Gastrointestinal Tract Stenting

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Introduction

Enteral stent placement for disorders of the gastrointestinal tract has evolved significantly over the past decade. While the majority of enteral stent placement is performed to palliate malignant obstruction, advancements in technique and device technology have created suitable alternative endoscopic options for certain benign conditions. This chapter focuses on the indications, techniques, and currently available technologies for stent placement in the esophagus, small intestine, and colon.

Esophageal Stent Placement

Indications

The leading indications for esophageal stent placement are for palliation of complications related to esophageal and extraesophageal malignancies (Fig. 20.1). In the United States, rates of esophageal squamous cell carcinoma have declined, while the incidence and mortality rate of esophageal adenocarcinoma have increased [54]. The majority of patients with esophageal cancer will present with unresectable disease, and the overall 5-year survival rates remain poor at less than 20% [11, 46, 54, 57]. In this group of patients, the treatment goals are essentially directed toward improvement in quality of life: maintenance of esophageal luminal patency, reduction in dysphagia, optimization of nutrition, and reduction in the risk of aspiration (and resultant pneumonia) [11, 57]. These patients may be prone to malignant fistula formation from local radiation therapy or invasion of cancer into the respiratory tract and, less commonly, aorta, mediastinum, or pleural space [33, 49, 57, 58, 81]. Aside from dysphagia secondary to intrinsic malignant obstruction, extrinsic esophageal compression and dysphagia can be observed in patients with various forms of lung cancer, mediastinal lymphadenopathy, and mediastinal metastases [3, 53, 80]. While these indications rarely exist in isolation for any given patient, esophageal stent placement is appropriate and well suited for each.

Self-expandable stent placement has also been utilized for benign diseases of the esophagus, including perforation, anastomotic leaks, and treatment of refractory benign esophageal strictures [46, 56, 57] (Fig. 20.2). Esophageal perforation, which may occur as a result of iatrogenic injury related to endoscopic therapy or spontaneous rupture (Boerhaave syndrome), is often associated with significant morbidity when repaired surgically [46]. In addition, abscess formation and mediastinitis can occur if these are left untreated [84]. The placement of a self-expandable metal stent (SEMS) or self-expandable plastic stent (SEPS) has emerged as an alternative therapeutic option in these cases [48, 15–17, 56, 66, 68, 74]. Esophageal leaks following esophagectomy and anastomotic breakdown following bariatric or bypass surgery have also been reported to be successfully managed using SEMS or SEPS without the need for an operative intervention [48, 15, 16, 56, 66, 68, 74, 77].

Contraindications

There are very few contraindications to esophageal stent placement. Severe cardiorespiratory compromise, which may limit the safe performance of upper gastrointestinal endoscopy, is an absolute contraindication to the placement of an esophageal stent. Uncontrolled coagulopathy and esophageal varices are additional contraindications.

Tumors located in the mid- to upper esophagus raise important clinical issues with regard to compression of the tracheobronchial tree. The radial expansion force associated with SEMS placement across tumors in this location has the

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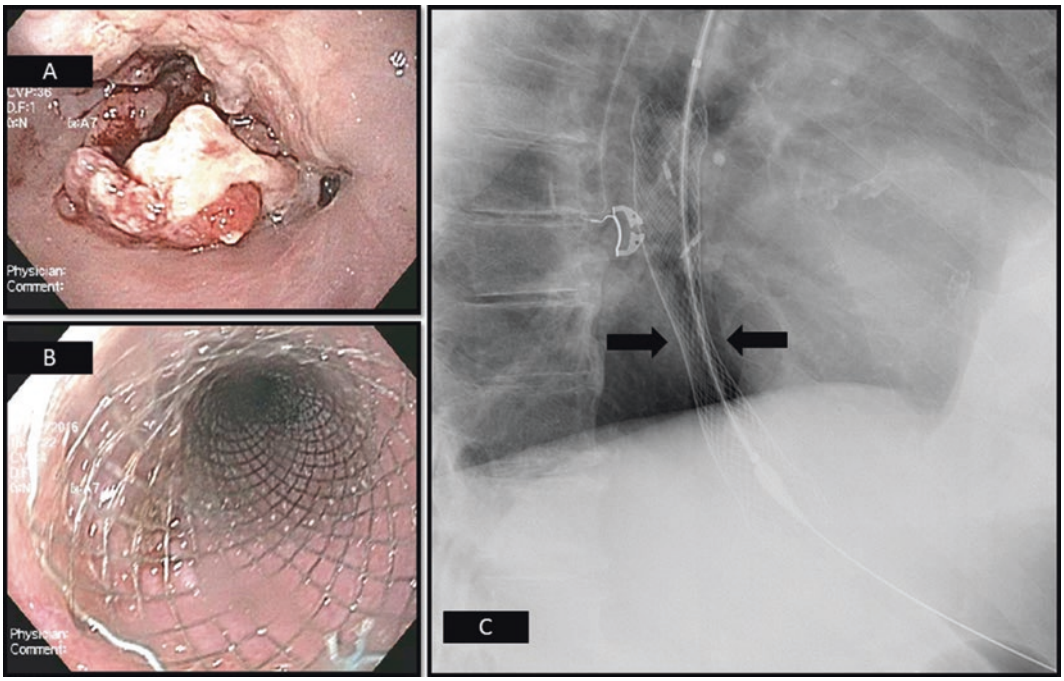

Fig. 20.1 Endoscopic (**a**) and (**b**) and radiographic views (**c**) of a partially covered SEMS for an esophageal adenocarcinoma (*arrows* highlight tumor preventing full stent expansion after deployment)

risk of causing iatrogenic airway obstruction [13, 31]. Although not a contraindication to esophageal stent placement, a chest CT scan should be obtained and reviewed with a thoracic surgeon prior to SEMS placement in patients with mid- to upper esophageal tumors. In some case, bronchoscopy with placement of a tracheal or bronchial stent may be indicated prior to, during, or immediately following esophageal stent placement [9, 45] (Fig. 20.3).

The risk of stent migration (see Complications) is typically lowest in patients with intrinsic strictures of the esophagus. Although not a contraindication, esophageal leaks or perforations where no intrinsic luminal narrowing is present should be stented with caution, with proper informed consent, and with the use of clips or endoscopic suturing (see Technique) to decrease the risk of stent migration.

The safety and efficacy of esophageal stent placement in patients who are undergoing chemotherapy and/or radiotherapy has been questioned [20, 41, 47, 60]. Concern exists from a surgical perspective with regard to the possibility of removing a SEMS at the time of surgery and the risk of esophageal perforation related to device insertion in those eligible for curative resection [59]. In addition, as tumors respond to therapy, stent migration may occur [41]. A recent retrospective study evaluating 55 individuals with locally advanced esophageal adenocarcinoma who underwent fully covered SEMS placement before neoadjuvant therapy revealed a statistically significant improvement in dysphagia, unchanged weight from baseline at 1-month follow-up, a 31% rate of stent migration, and successful stent extraction in all 8 patients who underwent eventual curative surgery [60]. Data from a multicenter European cohort of patients that underwent surgery for esophageal cancer with curative intent included 38 individuals who received a SEMS prior to surgery. The SEMS-related perforation rate was 5.3% (n = 2/38), and those with presurgical SEMS had a significantly lower 3-year survival rate (25% versus 44%, p = 0.023). Multivariate analysis independently identified SEMS as a predictor of poor prognosis (hazard ratio 1.6, p = 0.038) [38]. Given this controversy, the use of self-expandable stents prior to chemoradiotherapy is largely dictated by local practice bias.

Technique

The technique for endoscopic placement of esophageal stents, both plastic and metal, is relatively straightforward. Selection of appropriate candidates from the standpoint of medical stability and the ability to tolerate an endoscopic procedure is imperative. As for any endoscopic procedure, patients should be fasting for at least 6–8 h prior to the procedure. The choice of anesthetic is based on local practice bias. However, in our experience, the majority of procedures can be performed using conscious sedation with narcotic analgesics and a benzodiazepine. Patients being considered for esophageal stent placement due to a perforation or anastomotic breakdown following bariatric surgery should be

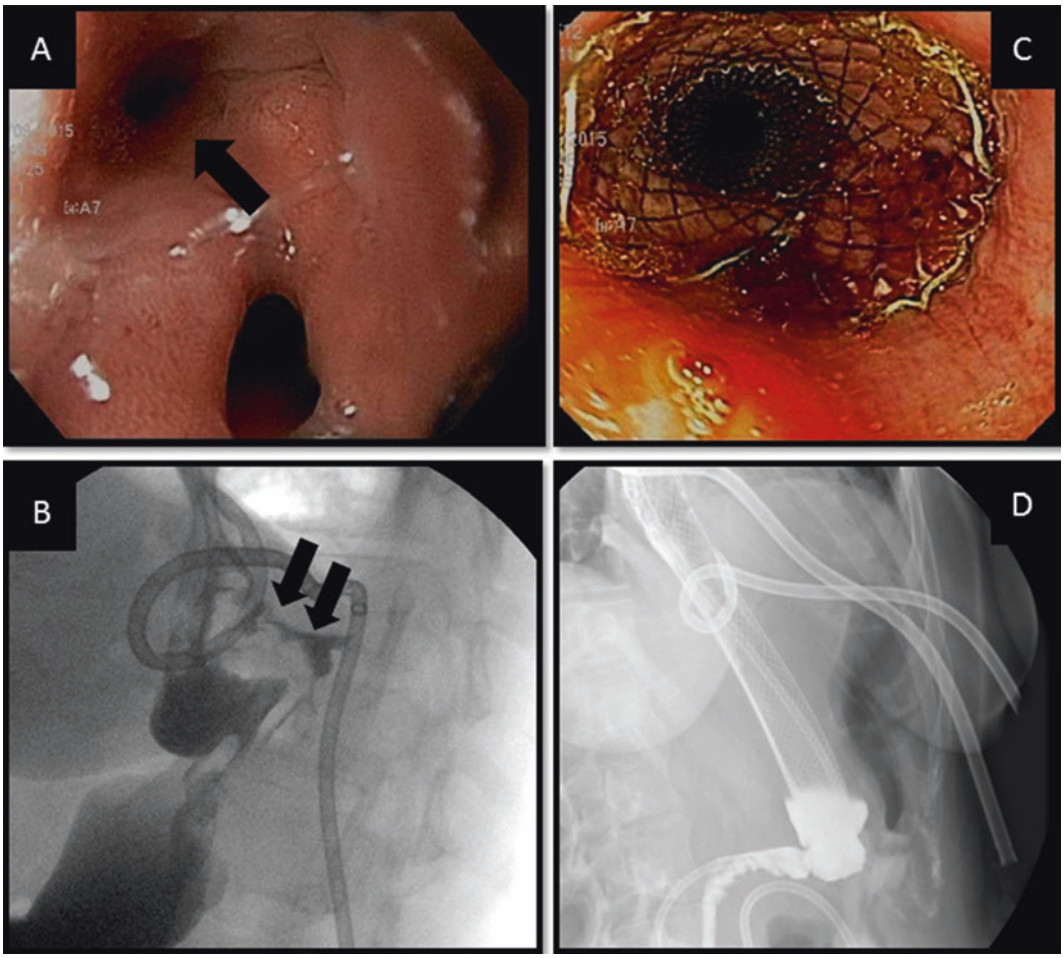

Fig. 20.2 Endoscopic view (**a**) of a gastric sleeve fistula and upper GI series (**b**) revealing leakage of water-soluble contrast into the thorax with a percutaneous drain in place. A partially covered SEMS (**c**) was placed and follow-up upper GI series (**d**) revealed no further contrast extravasation

approached with caution as these individuals are typically obese and have poor oral airways. In these individuals or others with multiple medical comorbidities, consultation with an anesthesiologist is recommended.

