Chapter 8
Stricture Management: Interventional Options

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Esophageal Anastomotic Strictures

Definition

Esophageal anastomotic strictures are typically defined as any form of cervical dysphagia in the anastomotic region requiring endoscopic dilation [1], or failure of passage of a 9-mm endoscope [2]. Post-esophagectomy anastomotic strictures are the most common reason for stricturing disease in the esophagus seen by general surgeons and gastroenterologists [3]. In the pediatric population, strictures from esophageal atresia repairs are the most common etiology [4].

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M. Kroh et al. (eds.), *The SAGES Manual Operating Through the Endoscope*, https://doi.org/10.1007/978-3-031-21044-0_8

Pathophysiology

Benign esophageal strictures are the result of collagen deposition and scar tissue formation from prolonged esophageal inflammation [5]. The majority of benign strictures are the result of peptic disease; however, with the advent of aggressive treatment of reflux, other causes like anastomotic strictures are becoming more common [6]. The exact mechanism behind anastomotic stricturing is yet to be elicited, but a compromised blood supply and reflux of stomach acid are likely involved in the pathophysiology [7, 8].

Incidence and Risk Factors

The incidence of anastomotic esophageal stricturing post-esophagectomy ranges between 5 and 48% [1, 2, 9–11]. Usually appearing between 3 and 6 months post-surgery [12], risk factors for stricture formation can be classified into four categories:

1. Patient factors: smaller esophagus [2, 9], increased preoperative weight [2], preoperative cardiac disease [11], diabetes mellitus [13].
2. Surgical technique: stapled anastomosis [9, 10, 14] with smaller stapler size [12], two-layer hand-sewn anastomosis [1], cervical anastomoses [12, 15], gastroesophageal anastomosis [2].
3. Postoperative complications: conduit ischemia [2], anastomotic leak [2, 11], anastomotic bleed [16], anastomotic infection [16].
4. Treatment factors: postoperative radiation [1].

The incidence of malignant esophageal stricturing post-esophagectomy ranges from 4 to 8% [1, 10]. These strictures usually appear later than benign, fibrotic strictures [12].

In the pediatric population, the incidence of anastomotic esophageal stricture post-esophageal atresia repair ranges between 18 and 50%[4]. Risk factors for stricture development are classified into three categories:

1. Patient factors: reflux, gap length.
2. Surgical technique: anastomotic tension, anastomosis suture material.
3. Postoperative complications: anastomotic leak, fistula [4].

Symptoms

The most common clinical presentation of esophageal stricturing disease is dysphagia, reported in 83% of patients [5]. The severity of dysphagia does not correlate to the degree of stricture due to patients often adjusting their diet to more tolerable foods [17]. Esophageal complaints of reflux were also quite common (66%), likely due to the strong correlation between reflux and stricture formation [5]. Potential extra-esophageal symptoms include chronic cough, weight loss, vomiting, chest pain, hoarseness, and asthma [5, 17].

Treatment

The mainstay of therapy for upper gastrointestinal anastomotic strictures that are associated with a clinically significant functional impairment is mechanical esophageal dilation [18]. The goal of dilation is centered on symptomatic relief of dysphagia [3]. Dilation can be performed with rigid or balloon dilators, with or without a guidewire to help positioning, and with or without endoscopy or fluoroscopy [19]. Esophageal anastomotic strictures generally are considered more complicated than simple peptic strictures, thus often require a number of dilation sessions, with the median ranging between 2 and 9 sessions per patient. Randomized controlled trials have shown no significant difference in efficacy between the rigid versus balloon dilators [20, 21]. Additional therapies like stenting, intralesional corticosteroid injections, and electrosurgery are generally reserved for refractory strictures after failed dilation, defined as clinical dysphagia despite dilation, in strictures that are unable to be mechanically dilated to 14 mm or to remain at least 14 mm in lumenal size [8, 16].

Dilators

Rigid Dilators

Rigid dilators have been the traditional treatment for esophageal strictures, dating back to the sixteenth century. Significant evolution has occurred since, progressing from initial tools that included whalebones and tapered wax candle dilators [8]. These fixed rigid dilators apply both axial and radial forces as they are advanced through the stricture [22]. Rigid fixed dilators can be quite variable in their appearance and subtleties of action, based on designs of different companies.

