-nodular BE lesions. Given the small point of contact in the MPEC probe, ablation is usually accomplished with application of the probe to the mucosa tangentially in a back and forth motion.⁴ The application time should be enough to produce a white coagulum similar to that produced with radiofrequency ablation. There have been two randomized studies comparing MPEC with other ablative techniques. In short segment BE (<3 cm in length) complete ablation was achieved in 80% of patients in spite of the limited surface area of the probe.²¹ No long-term follow-up studies are available.

Photodynamic therapy

Photodynamic therapy (PDT) has one of the longest experiences as a BE ablative therapy. Its mechanism of action involves the use of a photosensitizer administered systemically and subsequently activated within the esophageal lumen by a light of appropriate wave-length. One of the advantages of PDT is its significant depth of penetration and ease of wide field application as compared to APC, MPEC, and RFA. The drug is administered intravenously two days prior to photoradiation to allow adequate drug distribution at the time of photoradiation. The light dose is determined by the type of light delivery system with a balloon catheter system requiring 130 Joules per centimeter fiber and a bare fiber technique requiring 200 Joules per centimeter fiber. Light is applied at a power of 400 milliwatts per centimeter fiber with the limitations due to thermal energy being pronounced at powers higher than this and the rate of photobleaching of the photosensitizer as the power of light is increased. There have been oral agents clinically used in other countries (amino-levulinic acid) that actually can be given to patients on the day of photoradiation but this treatment was associated with significant pain during photoradiation as well as vascular instability after drug ingestion. Other limitations to photodynamic therapy include costs, high rate of strictures, and cutaneous photosensitivity that persisted for 4–6 weeks after drug administration. Nevertheless, only PDT and radiofrequency ablation have been shown to have durable results in reducing the risks of EAC in BE complicated by dysplasia (CR-D 77% at 5 years for PDT)¹⁷ Experience from the Mayo Clinic demonstrate that patients with HGD treated with PDT had long-term survival outcomes even comparable to esophagectomy.¹⁸

Cryoablation

Cryoablation is the application of extremely cold temperatures to induce tissue injury. It is the mainstay therapy for various applications in dermatologic, gynecologic, and other conditions in the nasopharyngeal tract. The mechanism of cryoablation entails rapid intense cooling followed by slow thawing, which results in injury.¹⁰ (Figure 6) The final result is cell death by mostly inflammatory and apoptotic processes. There are two available cryogens, which includes carbon dioxide and liquid nitrogen. The application of cryoablation for BE has been limited to very small studies. Most of these were studied in the setting of salvage therapy for persistent Barrett's dysplasia or palliative application in advanced esophageal cancer. The advantage of cryoablation is its low cost, simple technique and low complication rates, as compared to other thermal ablative device. However,

cryoablation still needs larger prospective clinical trials before it can be considered as a mainstay therapy for Barrett's dysplasia. Reported CR-D from a multicenter cohort study was 53% in patients with HGD.⁷

COMBINATION ENDOTHERAPY

The choice of endoscopic therapy starts with a detailed examination of the Barrett's mucosa under white-light high-resolution endoscopy. (Figure 7) Visible lesions can be targeted with EMR with diagnostic and therapeutic intent. Assessment of EMR margins is important to evaluate completion of resection and depth of invasion. Once the EMR site heals (4 to 6 weeks), the remaining BE segment can be eliminated with mucosal ablative techniques.¹⁶

The choice of ablative therapy will depend on institutional practice and patient factors. RFA may be best suited for flat mucosa in a fairly straight esophagus where the ablation catheter can be in direct contact with the entire mucosa. Cryoablation can be considered in patients with scarring or an irregular esophageal contour in which the cryogen can be sprayed over the treatment area. This may be the best therapy in areas with prior stricture as the stricture rates from this procedure are among the lowest reported. The use of photodynamic therapy has declined because of a higher rate of strictures compared to RFA.¹⁷ APC and MPEC are used for local treatment of non-nodular BE. Comparative studies between ablative therapies are needed to evaluate long-term outcomes including rate of recurrence.

Patients undergoing endoscopic eradication therapy should be enrolled in a comprehensive surveillance and staging program. The decision to pursue endoscopic therapy versus surgery should involve discussion of the advantages and disadvantages of each approach. Institutional expertise in the fields of endoscopy, surgery and pathology will likely influence choice of therapy and outcomes.

RECURRENT DYSPLASIA

Recurrence of dysplasia and intestinal metaplasia following combination endotherapy with PDT and RFA range from 17 to 22% over a 1 to 3 year follow-up period.^{2,22} Risk factors for recurrence include long-segment BE and piecemeal EMR.⁶ Continued endoscopic surveillance following endotherapy is recommended with intervals guided by prior histopathology and response to treatment. The treatment strategy for recurrent dysplasia is similar to primary dysplasia. EMR is used for the treatment and staging of areas highly suspicious for neoplasia and ablative therapy is performed over recurrent BE. It is unclear if switching to a different mucosal ablation modality has an added benefit in the eradication of recurrent dysplasia.