Practical Considerations

- Patients for stent placement due to a perforation or anastomotic breakdown following bariatric surgery should be approached with caution as these individuals are typically obese and have poor oral airways.

For patients with malignant disease, an upper endoscopy to define the proximal and distal margins of the tumor is the first step in esophageal stent placement. The total length of the stricture will help to determine the length of the desired stent. In the event that the upper endoscope cannot be passed beyond the esophageal stricture, careful esophageal dilation should be performed to allow passage of the endoscope beyond the tumor in order to obtain proper measurements. Although esophageal dilation techniques are beyond the scope of this chapter, controlled radial expansion balloon dilators may be preferable to bougies for this purpose as the former allow direct visualization of the stricture and a more "controlled" dilation. Fluoroscopy, while mandatory for esophageal stent placement, may be helpful when dilating malignant esophageal strictures.

The proximal and distal margins of the stricture can be marked using a variety of methods. Endoscopic clips can be applied or contrast dye can be injected into the submucosa. A less desirable (but cheaper) approach consists of marking the level of the endoscope externally using a radio-opaque object (such as a paper clip or hemostat). For malignant disorders, the stent should be deployed 2 cm above the proximal tumor margin to decrease the risk of distal stent migration. Once the tumor has been measured and the proximal and distal margins marked, a wire guide should be placed across the

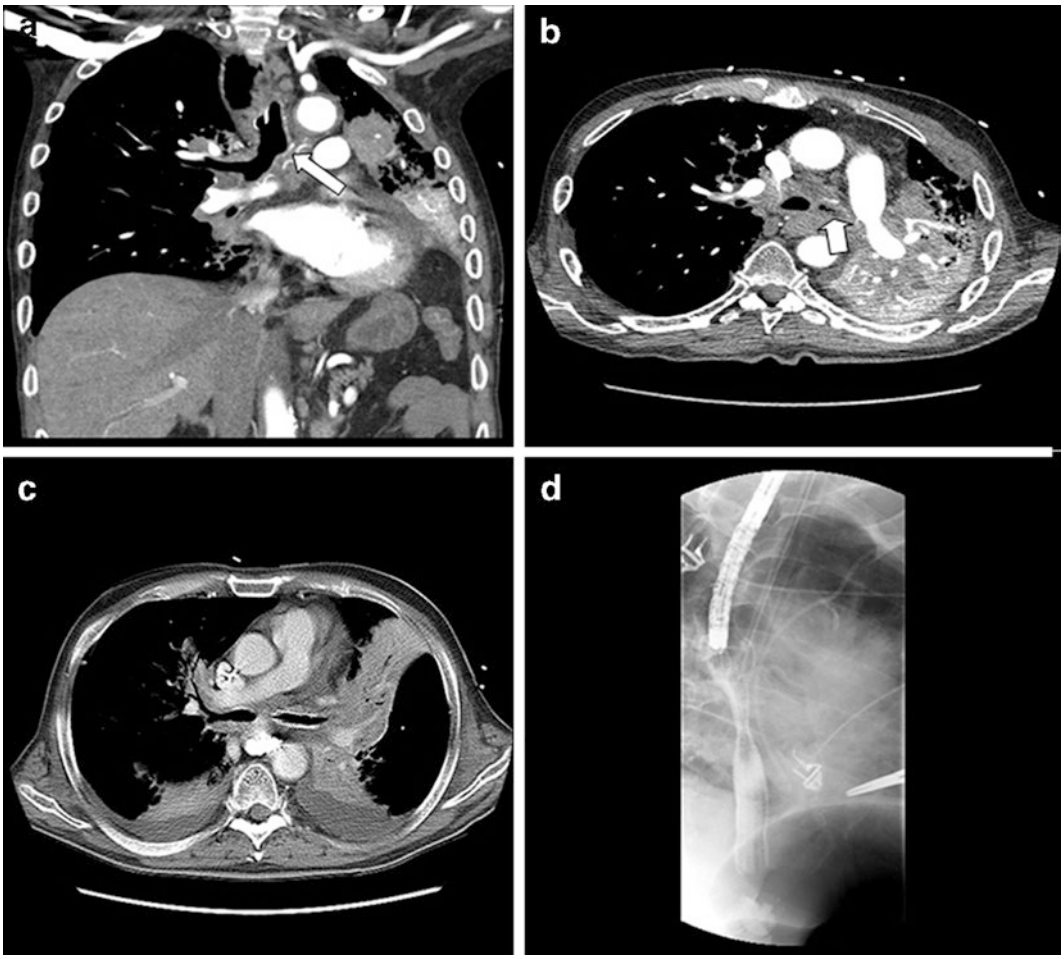

Fig. 20.3 Chest CT scan demonstrating left main stem bronchus (*arrows*) and proximal esophageal obstruction secondary to a squamous cell carcinoma of the lung (**a**) and (**b**). A bronchial stent was placed (**c**) following which a partially covered SEMS was successfully deployed (**d**) across the esophageal obstruction

stenosis into the stomach. The endoscope is then typically removed leaving the wire guide in place, unless a stent with through-the-scope deployment capabilities is being used at which point the endoscope remains in place and the stent is deployed under direct endoscopic visualization (Fig. 20.4) (see "Available Devices").

For malignant lesions, the type of stent utilized (i.e., fully covered (FC) versus partially covered (PC) SEMS, anti-reflux, length, and diameter) will depend on the lesion. In general, we prefer to place the stent with the largest diameter possible. A smaller stent diameter may be used for lesions within the cervical esophagus in order to decrease the possible "foreign body" sensation associated with stent placement in this location. Over the last two decades, the use of uncovered SEMS has fallen out of favor due to the high rate of obstructing tumor ingrowth, the recurrent dysphagia, and the need for repeated endoscopic interventions [72]. A partially or fully covered SEMS is preferable as the covered portion will prevent the tumor ingrowth and tissue hyperplasia. In addition, a covered SEMS should also be utilized for malignant tracheoesophageal fistulas with data revealing occlusion rates of 70–100% [57]. Studies on SEPS for malignant esophageal lesions reveal successful alleviation of dysphagia but high rates of complications, including stent migration [7]. For this reason, SEPS are not recommended for use in malignancy. With regard to length, stents should be long enough to cover the desired lesion. Because endoscopic measurements may be slightly inaccurate, it is best to err on the side of a longer (rather than shorter) stent in order to decrease the risk of failing to palliate the obstructing lesion.

For lesions in the distal esophagus where the stent may cross the gastroesophageal junction, patients almost invariably develop reflux of gastric contents into the proximal esophagus or oropharynx. A study comparing standard SEMS to specifically designed "anti-reflux" stents for the treatment of inoperable distal esophageal adenocarcinoma revealed a statistically significant reduction in reported reflux symptoms with those receiving the anti-reflux stent (96% versus 12%, $p < 0.001$) [35]. However, further data on their

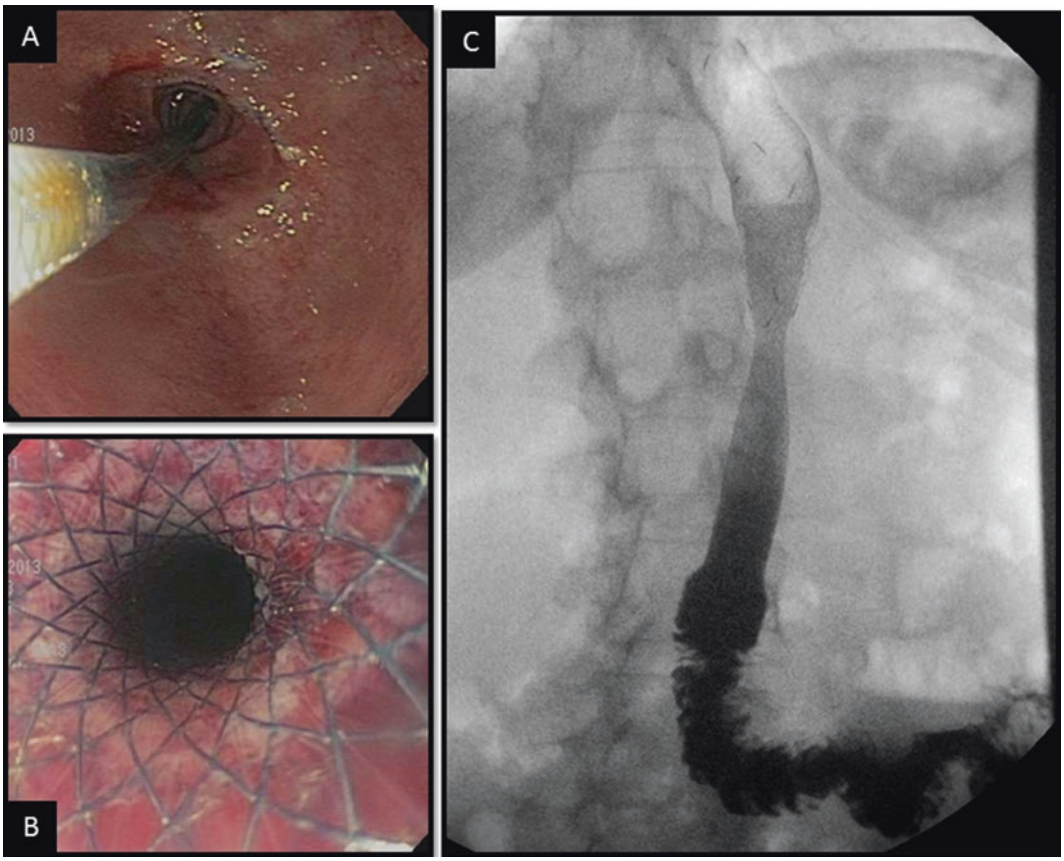

Fig. 20.4 Endoscopic view (**a**) and (**b**) of a through-the-stent deployment of an esophageal partially covered SEMS for a severe gastrojejunal anastomotic stricture in a patient with a prior subtotal gastrectomy presenting with dysphagia and PO intolerance. Follow-up upper GI series (**c**) reveals stent patency

efficacy is limited, and at the present time, anti-reflux stent availability in the United States is restricted.