The push type dilators (PTD), Hurst and Maloney, are internally weighted with mercury-free tungsten, ranging in sizes from 16 Fr to 60 Fr with their tips being rounded or tapered [19]. These dilators are best suited for simple strictures (straight, symmetric, diameter ≥12 mm) [3].

Wire-guided dilators (WGD) are polyvinyl chloride tapered tubes with a central channel that allow for a guide-wire [19]. The Savary-Gilliard and American Dilation System (Conmed, USA) dilators have varied-length tapered tips, radiopaque markings, and external distance markings [19]. These dilators can be used for more complicated strictures (torturous, asymmetric, length >2 cm, diameter <12 mm) [3, 8].

Rigid dilation, as a procedure, begins with an endoscopic or barium study assessment of the stricture; marking diameter, length, and evaluation of any suspicious lesions for cancer-recurrence [3, 23]. A guide-wire is then placed through the instrument channel into the gastric antrum; this step is omitted for the Hurst and Maloney dilators. The endoscope is then withdrawn and the wire position is maintained [3]. The wire is then grasped at the patient's mouth and its length noted (usually around 60 cm). The initial choice of dilator depends on the estimated diameter of the stricture. A general rule is that a 24 Fr, 30 Fr, and 36 Fr are trialed for strictures ≤6 mm, 7–10 mm, and ≥10 mm, respectively [3]. The dilator is lubricated and loaded onto the guidewire and passed with a fingertip grasp through the stricture and then subsequently removed. The guide-wire length at the patient's mouth is then noted again and further dilation can take place with larger diameter bougies. The first dilator to be used is estimated endoscopically by comparing the lumen with the diameter of the endoscope. The "Rules of Three's" has traditionally been employed, stating that: during any one dilation session, a maximum of three consecutive dilators of progressively increasing size (a total of 3 mm) should be passed after the first one that meets moderate resistance [3]. However, a retrospective analysis by Grooteman et al. found that non-adherence to this rule did not increase the risk of adverse events [24]. Endoscopic evaluation after dilation can be performed to assess any damage to the mucosa. Subsequent dilation sessions can be repeated until the patient has relief of swallowing difficulties [3].

Both PTD and WGD can be passed blindly or under fluoroscopic control. Fluoroscopy is an aid to help determine that the bougie has passed the strictured segment of esophagus and has entered the stomach. This is advantageous in situations where direct visualization with the endoscope cannot be performed [3].

The efficacy of rigid dilators for anastomotic strictures ranges between 78 and 100%[19, 25]. The median number of dilations prior to achieving clinical success ranges between 2 and 9 dilations [25]. 50% of patients will fail initial dilator therapy from rigid dilator therapy [20].

Balloon Dilators

First introduced by London et al. in 1981 for two patients who failed the conventional, bougie rigid dilator technique, this technique has gained widespread popularity in benign esophageal stricturing disease, including anastomotic strictures, for its less traumatic effect on esophageal tissue [7, 26]. Contrary to rigid dilators, balloon dilators exert only radial forces when expanded within a stenosis. There is substantial variability in the type of balloon dilators that exist, such as single-diameter, multi-diameter, and hydrostatic or pneumatic balloons [27].

Through-the-scope (TTS) balloon dilation, as a procedure, begins with an initial evaluation of the stricture via endoscopy or a barium study [23]. The balloon diameter used is once again dependent on the diameter size of the stricture [3]. A general rule is that 10 mm, 12 mm, and 15 mm balloons are used for strictures of ≤6 mm, 7–10 mm, and ≥10 mm, respectively. The endoscope is placed in the stomach, distal to the stricture, and the balloon is passed through the scope to the end of the endoscope. The endoscope is then withdrawn through the stricture and the balloon is then inflated with radiocontrast or water for 30–60 s [3]. The endoscope remains in the esophagus allowing the operator to directly visualize the dilation, an advantage of balloon dilators over most non-transparent bougies [19]. If fluoroscopy is used, the balloon is inflated until the waist deformity from the stricture disappears [23]. Fluoroscopic control has the advantages of visualizing both the proximal and distal ends of the stricture, not merely the entrance as in endoscopy, and allows visual control of the whole balloon catheter [28].

With the advent of controlled radial expansion, the same balloon can be inflated to three consecutive larger diameters rather than one balloon with only one diameter [3]. The rules of three can also be applied for balloon dilators [7]. Once again, the mucosa is then evaluated by the endoscope after dilation for trauma.

