Chapter 6
Endoluminal Interventions

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This chapter reviews task lists for the following procedures:

- Rigid esophagoscopy
- Esophageal biopsy
- Balloon and Savary dilation of esophageal strictures
- Endoscopic esophageal stenting
- Endoscopic suturing
- Endoscopic mucosal resection
- Botox injection
- Radiofrequency ablation
- Peroral endoscopic myotomy (POEM)
- Endoscopic drainage for esophageal perforations or anastomotic leaks

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Rigid Esophagoscopy

Rigid esophagoscopy (Fig. 6.1), though not often performed in the modern era, is an important skill to acquire. Its indications include foreign body impaction in the esophagus or bleeding from an esophageal mass that is difficult to control. In both of these situations, it may not be possible to perform the interventions required using a flexible endoscope. For an impacted foreign body, larger instruments such as graspers can be passed down a rigid esophagoscope. In the situation of severe bleeding, topical therapies such as epinephrine-soaked swabs may be more easily employed via a rigid scope.

Fig. 6.1 Rigid esophagoscopy. The rigid esophagoscope is carefully inserted, taking care to protect the patient's teeth. This procedure allows therapeutic endoscopy of the esophagus with larger instruments than with a flexible endoscope

Endoscopic Biopsy of the Esophagus

Esophageal biopsies are taken when pathology is seen. A number of forceps are available for these biopsies, and the use of cautery usually is not recommended for a diagnostic esophageal biopsy. The Prague classification (Fig. 6.2 and Table 6.1) is used to describe the Barrett's segment macroscopically. With regard to esophageal biopsies for Barrett's surveillance, the Seattle protocol of four-quadrant biopsies must be observed. This allows histological assessment of any Barrett's segment (Fig. 6.3).

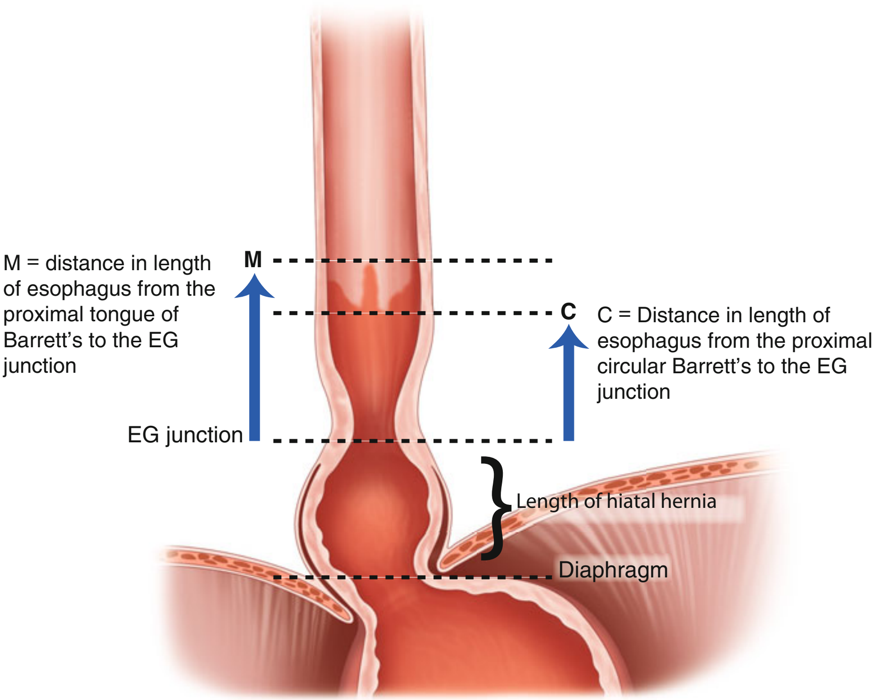

Fig. 6.2 The Prague classification of Barrett's esophagus. This schematic describes the steps for performing an esophagogastroduodenoscopy and assessing the Barrett's epithelium according to the Prague criteria [2] (Adapted from Sharma et al. [2]; with permission from Elsevier.) Table 6.1 further outlines the six numbered steps shown in this figure

Table 6.1 Steps of the esophagogastroduodenoscopy (EGD) examination in a patient with Barrett's esophagus

Steps	Action points
1	Full EGD examination. Particularly note the presence of any hiatus hernia. Observe the position of the gastroesophageal junction (GEJ) in relation to the hiatal impression of the diaphragm
2	Note the location (in centimeters from the incisors) of the GEJ. Anatomical clues: Top of gastric mucosal folds The "pinch" of the lower esophageal sphincter
3	Note whether the squamocolumnar junction (or Z line) is above the GEJ
4	Note the location (in centimeters from the incisors) of the most proximal **C**ircumferential extent of the suspected Barrett's epithelium. This measurement = **C**
5	Note the location (in centimeters from the incisors) at the **M**aximum extent (i.e., most proximal extension) of suspected Barrett's epithelium. This measurement = **M**
6	Subtract the **C** and **M** values noted in Step 4 and Step 5 from the depth of endoscope insertion noted in Step 2 (i.e., the GEJ). This is the relative position of the circumferential and maximal Barrett's in relation to the GEJ
7	Report these values as Prague C and M [2]. For example, e.g., Barrett's with a circumferential length of 4 cm but a maximum length of 8 cm would be C4M8