Once the appropriate stent has been selected, deployment is straightforward. The stent is advanced over the wire guide, and the outer markings of the stent aligned with the proximal and distal margins of the stricture, recognizing that most SEMS foreshortens by 30–40% with deployment. Release of the stent (which varies by device) can then proceed under fluoroscopic control. Post-deployment endoscopy can be performed to ensure proper stent positioning; however, the endoscope should not be passed through a tight "waist" in the stent in order to decrease the risk of stent dislodgement. In the case of fully covered metal stents, proximal repositioning, using grasping forceps, can be accomplished with ease in most cases. Partially covered stents can be repositioned with some difficulty, in most cases, immediately after deployment, especially when the deployed stent is a distal release device [46].

As is the case for malignant indications, esophageal stent placement for benign indications is technically straightforward. Typically, a contrast-enhanced radiograph or CT scan is indicated prior to esophageal stent placement for benign indications. This will allow the endoscopist to identify the exact location and extent of the stricture, leak, or perforation. Upper endoscopy is then performed to further define the proximal and distal margins of the stricture or defect, which can be marked using any of the three methods outlined above. A wire guide is then placed into the stomach following which the endoscope is removed leaving the wire guide in place. For benign indications, a self-expanding plastic stent or fully covered metal stent should be selected in order to allow removal at a later date. In instances of severe strictures, use of a temporary small caliber covered biliary stent is a feasible means to bridge to a larger caliber esophageal stent, though the data on this technique is limited (Fig. 20.5). Deployment is performed under fluoroscopic control in most cases (see below).

The risk of migration is highest in patients with benign indications for esophageal stent placement [23, 46, 56, 68]. Refractory benign esophageal strictures have different characteristics in comparison to their malignant counterparts. Although occasionally problematic (i.e., stent occlusion), ingrowth of tumor into the stent helps to anchor it in position. In addition, malignant strictures tend to be longer than

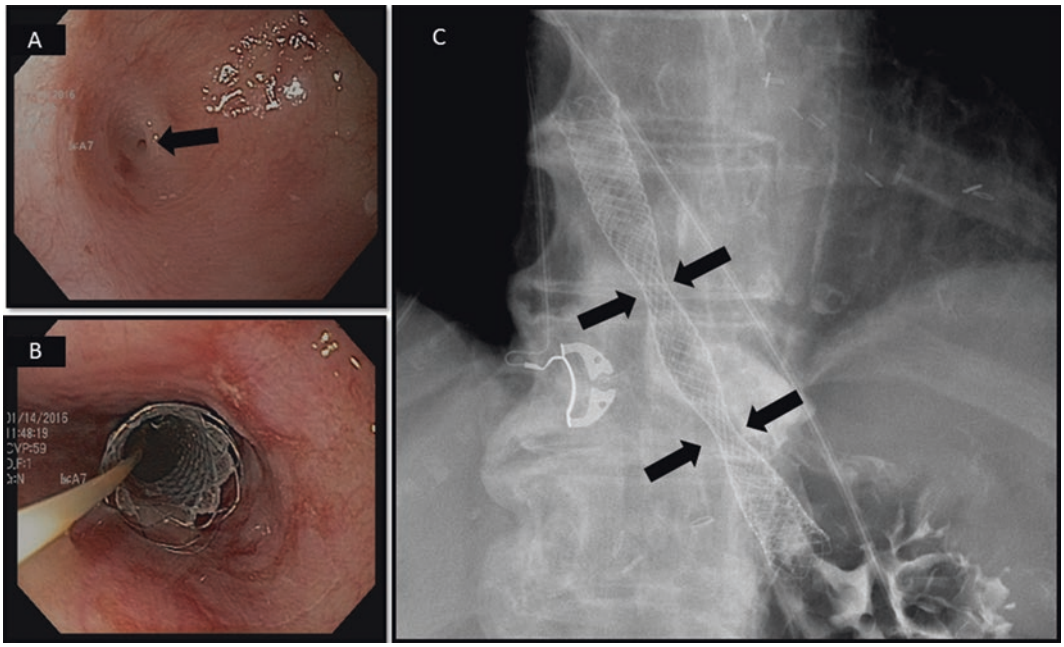

Fig. 20.5 A severe peptic stricture (**a**) with a pinpoint opening, treated with a covered biliary stent (**b**) as a bridge to a larger esophageal stent. Fluoroscopic images (**c**) after stent deployment revealed a multifocal process

most benign strictures. Finally, for perforations and anastomotic leaks, there is no stricture to hold a stent in place (and, therefore, this indication has the highest risk of migration). Several measures can be taken to reduce the risk of stent migration. First, the stent with the largest possible diameter should be selected. The length of the stent should be long enough to bridge the stenosis, leak, or perforation. For the latter two indications, we tend to select the longest stent available as an additional (potential) safeguard against stent migration. Endoscopic clips, including over-the-scope clips, can be applied to the proximal end of the stent in an attempt to maintain stent position [4, 25, 40]. Techniques to remove the over-the-scope clips include submucosal injection and submucosal electrocautery-assisted dissection [40]. The use of a PCSEMS has the added appeal of allowing tissue ingrowth at the uncovered portions of the stent to act in an anti-migration manner. Stent removal can be successfully and safely achieved with temporary placement of a FCSEMS within the PCSEMS ("stent-in-stent" technique) to facilitate pressure necrosis of the granulation tissue and subsequent extraction [8]. Lastly, fixation via application of interrupted or continuous sutures on the proximal aspect of a covered stent using an endoscopic suturing device has been reported with success [28].

Complications

Immediate and early procedure-related complications following esophageal stent placement occur in up to 10% of individuals [4, 46]. These include aspiration, airway compromise, malpositioning of the device, entrapment of the stent delivery system, dislodgement of the stent, hemorrhage, severe chest pain, nausea, and esophageal perforation [4, 57]. Careful intraprocedural airway management, including utilization of general anesthesia if necessary, can reduce the risk of aspiration. As discussed above, patients with stridor, wheezing, or mid- to upper esophageal tumors should undergo CT of the chest, prior to stent placement, to evaluate for airway compromise, which may be exacerbated by stent placement. As with all therapeutic endoscopic procedures, an INR of 1.5 or less is desired for elective esophageal stent placement to reduce the risk of bleeding.

Late (or delayed) complications occur in 30–50% of patients and include bleeding and fistula formation from stent erosion, severe gastroesophageal reflux, stent migration, and obstruction secondary to tissue ingrowth or food bolus impaction [4, 24, 41, 46, 57, 66, 74, 77]. Some malpositioned or migrated stents can be repositioned or removed, using grasping forceps, inflated balloon catheter, or a polypectomy snare. On occasion, migrated stents may be left in the stomach and a new stent placed [46]. The decision to remove a migrated stent should ideally be made based on the patient performance status as this is not without risk. But, leaving a migrated stent within the stomach is associated with a small (but definite) risk of migration into the small intestine with resultant perforation or obstruction. Stents that become occluded secondary to tumor ingrowth can be treated with argon plasma coagulation or placement of a second stent through the first (stent-within-stent design). Food bolus impaction can typically be treated endoscopically.

Practical Considerations

- For patients with malignant disease, an upper endoscopy to define the proximal and distal margins of the tumor is the first step in esophageal stent placement.
- Controlled radial expansion balloon dilators are preferable to bougies as the former allow direct visualization of the stricture and a more "controlled" dilation.
- The use of uncovered SEMS has fallen out of favor due to the high rate of obstructing tumor ingrowth, the recurrent dysphagia, and the need for repeated endoscopic interventions.
- A partially or fully covered SEMS is preferable as the covered portion will prevent the tumor ingrowth and tissue hyperplasia.

Post-procedural Care

A liquid diet can be resumed immediately for patients with malignant indications for esophageal stent placement. Diet can then be advanced as tolerated to a goal of reaching puree status; advancement beyond this level places the patient at risk for stent occlusion by large food particles. For patients in whom stents are placed for malignant tracheoesophageal fistula, esophageal perforation, or anastomotic leak, our practice is to withhold an oral diet until an esophagram (using water-soluble contrast) is obtained 24 h following stent deployment to ensure both proper positioning of the stent and closure of the leak.

Patients in whom stents are deployed across the EG junction require special attention. Because the natural barrier to reflux of gastric contents is rendered incompetent by the placement of the esophageal stent across the EG junction (unless using a prosthesis with an anti-reflux valve), aspiration remains a significant risk in these patients. For these individuals, twice daily proton pump inhibitors are prescribed indefinitely. We also suggest that these patients do not eat in close proximity to bedtime (2–3 h) and that the head of the bed is elevated to at least 30° at all times. This can be accomplished most easily by a specially designed wedge pillow available at most medical supply stores.

Outcomes

Although the concept of endoprosthesis placement for the palliation of malignant dysphagia had been around since the late nineteenth century, clinical success was hampered by high rates of complications and prolonged hospitalizations when using the available rigid plastic prosthetics. Stenting for palliation of malignant esophageal obstruction did not increase in popularity until over a century later, with the introduction into clinical practice of the self-expanding metal stent and a seminal randomized control trial demonstrating reduced complications and improved cost-effectiveness with SEMS versus rigid plastic prosthetics [18, 34]. By the following decade, high-quality data was available to compare uncovered SEMS versus covered SEMS. There were significantly higher rates of recurrent dysphagia, tumor ingrowth, and repeated endoscopic interventions in those receiving uncovered SEMS [72], since uncovered SEMS have fallen out of favor for their covered alternatives.

The ideal modality for the treatment of any patient with metastatic cancer and limited survival should meet the following criteria: wide availability, ease of use, minimal side effects, minimal complications, rapid symptom improvement, and minimal need for re-intervention [11]. With respect to esophageal malignancies, SEMS meet the majority of these criteria.