The efficacy of balloon dilators for anastomotic strictures ranges between 83 and 100% [7, 11, 13, 19, 29]. The average number of dilations prior to achieving clinical success ranges between 3 and 7 dilations [11, 29]. Studies have shown that restenosis rates after balloon dilation are approximately 50% [7, 13].

Predictive factors that determine the success of dilation include stricture diameter >13 mm [7], stricture length <12 mm [29], and strictures without prior history of leakage [29]. Predictors of failure of dilation include interval from esophageal surgery to the first initial intervention <90 days [7] and balloon dilations to 12 mm or less [7].

Novel Transparent Dilators

Direct visualization throughout the procedure is possible with newer, transparent dilators that fit over a standard endoscope [21]. However, there is limited evidence on the effectiveness of these dilators compared to non-transparent dilators as only small prospective data is available [30, 31].

Complications and Limitations of Dilators

The complexity of anastomotic strictures put them at risk for esophageal perforation or significant hemorrhage with dilation. The incidence of esophageal perforation or significant bleed is reported between 0.1 and 0.5% [3]. There remains a paucity in the literature as to predictive factors associated with decreased or increased dilation attempts prior to clinical success [32]. The drawbacks then of these dilators are the time and expense of repeated, indeterminate therapy sessions, with the potential for adjuvant therapy interruption [32]. Ultimately, the decision to use balloon or rigid dilation is based more on preference, experience, and regional availability [19].

Other Endoscopic Procedures

Stents

Stents are usually considered as a second-line treatment for patients with recurrent dysphagia, failing initial dilation attempts [33]. They have a primary role in patients with unresectable malignancy for palliation and improvement of dysphagia and are used sparingly in benign disease [34, 35].

Metal Stents

Self-expanding metal stents (SEMSs) are metal mesh cylinders usually composed of stainless steel or alloys, which are able to self-expand until they restore the lumen of hollow organs [36]. Traditionally SEMSs have been used as a palliative procedure for patients with stricturing disease from unresectable esophageal cancer, also encompassing recurrences at the anastomotic site [34, 37]. The indications for SEMSs in fibrotic anastomotic strictures are limited. The historical concern with bare metal stents focused on the increased tissue irritation leading to secondary strictures, tissue ingrowth, mucosa ulcerations at contact points, esophageal obstruction, perforation, and tracheoesophageal fistulas [33, 37]. In addition, due to tissue embedding, once placed, metal stents were considered permanent [37]. On the other hand, this tissue embedding does limit possible stent migration, with reported rates by Pennathur et al. to be as low as 8.7%.

Newer, fully-covered metal stents are challenging this non-reversible notion of metal stents, as recent studies have shown that they can be removed successfully [37]. However, the results with anastomotic strictures have only modest efficacy, with studies quoting a dysphagia resolution rate between 29 and 56% [35, 37].

Metal stents and non-metal stents are placed in a similar fashion [38]. The stricture requiring stenting is first visualized with the endoscope [36]. If the stricture is deemed to be too stenotic for the stent to traverse it, the operator might choose to perform a session of dilation with a rigid or balloon dilator prior to stenting [36]. Most gastrointestinal SEMS require the use of a guidewire for placement [36]. A distal hemoclip is placed approximately 2 cm distal to the stricture and the endoscope is advanced placing a guidewire into the second part of the duodenum. Upon the withdrawal of the endoscope, the guidewire remains and a proximal hemoclip is placed where the stent is planned to start. Under fluoroscopy guidance, using the hemoclips as landmarks, the stent is deployed. The endoscope is then inserted to confirm correct placement. Fully-covered stents are usually left for up to 3 months or less depending on the endoscopist's discretion, prior to being endoscopically retrieved. Partially covered self-expanding metal stents are left in place for a shorter duration, owing to more significant tissue ingrowth making retrieval after a longer period of time more challenging. This same characteristic likely decreases the migration rates of partially covered metal stents. Retrieval involves using foreign body forceps with a longitudinally directed force that narrows the stent for removal [33].