Adapted from Sharma et al. [2]; with permission from Elsevier

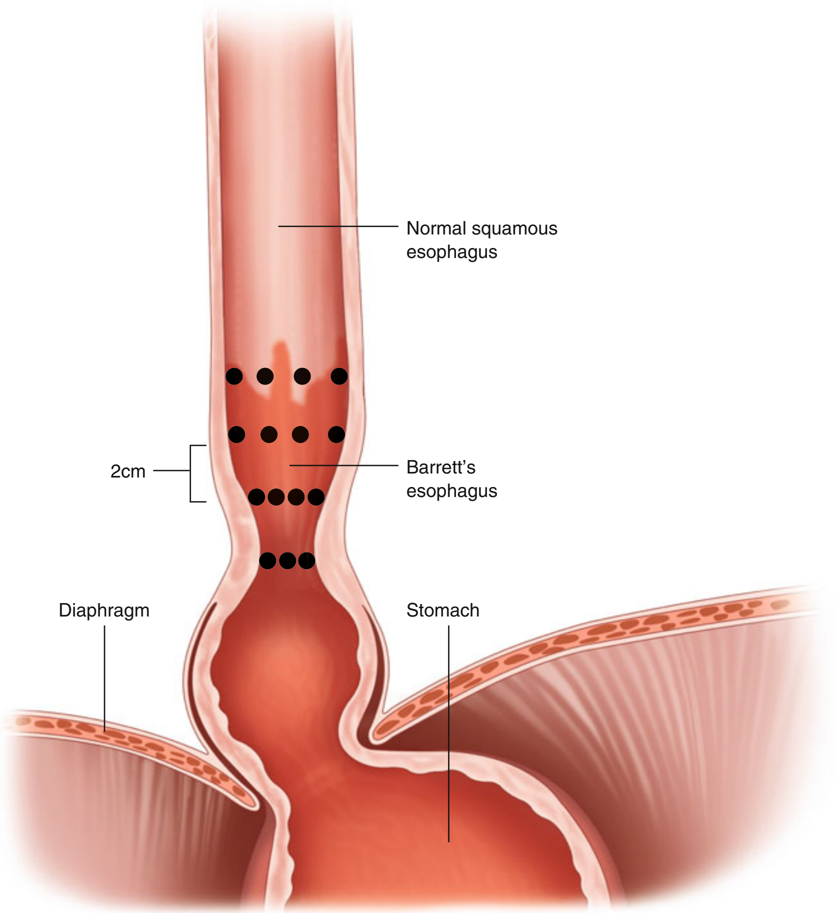

Fig. 6.3 The Seattle protocol of four-quadrant biopsies for histologic assessment of Barrett's epithelium. When Barrett's esophagus is seen, or at surveillance endoscopy, biopsies from all four quadrants of the circumference of the esophagus should be performed every 2 cm to clearly document the length of the Barrett's epithelium

Dilation of Esophageal Strictures

Esophageal strictures may be benign or malignant. At times, the distinction is unclear, so biopsy should be performed on all strictures of the esophagus. Dilation of the stricture will frequently facilitate biopsy and cytologic brushings and will also relieve dysphagia. Dilation should be undertaken with caution because of the risk of esophageal perforation.

Strictures vary in their diameter and in their response to dilation. Some are treated easily by the passage of the scope itself or by a single balloon dilation. Other strictures, such as those resulting from caustic ingestion, are inelastic, demonstrate great resistance to dilation, and frequently are long. The endoscopist should assess the most likely etiology for the stricture and proceed with caution. The use of intraoperative fluoroscopy is often advisable, and excessive force should be avoided. If the patient complains of pain, the procedure should be promptly terminated and a contrast study should be performed to rule out esophageal perforation.

Strictures following operations such as esophagectomy are usually very amenable to endoscopic dilation. Early dilation may result in a more effective and long-lasting result. The gastroscope is positioned immediately above the narrowing and the characteristics of the stricture are noted. Biopsy and cytologic specimens of the edges of the stricture may be obtained at this time and again after dilation.

Strictures of the esophagus may present initially with bolus obstruction. Urgent endoscopy must be undertaken to remove the bolus, usually with a snare or grasping forceps, but the endoscopist must not ignore the stricture that caused the event. It may be dealt with shortly after removal of the food bolus.

Balloon Dilation

To perform a balloon dilation of an esophageal stricture, the endoscope is positioned above the stricture and an appropriate balloon is selected. The normal human esophagus is 2 cm wide, and a 20-mm balloon is usually the maximum dilation that would be attempted. The flaccid balloon is passed through the biopsy channel of the scope and positioned within the stricture. If the stricture is complex and the lumen is narrow, contrast can be injected to allow fluoroscopic guidance of a wire over which the balloon is passed. This technique prevents inadvertent perforation and allows safe passage of the sheathed balloon into the lumen. The balloon should be long enough to traverse the entire length of the stricture. After positioning, the balloon is inflated using radiopaque contrast material under fluoroscopic monitoring. This step may be accomplished without fluoroscopic guidance, using saline to fill the balloon, but without fluoroscopy there can be no assurance that the maximum diameter of the balloon has been achieved.

Using fluoroscopic guidance and a manometer, the balloon is insufflated with contrast agent until the waist is obliterated (Fig. 6.4a–c). The manometer prevents balloon rupture. The balloon should be inflated for a minute to ensure adequate dilation. After the balloon is deflated and removed, the scope may be passed through the stricture, or a larger dilator may be used if necessary. Once the scope is passed through the narrowing, it is important to obtain tissue samples from the stricture's lower extent.

Balloon dilation of esophageal strictures allows rapid clinical improvement in a patient's dysphagia, but the strictures often recur and require repeated dilations.