SEMS in Malignant Disease

There are numerous covered self-expandable stents available to treat esophageal malignancy (see Available Devices), but no study to date has compared their relative efficacy or adverse event rates in a head-to-head manner; therefore, no single manufacturer's covered stent has been proven superior [46]. SEPS, FCSEMS, and PCSEMS can be utilized in esophageal cancer with the latter two options preferred. The technical success of SEMS placement for esophageal malignancy is nearly 100% [41, 56, 69, 79]. Similarly, SEMS are highly efficacious in their ability to palliate dysphagia and close malignant fistulae [41, 51, 56, 57, 65, 69, 79]. A single center study comparing FCSEMS versus PCSEMS for benign and malignant esophageal disease included 252 patients receiving a total of 321 SEMS (112 FC and 209 PC) with 78% (n = 197) suffering from malignancy. Technical success with placement was high, 97.6%, with no significant difference between FCSEMS and PCSEMS. Relief of malignant dysphagia was achieved in 83.8% (n = 140/167) and control of fistulae, leaks, and perforations achieved in 84% (n = 21/25). The adverse event rate was 22.2% with most events related to stent migration (19%, n = 61/321). Use of a FCSEMS ($p < 0.001$), benign indication ($p = 0.022$), and distal location of deployment ($p = 0.008$) were significant independent risk factors for stent migration. There was a statistically significant difference in the rate of tissue ingrowth and overgrowth in PCSEMS (53.4%) versus FCSEMS (29.1%) ($p = 0.004$) [56]. The data herein aligns with other studies and suggests no significant difference exists in the ability of FCSEMS and PCSEMS to palliate malignant esophageal complications.

One of the largest obstacles that remain is preventing recurrent dysphagia. The use of a FCSEMS and stent deployment in the distal esophagus increase the likelihood of stent migration, while the use of a PCSEMS increases the probability of tissue ingrowth/overgrowth [56, 57]. It is estimated that recurrent dysphagia requiring repeat intervention occurs in up to 30% of patients, following covered SEMS placement. Depending on the clinical scenario, migrated stents can be retrieved and/or replaced, while patients in whom stents are occluded by tumor ingrowth can be treated with repeat stent placement or argon plasma coagulation [46]. Ultimately, the choice of FCSEMS versus PCSEMS is dictated by clinical scenario, lesion location, and endoscopist preference. Due to the elevated risk of migration, PCSEMS are to be considered when stenting the distal esophagus/gastroesophageal junction.

SEPS Versus SEMS in Malignant Disease

The introduction of a SEPS carried the promise of a cost-effective, easily removable option to alleviate malignancy-associated esophageal obstruction and complications. A randomized controlled trial evaluating 101 individuals with malignant dysphagia assigned 47 patients to receive a SEPS and 54 to receive a PCSEMS. The technical and initial clinical success was not significantly different. Multivariate analysis revealed a significantly higher rate of complications with SEPS versus PCSEMS (OR 2.3, 95% CI 1.2 to 4.4) including the incidence of late stent migration (13% versus 4%) [7]. Verschuur et al. randomly assigned 125 patients to receive PCSEMS (n = 42), SEPS (n = 41), or a FCSEMS (n = 42) to palliate esophageal and gastric cardia malignancy. The technical success rate was significantly lower in those assigned to SEPS placement (83% versus 100% in PCSEMS and 95% in FCSEMS) with equivalent clinical improvement in malignant dysphagia across stent types. Stent migration was more common with SEPS (29% versus 17% in PCSEMS and 12% in FCSEMS), while tumor ingrowth/overgrowth was higher in the PCSEMS (31%) and FCSEMS (24%) compared to SEPS (10%) [82].

The technical difficulties with SEPS placement are, in part, related to the large caliber stent introducer (see Available Devices) which ranges from 12 to 14 mm and limits its use in tight malignant obstructions. While the clinical success rates of SEPS are equivalent to PCSEMS and FCSEMS, the difficulties with placement and higher rates of stent migration make SEMS a preferred choice in the treatment of esophageal malignancy-related complications.

SEMS in Malignant Extrinsic Compression

Late stage extraesophageal and metastatic malignant processes can manifest with dysphagia via extrinsic esophageal compression. Multiple studies have evaluated the technical success, clinical success, and safety of SEMS placement for malignant extrinsic compression. A single center retrospective review identified 28 individuals with advanced lung cancer and malignant dysphagia including 8 individuals with concomitant tracheoesophageal fistulas. SEMS placement was technically successful in all 28 patients, and all patients achieved clinical improvement, including a 100% fistula occlusion rate. Transient pain was experienced by 42% of the individuals, and one individual (3.5%) experienced recurrent dysphagia and required a gastrostomy [3]. A prospective single center study evaluated 50 individuals with lung cancer and mediastinal metastasis complicated by malignant dysphagia and extrinsic esophageal compression. SEMS were successfully placed in 100% of the patients, and median stent patency exceeded median patient survival. Five patients (10%) experienced severe complications, including two perforations and three hemorrhages of which two individuals died from blood loss. Eight patients (16%) experienced recurrent dysphagia, all managed successfully with a repeat endoscopic intervention [80]. Lastly, a retrospective review comparing the efficacy of SEMS for intrinsic versus extrinsic malignant esophageal obstruction identified 105 individuals, 85 with an intrinsic and 20 with extrinsic (predominately lung cancer) malignant dysphagia. Overall the technical and clinical success was high (100% and 91%, respectively) with no significant difference in the clinical success between the intrinsic and extrinsic groups. Stent patency was greater in the intrinsic versus extrinsic group (131 +/− 85 days versus 54 +/− 45 days, respectively), due in part to the shorter survival of the extrinsic patient population. A subgroup analysis did not identify any difference in stent patency when comparing uncovered SEMS versus FCSEMS [53].

Given data to date, we conclude SEMS placement is highly effective at alleviating symptoms of malignant extrinsic esophageal compression. Nevertheless, a discussion regarding the potential complications of SEMS placement, including perforation, hemorrhage, pain, and recurrent dysphagia, must be performed for all eligible candidates being considered for stenting.

Benign Disease

The use of SEMS and SEPS for benign indications continues to evolve. FCSEMS and PCSEMS represent a minimally invasive alternative to address benign strictures and otherwise catastrophic nonmalignant esophageal complications including esophageal perforations and postsurgical leaks. A common concern is safe SEMS extraction as tissue ingrowth and overgrowth can predispose to difficult removal. As opposed to their metallic counterparts, SEPS can be easily removed or repositioned, making them an ideal candidate for treating benign esophageal conditions.

A number of studies have now demonstrated the clinical safety and efficacy of using SEMS and SEPS for benign indi-

cations [15, 16, 48, 56, 68, 77]. Swinnen et al. retrospectively reviewed 88 individuals who underwent placement of 153 SEMS for esophageal perforations or postoperative leaks. Technical success was 100% and successful resolution of the perforation or leak was achieved in 84.2% of cases. Stent removal for eligible patients was seen in 96.1% and aided by the placement of a SEPS within the SEMS [66]. A review of 52 patients receiving 83 stents (61 PCSEMS, 15 FCSEMS, 7 SEPS) for anastomotic leaks (n = 32), iatrogenic perforations (n = 13), Boerhaave syndrome (n = 4), and other indications (n = 3) achieved clinical success in 76% with no significant difference noted across stent type. Stent removal was successful in all but eight individuals who received a PCSEMS due to tissue ingrowth. Thirty-three complications were noted in 24 individuals including 10 (30.3%) stent migrations [74]. Evaluating SEPS only, Holm et al. evaluated 30 individuals who received 83 SEPS for benign indications. Stent migration occurred in almost 82% of patients who underwent SEPS for benign esophageal strictures, 75% of patients with anastomotic strictures, 59% of patients with anastomotic leaks, and in 29% of patients with radiation-induced strictures. Long-term symptomatic improvement following stent removal occurred in only 6% of all procedures [23].

Data on stenting benign strictures suggest limited clinical efficacy compared to the clinical success seen when stenting other benign conditions. Seven et al. reviewed 252 patients receiving 321 SEMS, 22% for benign indications, and reported 95.6% successful stent removal rate with 84% successful treatment of fistula, leaks, and perforations. In contrast, the rate of refractory benign stricture resolution was 53% [56]. In one of the largest studies to evaluate the use of partially and fully covered SEMS for benign diseases (n = 70), the treatment success rate for refractory benign strictures was 33.3%, while treatment success for perforations, fistulae, and anastomotic leaks was 100%, 71%, and 80%, respectively [68]. The stent migration rate was 40% and highest in those being treated for benign strictures.

Until large, randomized control trials are available, SEMS and SEPS appear to be safe and clinically efficacious at treating benign esophageal conditions with higher rates of success reported with fistulas, postoperative leaks, and perforations. The type of stent to use in these circumstances is dependent on endoscopist preference, clinical situation, and discussion with the patient regarding stent-specific risks.

Biodegradable Stents

Interest in biodegradable (BD) stents has arisen, mainly to address issues with SEPS and covered SEMS-related stent migration and to avoid the need for repeated interventions. Two such stents exist, neither of which are available within the United States. The Ella BD stent (ELLA-CS, Hradec Kralove, Czech Republic) is composed of polydioxanone, a suture material, and the poly-L-lactic acid (PLLA) BD stent (Marui Textile Machinery, Osaka, Japan) comprised of knitted PLLA monofilaments [22]. The stents will typically dissolve within 2–3 months and therefore do not require removal. A recent systemic review and meta-analysis evaluating SEPS, SEMS, and BD stent placement in refractory benign esophageal strictures revealed a pooled clinical success rate of approximately 40% with no significant difference in success, migration, or adverse event rate when treating with SEPS and SEMS versus biodegradable stents [19]. Further studies will be required to determine the clinical relevance and role of BD stents.

Given these findings, appropriate candidate selection, proper device placement, and close follow-up are indicated in patients considered for SEPS or completely covered SEMS placement for benign disease.

Available Devices

There are a large variety of esophageal stents currently available in the marketplace. Table 20.1 lists the characteristics of various covered SEMS which are currently available in the United States. As mentioned previously, there are no data to suggest clinical superiority of any one manufacturer's device over another for any indication.

Two additional stents are worth mentioning. The PolyFlex (Boston Scientific, Natick, MA) stent is the only currently available SEPS in the United States and the only self-expandable stent currently FDA approved for benign indications. This device is composed of polyester mesh embedded in silicone; it is completely covered. The stent is available in a number of diameters and lengths, the largest diameter being a 25 mm flare at the proximal end. The device must be assembled prior to deployment, and the delivery system is rather large, with a diameter of 12–14 mm. The Niti-S stent (Taewoong Medical, Seoul, South Korea) is a single- or double-layered nitinol stent with an inner layer fashioned from polyurethane. This combination prevents stent migration by allowing tumor ingrowth and intercalation into the outer mesh while at the same time reducing recurrent dysphagia by having a completely covered inner core [81]. This is the only self-expandable metal stent available with a through-the-scope deployment system that allows direct endoscopic visualization at the time of placement.