Non-Metal Stents

Self-expanding plastic stents (SEPS) were developed to correct for some short-comings of metals stents and they have been shown to be a successful treatment tool for benign anastomotic strictures [33]. Usually made of a combination of polyester and silicone, where the silicone prevents hyperplastic tissue growth and the polyester helps with anchoring, these stents are able to be removed easily due to the lack of tissue embedding [33, 37]. As a second-line treatment modality for recurrent dysphagia post initial dilation, plastic stent placement has been associated with decreased median numbers of subsequent dilatations, improved dysphagia scores, and improved cost-effectiveness at 15 months of follow-up. Recurrent dysphagia rates after plastic stenting ranges between 5 and 36% [32, 33, 38]. Long-term resolution of dysphagia symptoms after SEPS removal is poor, with high associated dysphagia recurrence rates [6]. Evrard et al. stressed that SEPS should not be used as initial therapy for anastomotic strictures but should be considered in patients with cervical anastomotic stenosis and patients with refractory dysphagia to dilations [39].

There are a few other important drawbacks of SEPS. As a result of poor mucosa embedding, SEPS migration rates are high, ranging between 6 and 69% [40]. SEPS are also less effective than metal stents in managing esophageal perforations and leaks [40]. Lastly, they require a larger applicator compared to metal stents, therefore requiring pre-dilation of the stricture more often [33].

Biodegradable Stents

Biodegradable stents (BDS) are not widely available yet with only small case series speaking to their efficacy [41]. BDS potentially solve the problem with stent extraction and migration, as most stents are dissolved by 6 weeks. However, dedicated trials with larger patient populations are needed. In one small randomized trial, after three months, patients with strictures who had BDS stents required fewer dilations compared to dilation alone. However, by six months, the number of dilations was similar[42]. Other small studies have shown that dysphagia clinically improved in 33–100% of patients, but stent migration rates continued to be quite high ranging from 8 to 77% [43].

Corticosteroid (Triamcinolone acetonide) Injection

Intralesional injection of corticosteroids has been used for refractory esophageal strictures for the last 50 years. Used as an adjunct to dilation, intralesional steroids interfere with collagen synthesis and fibrosis, thereby inhibiting stricture formation. Triamcinolone, specifically, inhibits fibronectin and pro-collagen synthesis, reduces inhibition of collagenase, and prevents scar contracture. In addition to triamcinolone, betamethasone solutions are also commonly used. The procedure itself involves radial injections of the steroid using a sclerotherapy injection needle. Optimally, injections are given prior to dilation and radial injections in 4–6 quadrants just proximal to the stricture and then distally. Studies have shown that intralesional injection of corticosteroids in conjunction with dilation for anastomotic fibrotic strictures significantly reduces stricture recurrence, the number of periodic dilations required for recurrent strictures and increases the maximum dilation diameter achieved [8, 44–46].

Mitomycin C

Mitomycin C, a chemotherapeutic agent, has demonstrated success for the treatment of refractory esophageal strictures in small case series. In these case series, endoscopic application is performed via injection or rubbing with soaked gauze. These case series demonstrate decreased frequency of dilations and improvement in dysphagia [47]. One randomized controlled trial has been conducted in pediatric caustic esophageal strictures which demonstrated significantly higher rates of stricture resolution and decreased number of dilations needed in the mitomycin C group [48].

Electrosurgical Needle Knife

Limited, small case series have described the use of electrosurgery to treat esophageal surgical anastomotic strictures [16, 49]. A sphincterotome or endoscopic knife, under direct endoscope visualization, supplies an electrosurgical current to cut several longitudinal incisions (usually 6–12) with variable length and depth circumferentially around a stricture

[16, 25, 49]. The limited literature available is favorable toward electrosurgery as success rates are as high as 100% for dysphagia resolution with recurrence rates of 12.5% and without major complications [3, 49]. A randomized controlled trial comparing dilation versus electrosurgical needle knife as a primary therapy for esophageal anastomotic stricturing showed no significant difference between the two groups. The authors concluded that an electrosurgical needle knife can be used as primary therapy in the hands of an experienced endoscopist, but in less experienced hands it should be used as second-line therapy [25].

Medical Management

Based on the theory that benign strictures can be affected by the exposure of the surgical anastomosis by the reflux of acidic stomach contents, proton pump inhibitors (PPIs) have been shown to independently reduce fibrotic stricture formation 32% [12].

Gastric Anastomotic Strictures

Definition

Gastric anastomotic strictures are diagnosed clinically in patients with persistent vomiting and dysphagia with a history of a gastric anastomosis and endoscopically as a failure of passage of a 9-mm [50] or 9.5-mm [51] endoscope through the anastomosis [51]. Post Roux-en-Y gastric bypass, gastrojejunostomy strictures are the most common gastric anastomotic strictures seen by general surgeons and gastroenterologists and will become more common with the increasing number of bariatric surgical procedures performed worldwide [3, 51]. Other possible surgical etiologies include pancreaticoduodenectomy and gastrojejunostomy reconstructions, as well other gastric resections [3].