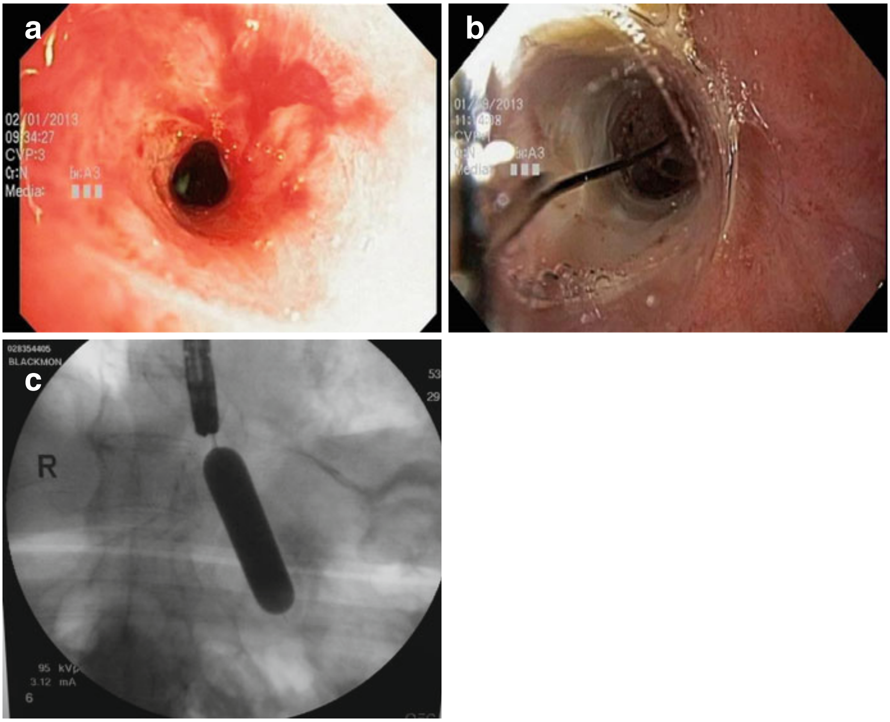

Fig. 6.4 (**a**) Endoscopic appearances of a benign esophageal stricture, pre-balloon dilatation. (**b**) Endoscopic appearances during balloon dilatation of a benign esophageal stricture. (**c**) Fluoroscopy demonstrating balloon dilation of an esophageal stricture. The balloon is filled with contrast to enable the endoscopist to observe adequate dilation of the stricture and obliteration of the "waist."

Savary Dilation

An alternative to using balloon dilation is wire-guided rigid Savary dilation of esophageal strictures. The Savary dilators are usually more successful in dilating recalcitrant strictures but are often more uncomfortable for the patient. One must use fluoroscopy when using these dilators. Savary dilators, which range in size from 15 Fr to 60 Fr (5–20 mm) in diameter, are passed over a guidewire in progressive size increments to dilate the stricture safely (Fig. 6.5). The endoscope should always be passed back into the esophagus after dilation to assess the esophageal mucosa.

Kenalog Injection

Injecting Kenalog (triamcinolone acetonide), a topical steroid, into the esophageal stricture may increase the length of time between necessary dilations. Our experience is that repeat dilations are still needed with the use of steroids, but the interval between dilations is increased in selected patients.

Fig. 6.5 Savary esophageal dilators. (**a**) Savary esophageal dilators have a narrow tip inserted over a guidewire that has been placed endoscopically. This wire allows the dilator to be passed safely even though the endoscope is removed during dilation. (**b**) Savary dilators are available in a range of sizes from 15 to 60 Fr (5–20 mm) and are passed sequentially to dilate the stricture

Esophageal Stenting

Patients who present with esophageal strictures, spontaneous esophageal perforation, or esophageal anastomotic leak may require the placement of an esophageal stent. We advocate the use of a partially covered, self-expanding metal stent such as those shown in Fig. 6.6 [1]. The uncovered portion of the stent will encourage tissue growth and help to reduce the risk of distal migration. Other stents are available, however, including fully covered, silicone, and uncovered stents. An uncovered stent must not be used for a benign stricture.

Indications

- Esophageal perforation
- Esophageal stricture
- Esophageal fistula

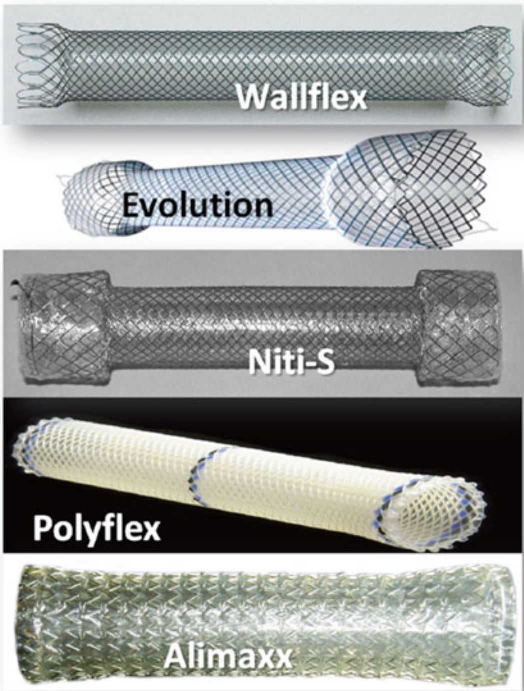

Fig. 6.6 Esophageal stents. A number of stents are available for the treatment of benign and malignant esophageal strictures. These may be metal or plastic and uncovered or covered. With uncovered stents or plastic stents, the risk of migration is increased and precautions should be taken, such as endoluminal suturing to secure the stent in place (Reprinted from Carrott and Low [1]; with permission from Elsevier)

Contraindications

- Uncovered aorta nearby
- Unsalvageable esophagus
- Aspiration risk
- Tracheoesophageal fistula with poor landing zone or large fistula
- Foreign body present within the fistula
- Spine hardware present adjacent to leak

Partially covered, self-expanding metal stents are available on a delivery device with a graded tip, allowing easy introduction into the pharynx and esophagus. We recommend placing a very stiff wire into the lumen of the stomach prior to stent placement and using fluoroscopy to guide the stent over the guidewire. If fluoroscopy is not available, it is possible to deploy the stent under endoscopic visualization. If a stricture is not involved and there is high risk for distal migration of the stent, it is possible to bridle the stent into place by placing an umbilical tape around the proximal interstices of the wire of the stent and bringing the tape out of each nostril, fastening it in place. This bridling technique will prevent the patient from swallowing the stent. Other fixation techniques, including endoscopic suturing of the stent, have been presented to prevent migration of a stent, especially when it is placed around the upper pharynx, where swallowing of the stent is common. We believe the Apollo OverStitch™ device (Apollo Endosurgery, Austin, TX), the tool currently used to fix stents into place, will be used in the future to secure stents and prevent migration in most cases, although this use currently is off-label with the US Food and Drug Administration (FDA).

To prevent impaction of the stent with food, a postoperative stent diet should be employed. When nitinol stents are used, it is important to educate the patient to avoid extremely cold food, which causes shrinkage and migration of the stent, and extremely hot food, which causes degradation of the stent's covering. Each patient should have an upper GI contrast evaluation performed after the deployment of a stent to ensure that the stent's position is satisfactory and that there is no leak or residual stricture.

Endoscopic Suturing

Endoscopic suturing is useful in a number of situations, including esophageal perforation (to close small defects) and the deployment of esophageal stents (to avoid distal migration).