Enteral Stent Placement

Obstruction of the gastric outlet or duodenum is commonly seen with malignant neoplasms of the pancreatic head, bile duct, proximal small intestine and major papilla, and gastric antrum as well as by malignant mesenteric lymphadenopathy and, rarely, metastatic disease or local extension of

Table 20.1 Self-expandable esophageal stents available in the United States

	Ultraflex	Alimaxx-ES	Evolution	WallFlex	Niti-S	PolyFlex
Stent material	Nitinol	Nitinol	Nitinol	Nitinol	Nitinol	Polyester
Covering	UC and PC	FC	PC and FC	PC and FC	FC and available in double layer of nitinol	FC
Delivery system (Fr)	16	16	24	18.5	10.5 (TTS)	36 39 42
Length (cm)	10 12 15	7 10 12	8 10 12 12.5 15	12 15	6 8 10 12 14 15	9 12 15
Shaft/max. flare diameter (mm)	18/23 23/28	18/22	18/23 20/25	18/25 23/28	18/26 20/26	16/20 18/23 21/28
Degree of shortening (%)	30–40	0	35	30–40	35	0
Manufacturer	Boston Scientific	Merit Medical Endotek	Cook Medical	Boston Scientific	Taewoong Medical	Boston Scientific

UC uncovered, *PC* partially covered, *FC* fully covered, *TTS* through the scope

colonic neoplasms [2]. Gastric outlet obstruction complicating pancreatic cancer occurs in up to 15% of all cases [6]. Recurrent tumor or stricture in the afferent limb following a Whipple resection and radiation therapy for pancreatic cancer can lead to the development of an "afferent limb syndrome" resulting in biliary obstruction and cholangitis. This represents an additional indication for enteral stent placement.

Besides malignant disease, enteral stents have occasionally been utilized in patients with benign etiologies of gastric outlet obstruction, namely, peptic strictures, inflammatory strictures from gastroduodenal Crohn's disease, and annular pancreas, among others. However, advancements in endoscopic balloon dilation technologies and minimally invasive surgery have nearly eliminated the use of enteral stents for benign indications [6].

Contraindications

There are few contraindications to enteral stent placement for malignant gastric or duodenal outlet obstruction. Patients who are medically unfit for endoscopic procedures should not undergo enteral stent placement. Enteral stent placement is also contraindicated in patients with uncontrolled coagulopathy and in individuals with life expectancy of less than 4–6 weeks. Localized intestinal perforation in the setting of malignancy represents a contraindication to enteral stent placement. Finally, enteral stents should not be placed in patients with multiple sites of distal intestinal obstruction (i.e., carcinomatosis) as relief of the proximal point of obstruction is unlikely to provide palliation in these individuals [21].

Technique

Self-expanding metal stents for malignant gastric or duodenal outlet obstruction are usually placed endoscopically with fluoroscopic control. However, they can be placed by radiologists using fluoroscopy alone. Endoscopic delivery has the advantage of real-time investigation of the obstructing lesion and direct visualization of stent positioning and deployment. Most patients presenting with malignant gastroenteric obstruction will have had imaging with either a CT or contrast-enhanced radiograph (Fig. 20.6). Although such studies are useful for preprocedural planning, identification of the location and extent of the obstructing lesion, as well as determination of the presence of distal points of intestinal obstruction, it is not imperative that they be obtained prior to performing the procedure [21].

Nasogastric decompression is imperative prior to the initiation of conscious sedation or the induction of general anesthesia. Patients with severe gastric outlet obstruction are also prone to gastroparesis (see below). As a result of both the intestinal obstruction and poor gastric contractility, several liters of fluid or semisolid gastric contents may be retained, making the risk of aspiration in a nondecompressed patient

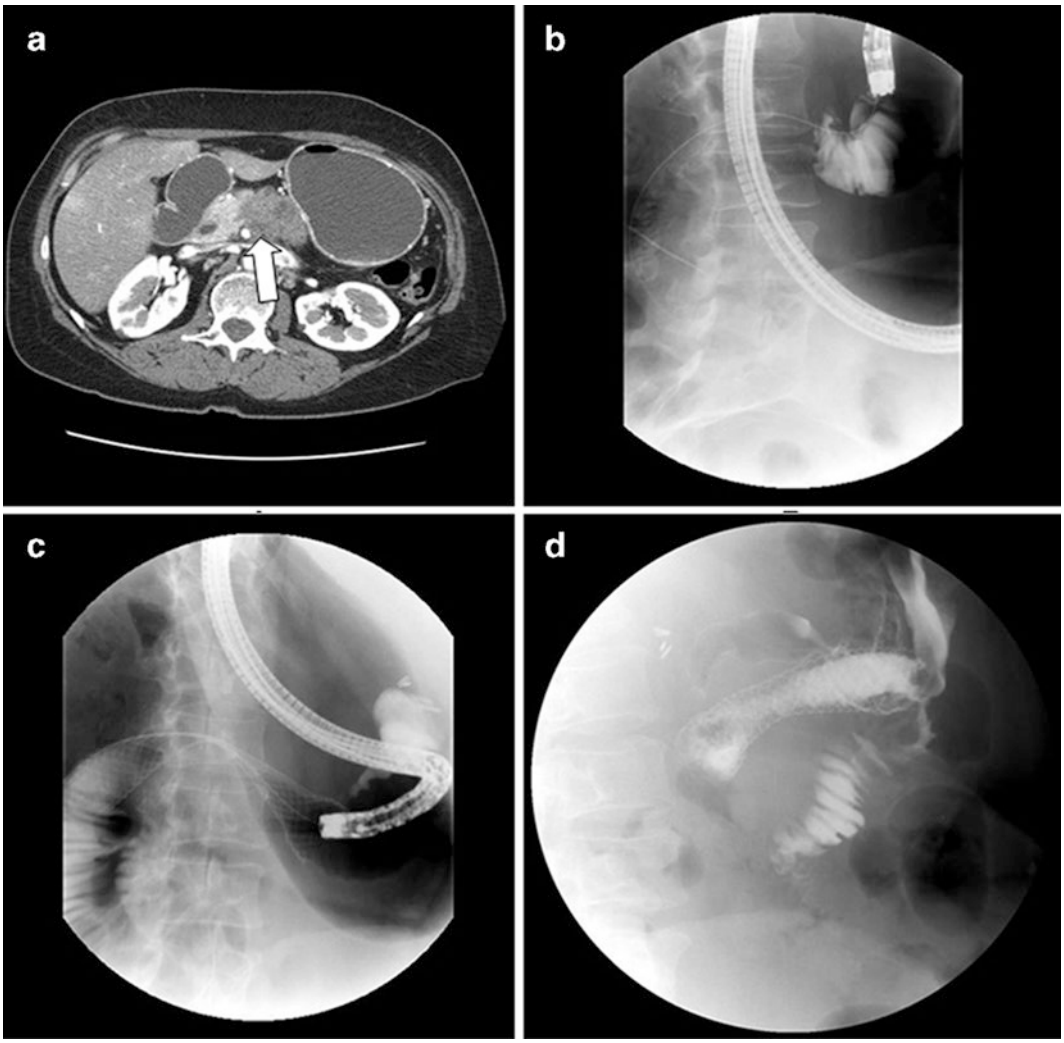

Fig. 20.6 Abdominal CT scan demonstrating a markedly dilated stomach and large pancreatic mass (*arrow*) (**a**). Contrast was injected following which a guide wire was placed across the stenosis (**b**). An uncovered SEMS deployment was successful (**c**); an upper GI series performed following stent deployment demonstrates passage of contrast through the stent (**d**) indicating luminal patency

significant. We usually prefer at least 24 h of nasogastric decompression or endotracheal intubation prior to endoscopic stent placement.

Once conscious sedation is achieved or general anesthesia induced, insertion of the endoscope typically begins with the patient in the left lateral decubitus position. The choice of endoscope depends on the location of the lesion: proximal lesions can be handled utilizing a therapeutic (3.7 mm working channel) upper endoscope or duodenoscope (4.2 mm working channel), while those distal to the second portion of the duodenum typically require the use of an adult colonoscope. If the obstruction can be passed using the endoscope, this should be done with extreme caution as the majority of enteral stents can be placed without crossing the stenosis. Balloon dilation is rarely indicated, except when required to pass a duodenoscope for performance of ERCP during the same procedure (see below) [21].

In the event that the stenosis is not crossed, a balloon catheter can be used to inject contrast beyond the obstruction so that the length of the stricture can be defined and an appropriate length stent selected (Fig. 20.6). A wire guide can then be placed through the stenosis into the distal bowel. The selected stent should be approximately 3–4 cm longer than the length of the stenosis to ensure adequate coverage on either side of the stricture [21]. Once the proper length stent is selected and advanced into position over the wire guide, deployment can proceed under endoscopic and fluoroscopic control. Most devices tend to deliver distally when released; therefore, gentle counter tension is used to ensure proper deployment and, ultimately, positioning. In some cases, direct visualization of the proximal margin of the stricture is not possible during deployment. This is especially true for lesions at the apex of the duodenum where the acute angulation and "straightening" of the endoscope as the stent is passed

through the working channel forces the endoscope tip into the stomach. In such cases, placement of an endoscopic clip or injection of contrast into the submucosa at the proximal margin of the stricture may be performed. This allows for visualization of the proximal margin during deployment in the event that stent deployment occurs with the endoscope tip in the stomach (see below).

In cases where the obstructing lesion extends into the duodenal bulb, the proximal end of the stent should be brought through the pylorus and positioned in the stomach. Most early generation self-expanding metal enteral stents contained sharp edges on the proximal and distal ends. Due to the thin-walled duodenum and increased risk of stent-related perforation, transpyloric deployment was preferable to leaving the proximal edge of the stent within the duodenal bulb. The design of the latest generation enteral stent (see below) has eliminated the sharp proximal and distal ends making (theoretically) deployment within the duodenal bulb safer, thus potentially obviating transpyloric positioning, unless clinically indicated [21].

Complications

The major risk of enteral stent placement is intestinal perforation, which has been reported to occur in 0.7% of individuals [6, 10]. The risk is increased in cases where balloon dilation is performed or when stents are deployed around intestinal angulations, which are relatively "fixed" in position due to obstructing malignant neoplasms. Because most patients in whom enteral stents are placed have an underlying advanced malignancy, surgical repair of stent-related intestinal perforation may be technically difficult or impossible, resulting in peritonitis and death. As such, proper informed consent of patients considered for enteral stent placement is imperative.