SUMMARY

Endoscopic eradication therapy is considered a safe, effective and durable treatment strategy for BE complicated by HGD and early EAC. The endoscopist should be familiar with both mucosal resection and ablation techniques and their respective indications. Patients should be enrolled in a comprehensive surveillance program that continues following endoscopic eradication therapy. Recurrent dysplasia can be approach endoscopically as long as appropriate staging is performed.

Acknowledgments

Support: Authors would like to support from the NIH U54 CA163004 and CA163004

References

1. Attwood SE, Lewis CJ, Caplin S, et al. Argon beam plasma coagulation as therapy for high-grade dysplasia in Barrett's esophagus. *Clin Gastroenterol Hepatol*. 2003; 1:258. [PubMed: 15017666]
2. Badreddine RJ, Prasad GA, Wang KK, et al. Prevalence and predictors of recurrent neoplasia after ablation of Barrett's esophagus. *Gastrointest Endosc*. 2010; 71:697. [PubMed: 19959164]
3. Barham CP, Jones RL, Biddlestone LR, et al. Photothermal laser ablation of Barrett's oesophagus: endoscopic and histological evidence of squamous re-epithelialisation. *Gut*. 1997; 41:281. [PubMed: 9378378]
4. Dulai GS, Jensen DM, Cortina G, et al. Randomized trial of argon plasma coagulation vs. multipolar electrocoagulation for ablation of Barrett's esophagus. *Gastrointest Endosc*. 2005; 61:232. [PubMed: 15729231]
5. Ell C, May A, Pech O, et al. Curative endoscopic resection of early esophageal adenocarcinomas (Barrett's cancer). *Gastrointest Endosc*. 2007; 65:3. [PubMed: 17185072]
6. Esaki M, Matsumoto T, Hirakawa K, et al. Risk factors for local recurrence of superficial esophageal cancer after treatment by endoscopic mucosal resection. *Endoscopy*. 2007; 39:41. [PubMed: 17252459]
7. Greenwald BD, Dumot JA, Horwhat JD, et al. Safety, tolerability, and efficacy of endoscopic low-pressure liquid nitrogen spray cryotherapy in the esophagus. *Dis Esophagus*. 2010; 23:13. [PubMed: 19515183]
8. Hornick JL, Mino-Kenudson M, Lauwers GY, et al. Buried Barrett's epithelium following photodynamic therapy shows reduced crypt proliferation and absence of DNA content abnormalities. *Am J Gastroenterol*. 2008; 103:38. [PubMed: 18076737]
9. Inoue H, Minami H, Kaga M, et al. Endoscopic mucosal resection and endoscopic submucosal dissection for esophageal dysplasia and carcinoma. *Gastrointest Endosc Clin N Am*. 20:25. [PubMed: 19951792]
10. Johnston MH. Cryotherapy and other newer techniques. *Gastrointest Endosc Clin N Am*. 2003; 13:491. [PubMed: 14629105]
11. Krishnan K, Pandolfino JE, Kahrilas PJ, et al. Increased risk for persistent intestinal metaplasia in patients with Barrett's esophagus and uncontrolled reflux exposure before radiofrequency ablation. *Gastroenterology*. 143:576. [PubMed: 22609385]
12. Leers JM, Vivaldi C, Schafer H, et al. Endoscopic therapy for esophageal perforation or anastomotic leak with a self-expandable metallic stent. *Surg Endosc*. 2009; 23:2258. [PubMed: 19184216]
13. May A, Gossner L, Pech O, et al. Local endoscopic therapy for intraepithelial high-grade neoplasia and early adenocarcinoma in Barrett's oesophagus: acute-phase and intermediate results of a new treatment approach. *Eur J Gastroenterol Hepatol*. 2002; 14:1085. [PubMed: 12362099]
14. Mino-Kenudson M, Hull MJ, Brown I, et al. EMR for Barrett's esophagus-related superficial neoplasms offers better diagnostic reproducibility than mucosal biopsy. *Gastrointest Endosc*. 2007; 66:660. [PubMed: 17905005]
15. Namasivayam V, Wang KK, Prasad GA. Endoscopic mucosal resection in the management of esophageal neoplasia: current status and future directions. *Clin Gastroenterol Hepatol*. 8:743. [PubMed: 20541628]
16. Okoro NI, Tomizawa Y, Dunagan KT, et al. Safety of Prior Endoscopic Mucosal Resection in Patients Receiving Radiofrequency Ablation of Barrett's Esophagus. *Clin Gastroenterol Hepatol*. 2012; 10:150. [PubMed: 22056303]
17. Overholt BF, Panjehpour M, Halberg DL. Photodynamic therapy for Barrett's esophagus with dysplasia and/or early stage carcinoma: long-term results. *Gastrointest Endosc*. 2003; 58:183. [PubMed: 12872083]
18. Prasad GA, Wang KK, Buttar NS, et al. Long-term survival following endoscopic and surgical treatment of high-grade dysplasia in Barrett's esophagus. *Gastroenterology*. 2007; 132:1226. [PubMed: 17408660]
19. Prasad GA, Wang KK, Halling KC, et al. Utility of biomarkers in prediction of response to ablative therapy in Barrett's esophagus. *Gastroenterology*. 2008; 135:370. [PubMed: 18538141]