Endoscopic suturing devices such as the Apollo OverStitch™ device use pre-loaded sutures to close defects or anchor stents in place (Fig. 6.7). Other methods of anchoring or closing defects include over-the-scope clips (OTSC®; Ovesco Endoscopy, Tübingen, Germany). Resolution® Clips (Boston Scientific, Natick, MA), however, are not effective in securing stents to prevent migration. Newer applications of these suturing devices include endoscopic sleeve gastrectomy.

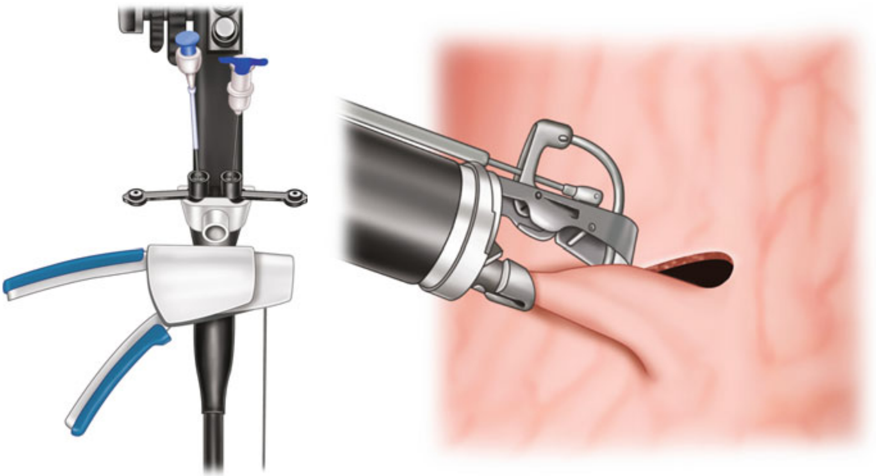

Fig. 6.7 The Apollo OverStitch™ device (Apollo Endosurgery, Austin, TX). This endoluminal suturing device can be used to suture esophageal perforations and to secure stents in place (Reprinted with permission from Apollo Endosurgery)

The endoluminal suturing device is placed on the tip of the gastroscope and passed through an overtube to prevent damaging the lining of the esophagus. The suture is preloaded, and a dual-channel scope is necessary. Through the second channel, a drill is passed to embed into the esophageal wall and pull tissue into the suture as it is passed through the wall. Full-thickness bites of the esophageal wall are typically taken. Once the suturing is finished, the suture is "cinched" with a plastic fixation tip (resembling a T fastener) that is passed through the working channel to tighten the stitch. This process then allows the operator to cut the end of the suture after tightening, completing the process of placing either a figure-of-eight or simple stitch (Fig. 6.8).

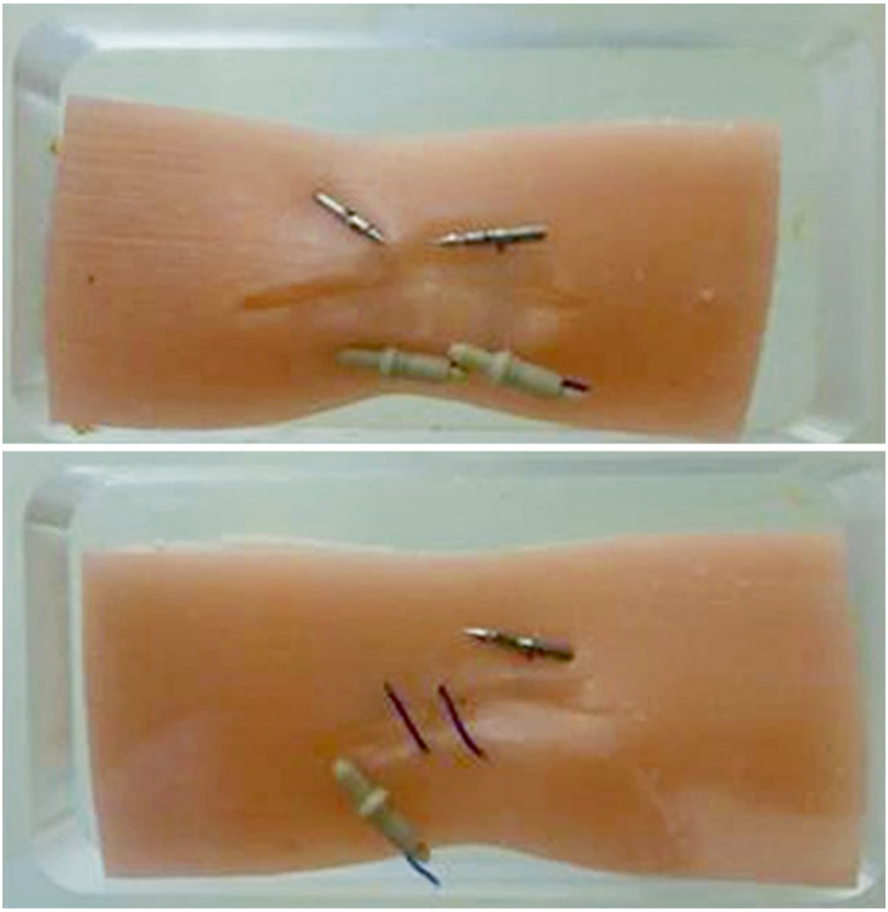

Fig. 6.8 The Apollo OverStitch™ device can be used to suture tissue in an interrupted fashion (*top*) or a continuous fashion (*bottom*)

Endoscopic Mucosal Resection

Endoscopic mucosal resection (EMR) can be performed with several different techniques, as illustrated in Figs. 6.9, 6.10 (ligation device), and 6.11 (cap and snare).

The loose connective tissue attaching the muscle and mucosal layers of the esophagus enable EMR to be performed easily. It is possible to resect the mucosa and submucosa without injury to the muscle layer, but the wall of the esophagus is only 4 mm thick, so precautions must be taken to avoid perforation. Correct lifting of the mucosa is extremely important. Injecting saline or other liquids into the submucosal layer, or mechanical lifting using special instruments like a ligation device, is the easiest and most effective way to avoid muscle involvement. After lifting the mucosa, including the target lesion, the lesion can be safely captured, grasped with a narrow wire, and resected by electrocauterization. When removing the specimen from the scope, it is extremely important to orient it accurately so that the locations of any positive margins are correctly identified (Fig. 6.12).