The performance of endoscopy in patients with gastric outlet obstruction can lead to aspiration of gastric contents and resultant pneumonia. This risk is increased in cases performed without adequate measures taken to protect the airway or insufficient gastric decompression. Another risk of enteral stent placement within the duodenum is biliary obstruction and precipitation of cholangitis. This complication is not limited to patients with a native papilla. Subclinically occluded biliary stents can become completely occluded by the radial expansive force of the duodenal stent. Accordingly, measurement of liver chemistries and a CT scan of the abdomen are essential parts of preprocedural planning for patients in whom duodenal stents may cross the major papilla. ERCP should be performed prior to duodenal stent placement in patients with evidence of biliary obstruction. However, "prophylactic" biliary stenting is not supported by any clinical evidence to date [21].

Other complications of enteral stent placement include stent migration (5%) and bleeding (0.5%) (especially with older stent designs) in addition to stent occlusion (18%) [6, 10, 21]. Stent migration in malignant disease is rare. Migrated stents may pass spontaneously or, in rare cases, lead to small bowel obstruction or delayed intestinal perforation requiring surgery. Occlusion of enteral stents can be secondary to food bolus impaction, tissue hyperplasia, or tumor ingrowth (Fig. 20.7). Food bolus impaction can typically be handled endoscopically, whereas ingrowth of tumor and tissue hyperplasia require placement of a second endoprosthesis [6, 21]. Finally, newer-generation enteral stents are fashioned from nitinol (see below). Although superior in terms of radial expansive force, these devices foreshorten. In cases where an adequate "safety" margin of 2–3 cm of stent on either end of the obstruction does not exist, recurrent intestinal obstruction following stent foreshortening can be observed. Stent revision (insertion of a longer stent) is required in such cases.

Post-Procedural Care

Patients are typically allowed nothing by mouth for the first 24 h following enteral stent placement as most prostheses require this period of time to reach maximum expansion. A liquid diet can be initiated after 24 h, and if tolerated, the diet advanced to a maximum of mechanical soft or puree. An upper GI series (Fig. 20.6) with small bowel follow-through should be obtained in patients with continued obstructive symptoms following enteral stent placement, in order to rule out early complications such as stent migration, malposition, or more distal intestinal obstruction. Patients with severe pain, fever, or leukocytosis should undergo a CT scan of the abdomen in order to evaluate for intestinal perforation. Many patients with long-standing gastric or duodenal outlet obstruction will have coexisting gastroparesis. In these cases, enteral stent placement may not provide adequate symptomatic relief, and treatment with promotility agents may be required. In patients for whom promotility agents do not provide adequate relief of symptoms, alternative methods of nutrition should be discussed and a decompressive gastrostomy considered.

Clinical Efficacy

Over the past several years, enteral SEMS placement has emerged as an alternative to surgery for the palliation of malignant gastric outlet obstruction. Several early uncontrolled case series have demonstrated technical success rates of greater than 90% [1, 12, 42]. Dormann and colleagues performed a systematic review of the published series on the use of SEMS for palliation of gastroduodenal malignancies.

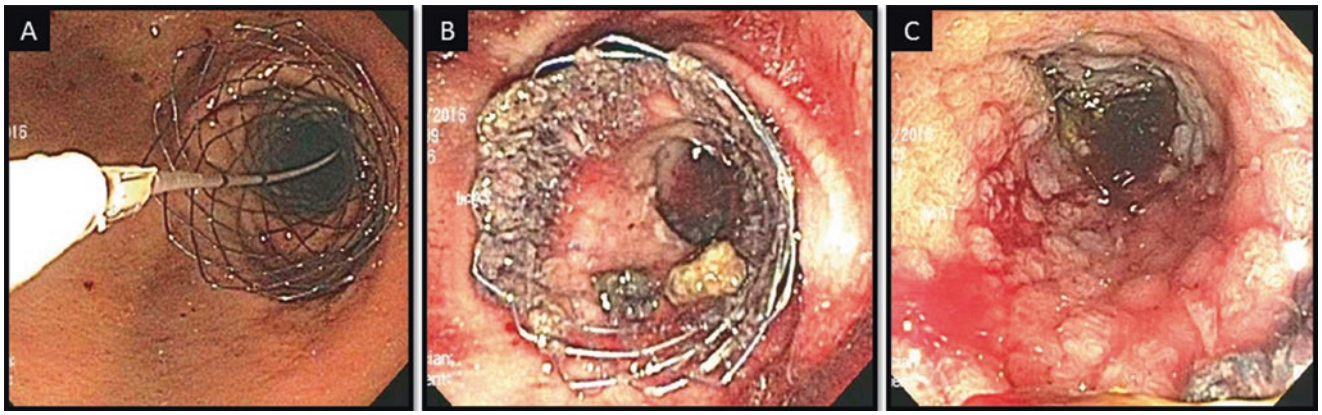

Fig. 20.7 Endoscopic placement (**a**) of a duodenal stent for malignant gastric outlet obstruction due to pancreatic adenocarcinoma. An endoscopy is performed 16 days later to investigate a source of GI blood loss (**b**) and (**c**) reveals nonobstructive tissue hyperplasia and granulation

Findings included successful stent deployment in 589 of 606 patients (97%) in whom it was attempted. Clinical success, as defined by resumption of oral intake following stent placement, was achieved in 89% of patients in whom stents could be successfully placed with full resolution of symptoms occurring at a mean of 4 days. Procedure-related mortality was zero. Major complications such as bleeding and perforation occurred in 1.2% of patients; stent migration was reported in 5% [10].

A more recent prospective multicenter cohort evaluating the efficacy of the Evolution duodenal stent revealed 89% technical success (95% CI 77–95%) with 72% clinical success (95%CI 58–83%). Multiple objective measures of gastric outlet obstruction revealed significant improvement. Stent dysfunction occurred in 14 individuals (30%) and included stent ingrowth (n = 9) and migration (n = 2). No perforation or hemorrhage was noted [75]. A similar single institution review of the WallFlex enteral stent identified 21 patients with malignant gastric outlet obstruction. The technical success in placement was 100% with 81% of individuals achieving improved clinical symptoms. There was no hemorrhage or perforation noted, but one patient (4.7%) developed pancreatitis [27]. In a large pooled analysis of 19 prospective studies including 1281 patients with malignant gastric outlet obstruction, the technical success of SEMS placement was 97.3%, and the clinical success was 85.7%. The complication rate was 19.6% with re-obstruction (12.6%) the commonest issue. Intestinal perforation was noted in 1.2% and major hemorrhage in 0.8% [76].

There remains limited data on the natural history and survival rates of post-stenting malignant gastric outlet obstruction. In the largest North American study to date, Oh et al. retrospectively reviewed 292 patients, 196 with pancreatic adenocarcinoma and 96 with non-pancreatic malignancy who underwent gastroduodenal stenting for malignant gastric outlet obstruction. The technical success rate was similar between both groups at 99% in the pancreatic and 100% in the non-pancreatic populations (p = 0.300). There was no difference on median post-stenting survival, 2.7 months versus 2.4 months (p = 0.600), in those with pancreatic versus non-pancreatic malignancy, respectively. Both post-stenting chemotherapy and the absence of distant metastasis were independently associated with increased survival. Clinical success defined by maintaining adequate oral intake without repeat endoscopic intervention was significantly higher in the non-pancreatic group versus pancreatic group (91% versus 71%, p = 0.004) at 2 months post-stenting but comparable at 12 months (70% versus 56%, p = 0.450). The frequency of re-intervention was similar at 30% versus 23% (p = 0.200) in the pancreatic and non-pancreatic groups with repeat stent placement the most common re-intervention. The overall adverse event rate was 29% with no significant difference between groups. A total of 84 stent occlusions occurred in 61 individuals (21%). Hemorrhage, stent migration, and perforation occurred in 5.1%, 4.4%, and 3.4% of individuals, respectively, and rates did not differ between groups [44].

There are now several series in the literature, which compare SEMS placement to surgical bypass for the treatment of malignant gastroduodenal outlet obstruction [26, 37, 39]. In a single center retrospective cohort, Khashab et al. compared 120 individuals who received enteral stenting for malignant gastric outlet obstruction to 277 individuals who underwent palliative gastrojejunostomy. The technical success was significantly different, but similarly high (99% gastrojejunostomy versus 96% enteral stenting, p = 0.004). Gastrojejunostomy was associated with a higher complication rate (22.1 versus 11.6, p = 0.02), while enteral stenting was associated with an increased risk of re-intervention (OR 9.18, $p < 0.0001$) but a shorter length of hospital stay (p = 0.005) [29].

As seen above, most have found high technical success rates for both procedures. However, patients who underwent

surgical bypass tended to have an increased duration of hospitalization, a higher rate of postoperative complications, and a longer time interval to restoration of oral intake. A survival benefit has not been demonstrated for either modality. Regardless, in patients with incurable malignancies and anticipated short-term survival, the advantages of SEMS placement may provide for an improved quality of life over surgery [21, 36].

Available Devices

At present, the devices approved in the United States for palliation of malignant gastroduodenal obstruction include the WallFlex duodenal stent (Boston Scientific) and the Evolution duodenal stent (Cook Medical). All devices are uncovered self-expandable metal stents that can be deployed either through the endoscope (10 Fr delivery system) or over a guide wire using fluoroscopic control. The length of the delivery systems (230 cm) facilitates passage through a colonoscope for deeper enteral deployment if required.

The WallFlex and Evolution enteral stents are fashioned from nitinol, and the diameter of the stent body is 22 mm, and available lengths are 6, 9, and 12 cm. The WallFlex has a single 27 mm proximal flare, and the Evolution stent has a double-flanged design with a 27 mm proximal and 27 mm distal flare.

Like its esophageal counterpart, the Niti-S Pyloric Stent (Taewoong Medical, Korea) is fashioned from a double-layered nitinol outer core with an inner polyurethane covering. Although this stent is not currently available in the United States, the double-layered design represents important technology, potentially reducing tumor ingrowth and resultant stent occlusion, which can require endoscopic re-intervention.

Alternative Treatments

The traditional alternatives to enteral stent placement for the treatment of malignant gastric or duodenal outlet obstruction include surgical gastroenteric anastomosis and placement of an enteric feeding tube combined with a decompressive gastrostomy, in addition to placement of a decompressive gastrostomy with or without parenteral nutrition.

Recent reports of safety and success using a novel endoscopic ultrasound-based technique to create a gastroenterostomy with a lumen-apposing fully covered self-expandable metal stent in cases of benign and malignant gastric outlet obstruction are promising and highlight the future potential of endoluminal stenting to address malignant obstruction (Fig. 20.8) [30].