20. Rastogi A, Puli S, El-Serag HB, et al. Incidence of esophageal adenocarcinoma in patients with Barrett's esophagus and high-grade dysplasia: a meta-analysis. *Gastrointest Endosc.* 2008; 67:394. [PubMed: 18045592]
21. Sampliner RE, Fennerty B, Garewal HS. Reversal of Barrett's esophagus with acid suppression and multipolar electrocoagulation: preliminary results. *Gastrointest Endosc.* 1996; 44:532. [PubMed: 8934157]
22. Shaheen NJ, Overholt BF, Sampliner RE, et al. Durability of radiofrequency ablation in Barrett's esophagus with dysplasia. *Gastroenterology.* 2011; 141:460. [PubMed: 21679712]
23. Shaheen NJ, Sharma P, Overholt BF, et al. Radiofrequency ablation in Barrett's esophagus with dysplasia. *N Engl J Med.* 2009; 360:2277. [PubMed: 19474425]
24. Shimizu Y, Kato M, Yamamoto J, et al. Endoscopic clip application for closure of esophageal perforations caused by EMR. *Gastrointest Endosc.* 2004; 60:636. [PubMed: 15472698]
25. Stein HJ, Feith M, Bruecher BL, et al. Early esophageal cancer: pattern of lymphatic spread and prognostic factors for long-term survival after surgical resection. *Ann Surg.* 2005; 242:566. [PubMed: 16192817]
26. Wani S, Mathur SC, Curvers WL, et al. Greater interobserver agreement by endoscopic mucosal resection than biopsy samples in Barrett's dysplasia. *Clin Gastroenterol Hepatol.* 8:783. [PubMed: 20472096]
27. Yamashita T, Zeniya A, Ishii H, et al. Endoscopic mucosal resection using a cap-fitted panendoscope and endoscopic submucosal dissection as optimal endoscopic procedures for superficial esophageal carcinoma. *Surg Endosc.* 25:2541. [PubMed: 21359894]

1. Endoscopic eradication therapy is considered a safe, effective and durable treatment strategy for BE complicated by HGD and early EAC.
2. The endoscopist should be familiar with both mucosal resection and ablation techniques and their respective indications.
3. Patients should be enrolled in a comprehensive surveillance program that continues following endoscopic eradication therapy.
4. Recurrent dysplasia can be approach endoscopically as long as appropriate staging is performed.

FIGURE 1.

This represents the development of intestinal metaplasia with the effects of cytokines on gastric stem cells causing intestinal metaplasia with cytokines that promote intestinal metaplasia. The intestinal phenotype is marked by expression of transcription factors such as BMP4 and CDX2. Upon ablation therapy, the intestinalized phenotype disappears and squamous regeneration appears to occur from neighboring squamous cells and bone marrow derived stem cells.

FIGURE 2.

Endoscopic mucosal resection band technique in a cartoon format. Following high-resolution white-light endoscopy a nodular lesion is identified. The lesion is suctioned into the band ligation device and a band is deployed creating a pseudopolyp. (A) A hexagonal snare is placed over the pseudopolyp and (B) electrocautery is applied for resection.

FIGURE 3.

This sequence represents initial placement of a snare in the resection cap. The snare is seen fitting around the lip of the cap. The second figure illustrates suctioning and snaring with the cap technique. The third is the resulting defect in the mucosa after resection.

FIGURE 4.

In the image above, the Halo360 circumferential balloon device is shown deflated after a single application of energy to the mucosa. The damage mucosa is blanched indicating thermal destruction of the mucosa. Along side is an Image of Halo90 device illustrating the presence of the electrode surface of the focal device that is typically mounted on an endoscope.

FIGURE 5.

Argon plasma coagulation of residual Barrett's mucosa. Electrical energy is conducted to the mucosa by a flow of ionized argon gas through a catheter causing thermal damage by a non-contact method.

FIGURE 6.

Cryotherapy. Following high-resolution white-light endoscopy and biopsy acquisition per standard protocol, the (A) cryoablation catheter is advanced to the distal esophagus. (B) Cryotherapy is applied in repeated cycles of rapid freezing and slow thawing to induce (C) tissue necrosis.

FIGURE 7.

Approach of endoscopic eradication therapy for early esophageal adenocarcinoma (EAC) and high-grade dysplasia (HGD) in Barrett's esophagus (BE). EMR, endoscopic mucosal resection; IMC, intramucosal adenocarcinoma; RFA, radiofrequency ablation.