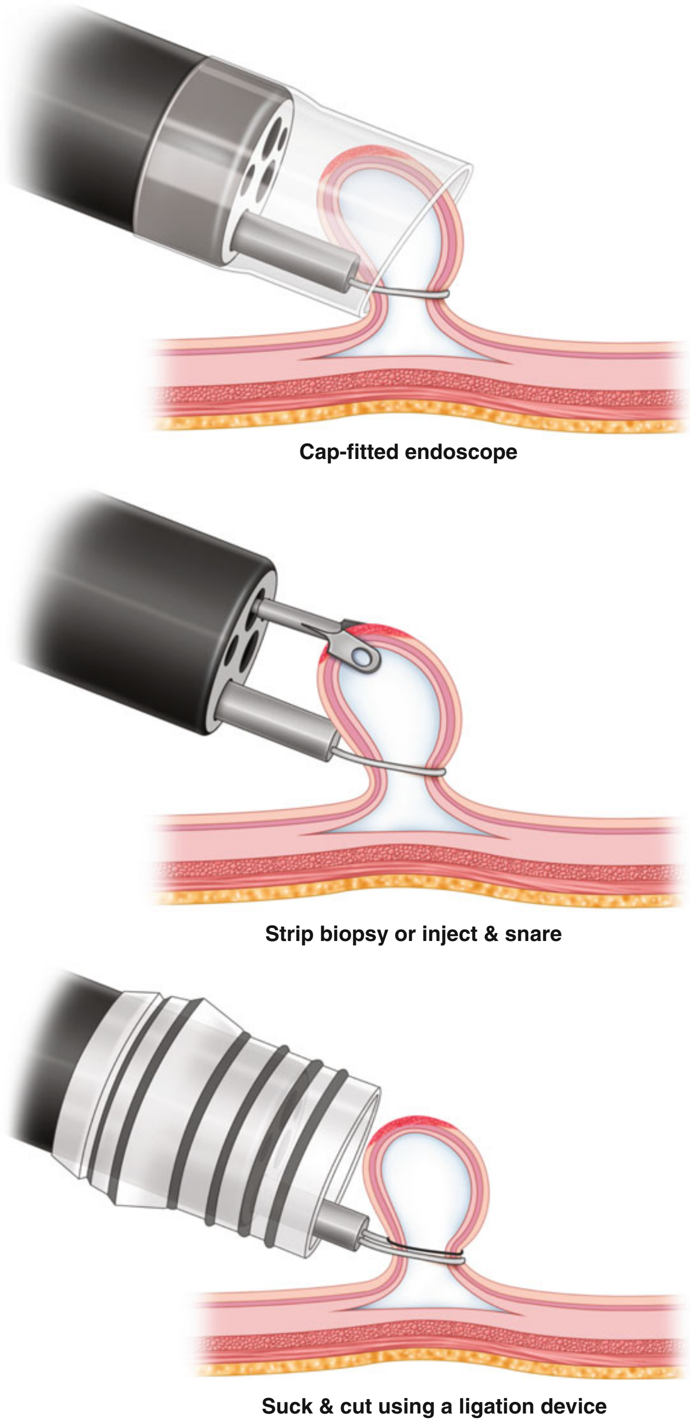

Fig. 6.9 Endoscopic mucosal resection (EMR) techniques include using a cap-fitted endoscope, strip biopsy (inject and snare), or "suck and cut" using a ligation device