Colonic Stenting

Obstructing colorectal neoplasms, namely, adenocarcinoma, can lead to significant morbidity and mortality. Not surprisingly, relief of obstruction from intrinsic neoplastic disorders of the large bowel is the leading indication for colonic stent placement [21]. Colonic stents can be placed to relieve obstruction for extracolonic malignancies, which cause extrinsic compression, leading to colonic obstruction [21]. Cancers of the prostate, ovary, and cervix can often lead to colonic obstruction due to this mechanism. Colonic stents have also occasionally been placed for benign disease including ischemic colonic strictures, strictures related to diverticular disease, and Crohn's and anastomotic strictures [14, 63, 67]. Endoscopic ultrasound and lumen-apposing self-expandable metals stents have broadened the indication for stenting benign conditions; however, at the present time this use has been limited to case reports (Fig. 20.9). The focus of the discussion that follows is colonic stenting for malignant obstruction.

In patients with malignant colonic obstruction, stents have been used in two scenarios. The first is in patients who either have metastatic disease at the time of presentation or in those who are poor surgical candidates. In this situation, colonic stenting is palliative. The second is in patients who are good surgical candidates with complete colonic obstruction in whom a bowel preparation is preferred to a diverting colostomy with Hartmann's pouch followed by a second surgery several weeks to months later. If successful in relief of obstruction, colonic stenting in this group of patients allows for a single-step operation [21].

Contraindications

As for other endoscopic procedures performed under conscious sedation, patients medically unfit for endoscopy should not undergo colonic stent placement. This procedure is also contraindicated in patients with signs or symptoms consistent with intestinal perforation and peritonitis. In some patients, obstructing colonic malignancies can perforate the colon yet not be associated with gross peritonitis. Identification of mesenteric fat at endoscopy should alert the endoscopist to the presence of a perforation, and the stent should not be placed. Patients with obstructing colonic lesions approximating the anal verge should not undergo colonic scenting as there may be insufficient clearance for expansion of the distal portion of the stent. In addition, stents placed in this region may cross the dentate line leading to severe discomfort.

Colonic stents should not be placed in patients with uncontrolled coagulopathy or those with life expectancy less

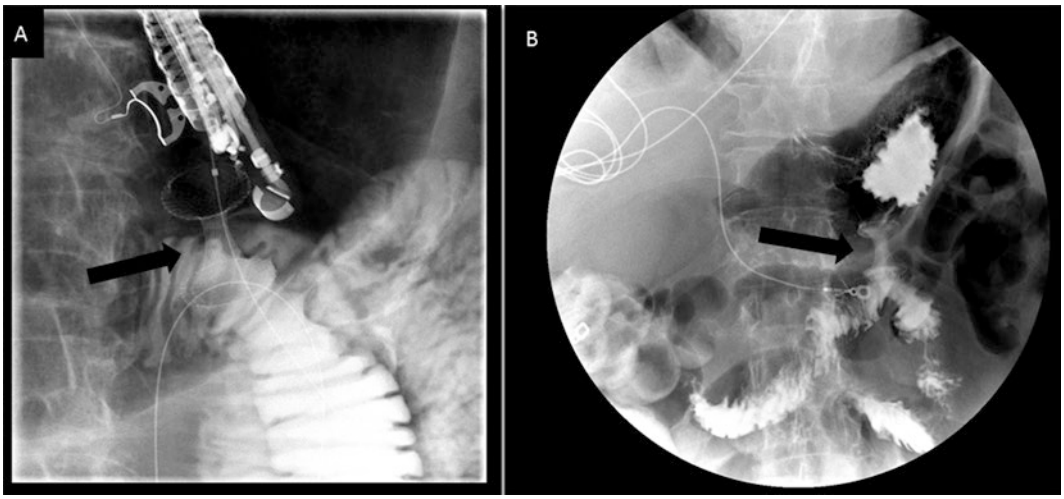

Fig. 20.8 Endosonographic placement of a gastrojejunostomy using a lumen-apposing fully covered self-expandable metal stent (**a**) in a patient with metastatic duodenal adenocarcinoma and a high-grade duodenal obstruction. An upper GI series and small bowel follow-through performed the following day (**b**) demonstrate stent patency and bypass of water-soluble contrast beyond the duodenum (Case details and images courtesy of Shayan Irani, MD)

Practical Considerations

- Colonic stents should not be placed in patients with uncontrolled coagulopathy or those with life expectancy less than 30 days.
- Patients with multiple obstructing colonic lesions are unlikely to benefit from the placement of a single colonic stent.

than 30 days. Finally, individuals with multiple obstructing colonic lesions are unlikely to benefit from the placement of a single colonic stent.

Procedure

Because patients with acute colonic obstruction cannot undergo full oral bowel preparation, colonic stents are typically placed into the unprepped colon. In patients with obstruction of the rectosigmoid or descending colon, enemas may be used to clear the distal colon. The choice of endoscope depends on the location of the obstruction. Lesions within the left colon up to the splenic flexure can typically be reached using a sigmoidoscope or therapeutic upper endoscope, while those in the more proximal colon will require the use of a colonoscope. Patients with acute colonic obstruction should undergo nasogastric suction to decompress the bowel proximal to the stenosis and reduce the risk of aspiration of gastric contents. A gastrografin enema should be performed for planning purposes in all patients with suspected proximal obstruction and in those patients with distal obstruction in whom additional stricture characterization is desired [21].

After sedating the patient, the endoscope is advanced through the unprepped colon to the level of the stenosis. Insufflation should be used judiciously as overdistension can lead to proximal bowel perforation. Once the level of the stenosis is reached, a stiff guide wire can be placed through the stricture using an ERCP catheter or balloon catheter. Injection of contrast through the stenosis should be performed to help to define the length of the obstruction (Fig. 20.10). Passage of the endoscope proximal to the stricture is not mandatory and can lead to colonic perforation. Because visualization may be difficult in the colon and some devices cannot be placed through the endoscope, an endoscopic clip should be placed 1–2 cm below the distal margin of obstruction to allow for fluoroscopic visibility. Alternatively, water- or lipid-soluble contrast material can be injected with a sclerotherapy needle to delineate stricture margins.

The choice of stent should be 3–4 cm longer than the estimated length of the obstruction in order to allow for adequate coverage, especially with stents fashioned from nitinol, which tend to foreshorten as they expand. Stents can be delivered through the working channel (Fig. 20.10) of the endoscope or over the guide wire alone. In either case, deployment should be performed under fluoroscopic control. Because obstructing colonic neoplasms can often cause acute angulations in the bowel, maintaining proper endoscope position during stem deployment can often require the assistance of a nurse, technician, or additional physician.

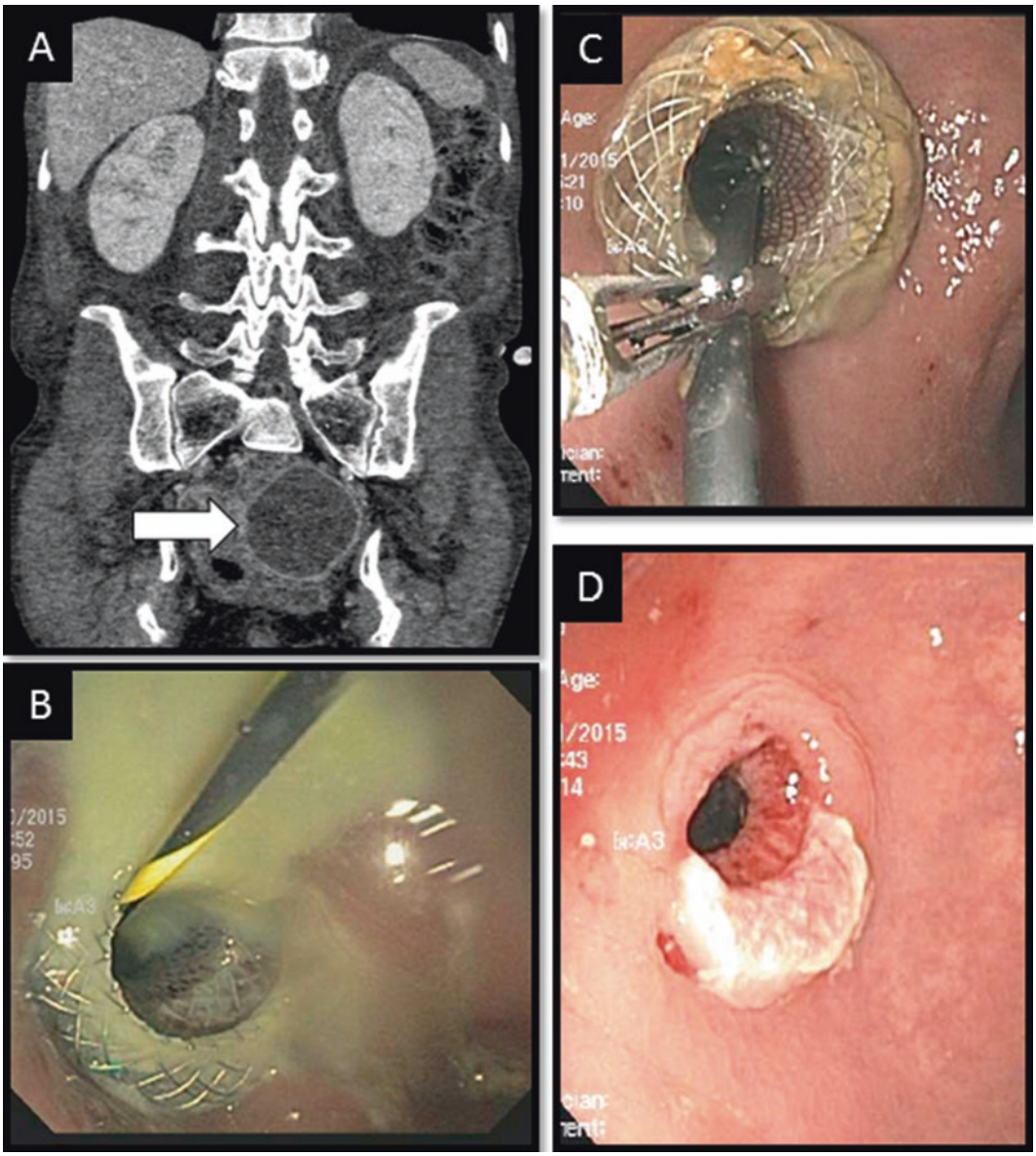

Fig. 20.9 Radiographic view of a difficult to drain perirectal abscess (**a**) in a poor surgical candidate. An endoscopic ultrasound-guided lumen-apposing self-expandable metal stent was used to drain the abscess (**b**). Two weeks later the stent was removed (**c**) and (**d**) with resolution of the abscess (Case details and images courtesy of Shayan Irani, MD)

Complications

The major complication associated with colonic stent placement is intestinal perforation. This occurs in approximately 5–7% of cases [78, 83]. Many cases of colonic perforation are encountered when stents are placed around acute angulations in the colon. This is due to straightening of the bowel, which occurs with expansion of the stent. In addition, prior case reports and a retrospective review implicated the anti-angiogenic chemotherapeutic agent, bevacizumab, as a potential contributor to stent-related colonic perforation [5, 64]. A more recent multicenter review identified bevacizumab as an independent risk factor for stent-related colonic perforation with a rate of 12.5% [78]. As in all cases of colonic perforation, prompt recognition, administration of broad-spectrum antibiotics, and surgical consultation are essential.