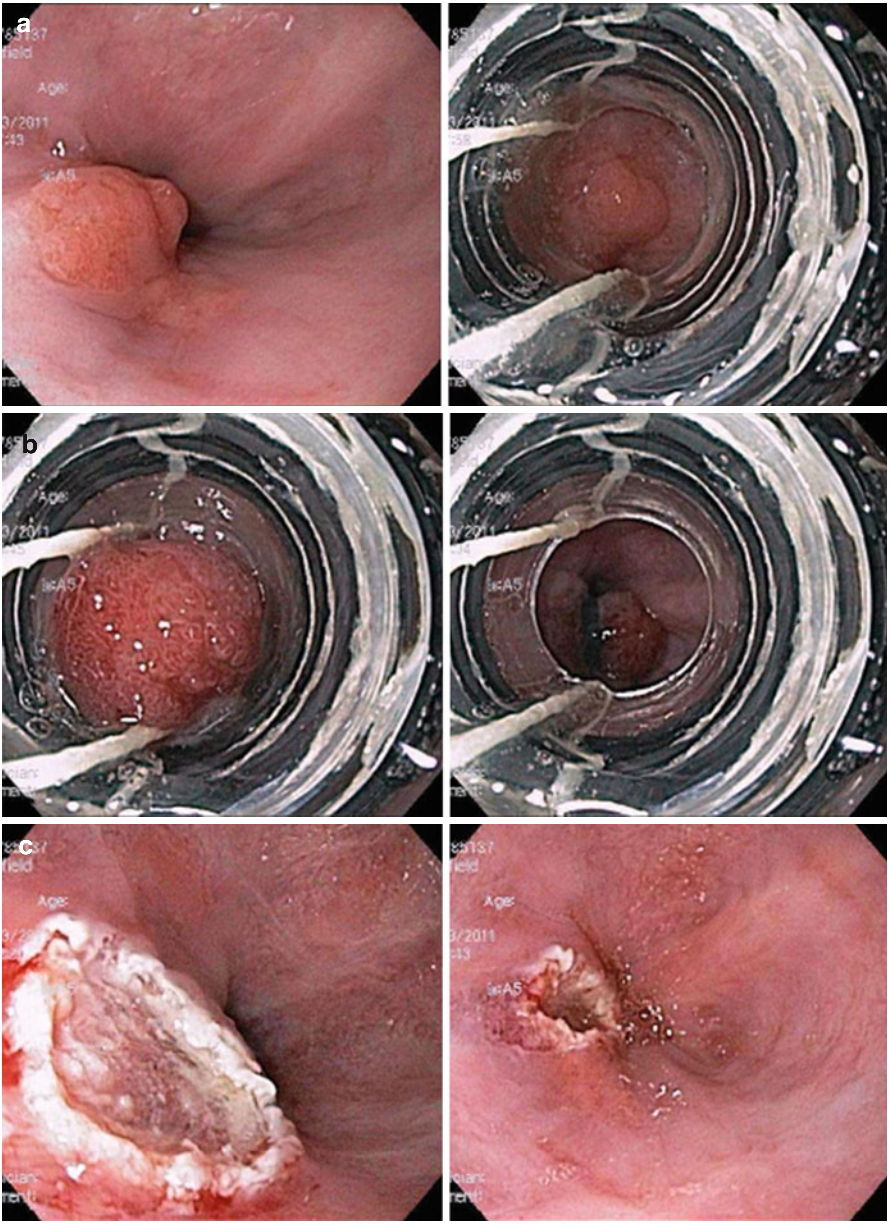

Fig. 6.10 EMR performed using the ligation device. (**a**) The lesion for EMR is identified (*left*) and the endoscope with the ligation device fitted is brought into position to perform the EMR (*right*). (**b**) The endoscope is positioned directly over the lesion and suction is applied to bring the lesion into the scope (*left*). The band device is deployed whilst maintaining suction to allow band ligation of the lesion to facilitate subsequent EMR (*right*). (**c**) A snare is passed through the scope and positioned beneath the band. Electrocautery is carefully applied and the EMR completed. The base of the EMR site is carefully inspected to identify any perforation. If there is any concern regarding perforation, then endoclips (e.g., Resolution® Clips; Boston Scientific, Natick, MA) should be applied

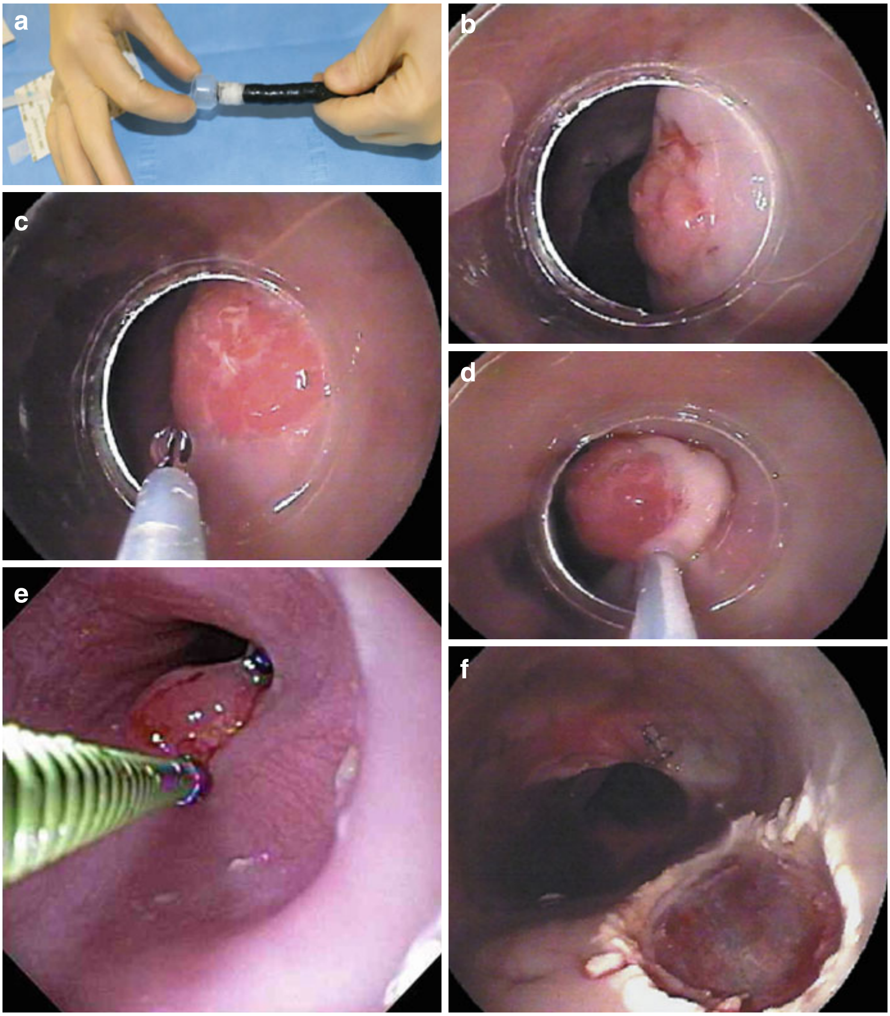

Fig. 6.11 EMR performed with a cap-fitted device and snare. (**a**) The cap is fitted to the endoscope. (**b**) The endoscope is passed orally and the lesion is identified through the cap. (**c**) The lesion may be elevated with a submucosal bleb of solution (saline-diluted methylene blue with or without epinephrine), and a snare is passed through the scope. (**d**) The lesion is snared. In this picture, normal mucosa can be seen beyond the target mucosa, important in ensuring adequate resection. (**e**) Electrocautery is applied to the snare and gentle upward traction is applied to complete the EMR. (**f**) The base of the lesion is inspected to rule out any perforation. If perforation is suspected, clips are applied through the scope

Fig. 6.12 Orienting the EMR specimen. (**a**) The EMR specimen is retrieved carefully from the snare. (**b**) The specimen is pinned and oriented on a cork board to allow both the pathologist and the surgeon to understand which borders are involved or are clear of dysplasia or intramucosal carcinoma

Botox Injection

The injection of botulinum toxin (Botox) is useful in esophageal pathology in two situations. The first is in the treatment of achalasia, when Botox is injected into the lower esophageal sphincter (LES) in order to improve symptoms. Usually 100 units are injected into the LES quadrantically. Future surgical myotomy may be made more difficult but is not a contraindication. The second clinical application is the injection of Botox into the pylorus as treatment for established gastroparesis or during esophagectomy. Botox is injected into the pyloric sphincter at a dose of 25 units to each quadrant. The effects of Botox are temporary and usually last up to 4–6 months.