Other complications related to colonic stent placement include bleeding, stent migration (11.8%), and occlusion (7.3%) [83]. Like other enteral stents, occlusion is typically due to ingrowth of tumor or bolus impaction. In the case of tumor-related occlusion, revision with *a* second stent typically leads to clinical improvement. Migrated stents may pass spontaneously or require endoscopic removal if they become lodged at the anal verge.

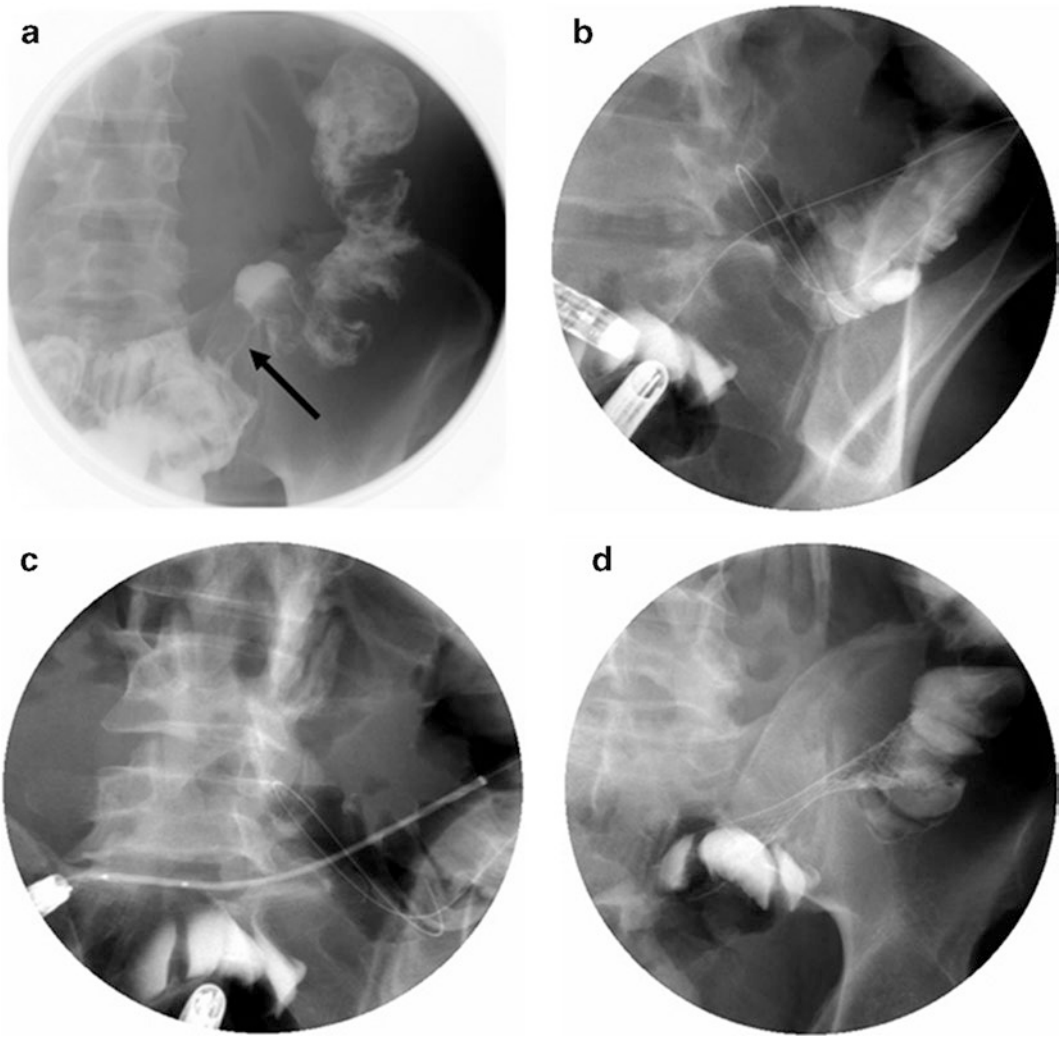

Fig. 20.10 Barium enema demonstrating a severe stenosis (*arrow*) in the sigmoid colon (**a**). A guide wire was placed beyond the stenosis following injection of contrast (**b**). A through-the-scope colonic SEMS was positioned across the stenosis over the guide wire, through the scope (**c**), and deployed in satisfactory position (**d**)

Postoperative Care

Most patients who undergo successful colonic stent placement experience immediate relief of symptoms. A clear liquid diet can be initiated after 24 h and if surgery is planned, a full bowel prep can be administered.

In patients undergoing palliative stenting, diet can be advanced as tolerated. Patients who do not experience colonic decompression following stent placement should undergo an abdominal radiograph to determine whether the stent has migrated or is malpositioned [21]. If the stent appears in good position with full expansion, repeat endoscopy can be considered to determine the reason for stent dysfunction or whether a second, upstream obstruction exists (more common in extrinsic malignancy). Alternatively, a water-soluble contrast study can be obtained initially. Patients with signs and symptoms of peritonitis following stent placement should undergo an urgent abdominal CT scan to evaluate for colonic perforation.

Clinical Data

Malignant Disease

Several case series and pooled analyses have now demonstrated the efficacy of colonic stent placement [50, 61, 83]. In a comprehensive review of available data, Sebastian and colleagues [55] reported a technical success rate of more than 93% for stent placement on the first attempt. Clinical success rates, as defined by colonic decompression (either clinically or radiographically), were found to be greater than 88%. Compared to surgery, SEMS placement in the colon was associated with a shorter duration of hospitalization, lower

rates of complications, and a decrease in the need for colostomy [43, 71]. The limited available evidence also suggests that initial SEMS placement for malignant colonic obstruction is a cost-effective strategy when compared to surgery [62, 70]. In many centers, an attempt at SEMS placement is now the preferred strategy for the initial management of acute colonic obstruction secondary to malignancy [32].

Benign Disease

Little is known about the feasibility, safety, and efficacy of colonic stenting in the management of nonmalignant colorectal strictures. In a multicenter retrospective study evaluating 43 patients with obstructive colonic symptoms due to anastomotic (n = 40), postischemic (n = 2), and postradiation (n = 1) strictures who underwent stenting with a FCSEMS, the technical success was 100% and the clinical success 81% (n = 35). However, migration was observed in 63% (n = 27), and recurrent obstructive symptoms occurred in 53% (n = 23) irrespective of stent migration [73]. A retrospective analysis of 11 individuals with refractory anastomotic strictures who underwent placement of an esophageal BD (polydioxanone based) revealed a 100% technical success rate with stent migration occurring within 2 weeks in four individuals (36%) who subsequently developed recurrent obstructive symptoms. Of the seven remaining patients, five developed complete symptomatic resolution and the other two required surgery [52].

From a conceptual standpoint, stenting appears to be a promising intervention for benign colorectal strictures; however, until optimized colorectal specific devices and further studies are available, the high rate of stent-related complications raises concerns over patient safety and suggests alternative endoscopic options must be sought initially to address these stricture-related ailments.

Available Devices

There are currently five SEMS approved by the US Food and Drug Administration for the palliation of malignant colonic obstruction. The colonic Wallstent, WallFlex, and Ultraflex Precision are all manufactured by Boston Scientific (Natick, MA). The colonic Wallstent is fashioned from Elgiloy and is available in a 20 or 22 mm diameter and lengths of 6 and 9 cm. The delivery system is 10 Fr, with a working length of 230 cm. The colonic WallFlex is fashioned from nitinol. However, as opposed to the Wallstent, the ends of the stent are interwoven, which may potentially decrease the risk of perforation. The WallFlex colonic stent is available in diameters ranging from 22 to 25 mm and has a 27 or 30 mm proximal flare. Lengths are 6, 9, and 12 cm, and they are inserted using a 10 Fr delivery system with a working length of either 135 or 230 cm. Finally, the Ultraflex Precision colonic stem is fashioned from nitinol and has a central diameter of 25 mm and a 30 mm proximal flare. This device can only be inserted over an endoscopically or fluoroscopically positioned guide wire using a 105-cm-long delivery catheter.

The colonic Z stent and Evolution colonic stents are manufactured by Cook Medical. The colonic Z stent is a stainless steel stent, which is available in lengths of 4, 6, 8, 10, and 12 cm. The stent can only be placed over a guide wire under fluoroscopic control as the delivery catheter is 10 mm. The stent is 25 mm in shaft diameter with a 35 mm proximal flare. The introducer is 40 cm in length and its use is, therefore, limited to the left colon. The Evolution colonic stent is a nitinol-based stent with a through-the-scope deployment system. It is available in lengths 6, 8, and 10 cm and has a 25 mm mid-body shaft diameter and 30 mm proximal and distal flange.

Alternative Procedures

Alternatives to colonic stenting for acute colonic obstruction include a diverting colostomy or, in patients who are not surgical candidates, placement of a transrectal colonic decompression tube.

Conclusions

- Self-expandable stents are utilized for the treatment of benign esophageal diseases including perforation, anastomotic leaks, and refractory benign esophageal strictures.
- Tumors located in the mid- to upper esophagus raise the theoretical risk of causing airway obstruction.
- The risk of stent migration is typically lowest in patients with intrinsic strictures of the esophagus.
- For most malignant lesions, a partially or fully covered SEMS is preferable to an uncovered stent in order to prevent the tumor ingrowth.
- The major drawback to partially or fully covered stents is the increased risk of stent migration.
- Stents placed across the gastroesophageal junction obliterate the natural reflux barrier, and patients almost invariably develop reflux of gastric contents into the proximal esophagus or oropharynx; specifically designed “anti-reflux” stents may help to decrease symptoms.
- Because endoscopic measurements may be slightly inaccurate, it is best to err on the side of a longer (rather than shorter) stent in order to decrease the risk of failing to palliate the obstructing lesion.

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