Radiofrequency Ablation

Radiofrequency ablation (RFA) is used in the treatment of Barrett's esophagus, usually in the setting of dysplasia (Fig. 6.13). The most commonly used device is Barrx™Ablation System (Covidien GI Solutions, Sunnyvale, CA), formerly known as HALO. A 360° device (Barrx™ 360 RFA Balloon Catheter) can be used for circumferential lesions, or 90- or 60° focal catheters can be used for localized treatment (Barrx™ 90/60 RFA Focal Catheter). Previously a sizing balloon was required before treatment was instituted for circumferential lesions, but a new device that can size and treat will soon be available. The thickness of Barrett's esophagus is usually less than 500 μm and the ablation from these devices is 500–1000 μm. At this time, the American Gastroenterological Association recommends endoscopic ablative therapy for Barrett's with high-grade dysplasia (Fig. 6.14), rather than surveillance or proceeding to esophagectomy.

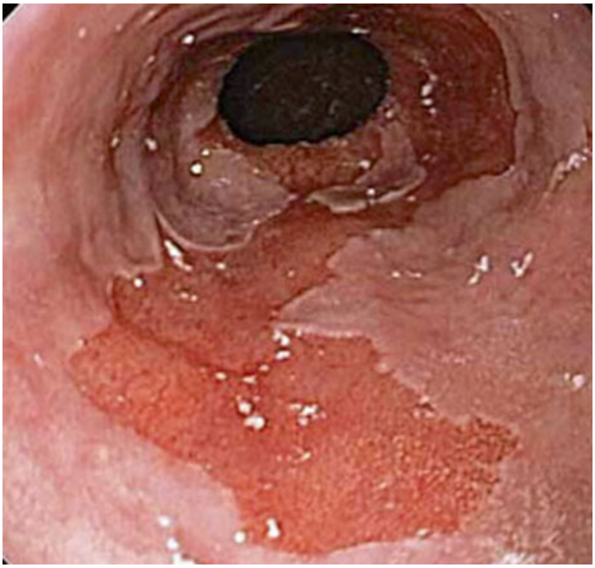

Fig. 6.13 The endoscopic appearance of Barrett's esophagus

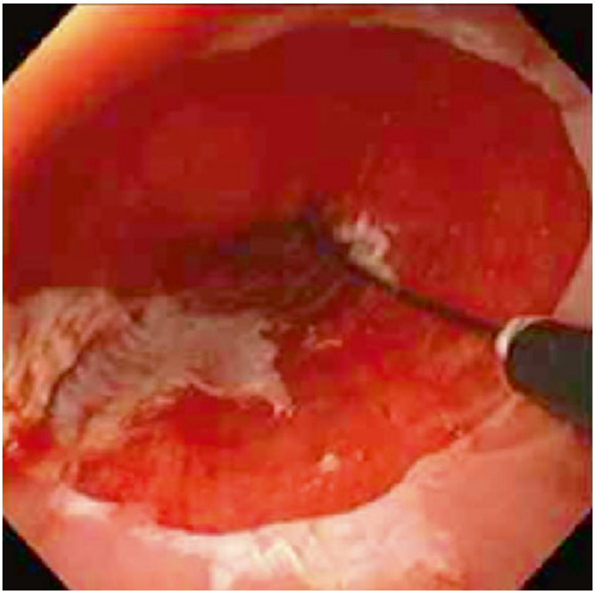

Fig. 6.14 The endoscopic appearance of Barrett's esophagus following radiofrequency ablation with the Barrx device

Peroral Endoscopic Myotomy

The use of peroral endoscopic myotomy (POEM) in the treatment of achalasia began in Japan and has been increasing in the West. This technique involves endoscopic myotomy of circular or circular and longitudinal muscle fibers over the lower esophagus and proximal stomach. The use of the POEM technique is still in the early years of development, and long-term results are awaited.

A dual-channel or single-channel endoscope is used; the dual channels allow two instruments to be passed. A cap on the endoscope is desirable for optimal visualization, and a high-pressure water pump (ERBEJET® 2; ERBE, Tübingen, Germany) allows waterjet dissection. The submucosal layer may be injected with methylene blue and dextrose or hyaluronic acid to facilitate dissection. The ERBE VIO 300 D waterjet dissector is used in conjunction with a cautery device. The endoscope is passed into the esophagus and a diagnostic esophagoscopy is performed, with irrigation of the esophagus using débridement antibiotic (DAB) solution. After injection of the submucosa with methylene blue and dextrose, an incision is made in the mucosal lining of the esophagus proximal to the LES (Fig. 6.15a). This mucosal incision facilitates entry of the scope into the submucosal plane. Once the endoscope is passed into the submucosal plane, dissection continues caudad, with attention directed to controlling with cautery the blood vessels passing the submucosal space (Fig. 6.15b). The submucosal dissection is continued using the endoknife and waterjet dissection to distend the space and enhance visualization. We do not recommend balloon dissection of this plane, as we have encountered increased bleeding with balloon dissection. During this phase, we monitor peak airway pressures and perform regular abdominal and neck examination to detect any pneumothorax, pneumoperitoneum, or crepitus. The submucosal dissection is continued until gastric sling fibers are identified (Fig. 6.15c) and dissection continued 2 cm beyond this point. The endoscope is withdrawn and the myotomy is begun, using the endoknife to divide first the inner circular muscle fibers and then the outer longitudinal muscle fibers (Fig. 6.15d, e). Continuous periodic inspection of the mucosa ensures no mucosal injury. The myotomy is continued until the gastric sling fibers are encountered; then the myotomy is continued 1–2 cm onto the gastric wall. The endoscope is withdrawn with retroflexion to check the myotomy and mucosa. The mucosa is closed with Resolution® Clips at the end of the myotomy, working from distal to proximal along the mucosal defect (Fig. 6.15f). The myotomy can be checked by endoscopy and by fluoroscopy after the procedure. In our practice, a laparoscopic antireflux procedure (a Toupet or Dor fundoplication) is performed after POEM (during the same anesthesia), based on patient preference.

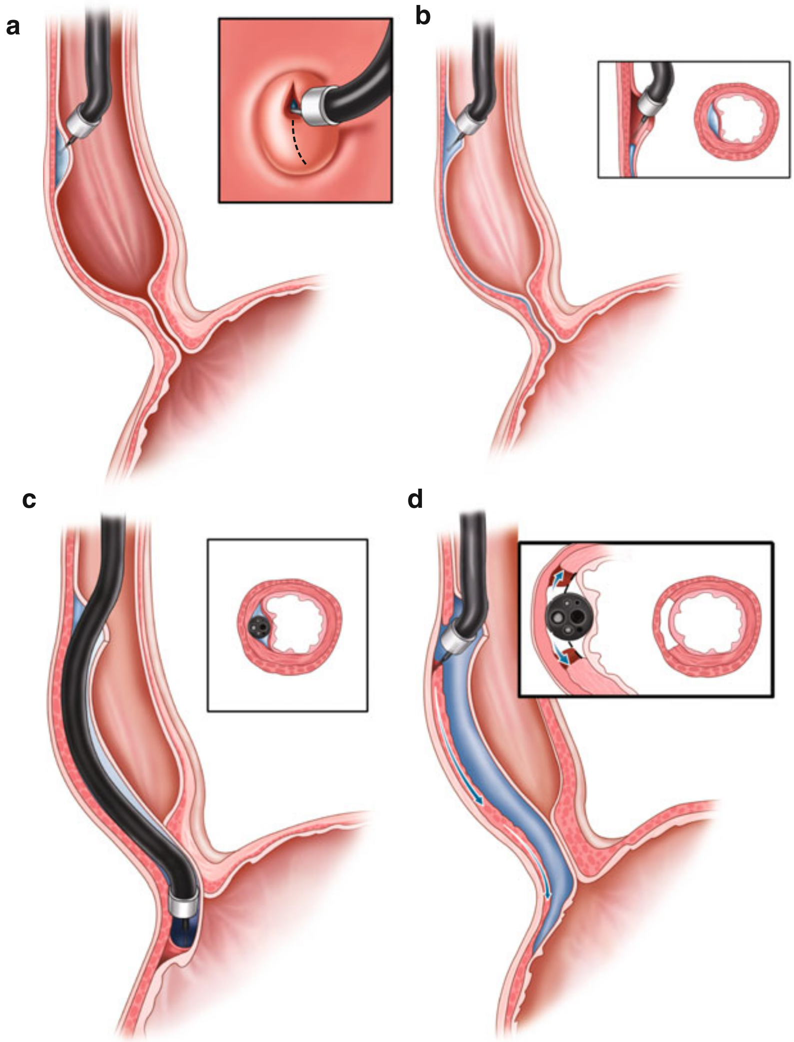

Fig. 6.15 Peroral endoscopic myotomy (POEM). (**a**) A diagnostic esophagogastroduodenoscopy (EGD) is performed. Approximately 10 cm cephalad of the gastroesophageal junction (GEJ), the mucosa is incised with electrocautery using the T-knife. A submucosal injection of a mixture of methylene blue, hypromellose, and epinephrine to a final concentration of 1:10,000 can facilitate this step. (**b**) Once the mucosa is incised, a submucosal tunnel is created. This step can be achieved using gentle electrocautery dissection and an ERBEJET® two waterjet dissector (ERBE, Tübingen, Germany). Any vessels traversing the tunnel can be cauterized using rats-tooth forceps with electrocautery. (**c**) The submucosal tunnel is continued until a point 2 cm distal to the GEJ is reached. This point can be recognized by the visualization of gastric "sling" fibers of muscle. Periodically, the scope is withdrawn from the tunnel and the mucosa is inspected to ensure that there are no breaches. (**d**) The circular muscle fibers are divided throughout the length of the submucosal tunnel. (**e**) The longitudinal muscle fibers are divided next. The length over which these muscle fibers are divided varies between practitioners. (**f**) Once the myotomy is completed and hemostasis achieved, the mucosal defect is closed with endoclips (e.g., Resolution® Clips)

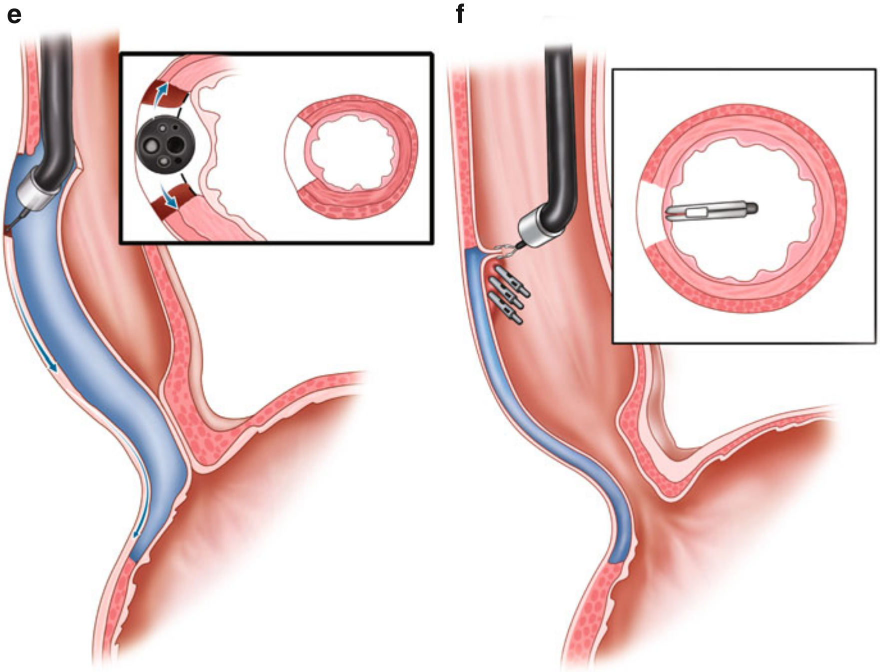

Fig. 6.15 (continued)

Endoscopic Drainage for Esophageal Perforation or Anastomotic Leak

The management of esophageal perforations and anastomotic leaks is often challenging. The focus is on control of sepsis, adequate nutrition, and closure of the leak or defect. In some patients, esophageal stenting, surgery, or a combination of the two is required to close the esophageal defect. In other instances, an endoscopic vacuum sponge may be used to control the cavity and promote healing. This kind of vacuum-assisted closure device (V.A.C.®, Kinetic Concepts, Inc., San Antonio, TX, USA) is passed into the esophagus and the vacuum is attached via a tube passed nasally to connect to wall suction. This device is not currently approved by the FDA for use in treating esophageal perforations, but preliminary results have shown it to be effective in selected patients.

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