Pathophysiology

The mechanism behind gastrojejunal anastomotic stricturing is not completely understood [52]. Benign gastrojejunostomy anastomotic strictures are the result of fibrosis and the inflammation response secondary to a number of factors including gastric acid secretion from the neo-pouch, anastomotic ischemia or leak, technical problems, marginal ulcerations, NSAIDS, alcohol, or smoking [52–54].

Incidence and Risk Factors

The incidence of anastomotic gastrojejunostomy stricturing post-gastric bypass ranges between 0.6 and 27%, with no difference between open versus laparoscopic approaches [3, 51, 54].

Usually appearing as a late complication, risk factors for stricture formation can be classified into three categories:

1. Patient factors: female gender [3], healing capacity [51].
2. Surgical technique: stapled anastomosis [51] with a circular stapler [3, 51, 52], 21-mm stapler size [51, 54], anastomotic tension [51], large volume gastric pouch [54], surgeon inexperience [55].
3. Postoperative complications: anastomotic ischemia [3, 51].

Treatment

The mainstay of therapy for a post-gastric bypass anastomotic stricture that is associated with a clinically significant functional impairment is mechanical gastrojejunostomy dilation using balloon dilation [51]. Considered the gold standard treatment, these strictures respond favorably to dilation with efficacy rates reaching 100% and require less dilation sessions compared to esophageal anastomotic strictures, with 55–90% of patients requiring only one session [50, 51, 56, 57]. TTS balloon dilation has a low overall complication rate and an acceptable perforation rate under 2% [50]. The role for other treatments, like surgical revision and to a lesser extent endolumenal stenting and Savary-Gilliard bougies are usually reserved for refractory strictures, defined as recurrence of stenosis despite 3–5 balloon dilation attempts [50, 53].

Balloon Dilators

As described earlier, balloon dilation can be performed under endoscopic or fluoroscopic guidance [51]. TTS dilation has the advantage of assessing the stricture visually. The procedure is as described earlier. Briefly, the stricture is visualized by gastroscopy, 6–18 mm balloon catheter is inserted through a side channel and through the stricture [51, 56]. Fluoroscopy then confirms that the balloon is traversing the waist of the stricture and the balloon is inflated until the waist disappears on fluoroscopy [51]. After 30–60 s, the balloon is deflated, withdrawn and the endoscope is advanced through the dilated anastomosis [51]. The goal of dilation is to achieve a diameter at least 2.5 times the original strictured diameter or at least 12-mm, with repeated dilations as necessary with progressively larger balloon sizes and repeated sessions for recurrences [3, 50]. For strictures post-gastric bypass, dilation above 15mm is discouraged as it can impair postoperative weight loss.

Other Endoscopic Procedures

Endolumenal Stents

The role of endolumenal stents in the treatment of refractory gastrojejunal anastomotic strictures is controversial [53]. Small case series have shown varying success with management of refractory strictures causing continued feeding intolerances, with success rates ranging from 0 to 80% [53, 54, 58]. Eubanks et al. reported significant abdominal pain associated with all patients in their anastomotic stricture subgroup, requiring most stents to be removed after only one week [58]. Stent migration from the gastrojejunostomy is the most common complication, reported in almost 50% of patients, likely from small bowel peristalsis and the unique stricture formation of these particular strictures [53, 58]. Distal migration may be less with partially covered stents. Securing the stent with endoscopic sutures is a promising technique that was able to decrease stent migration to less than 20% in a small case series [59].

Savary-Gilliard Dilators

Bougie dilators have been reported to be successful in treating gastric anastomotic strictures [50, 60]. The procedure is the same as described previously and often involves fluoroscopy [3]. While rigid dilators have been reported to be successful, TTS balloon dilation is the preferred method due to the long distance from the mouth to the anastomosis and the presence of a potentially difficult and variable curvature of the Roux limb [3, 50].

Colorectal Anastomotic Strictures

Definition

Colorectal strictures can be defined clinically as a significant intestinal obstruction causing either defecation difficulties, pain with passing flatus or stool, and abdominal distention in a patient with a history of a colorectal surgery [61]. Endoscopically, it is the inability to pass a 12-mm [62] endoscope through the anastomotic stricture [61, 62]. This is an extremely heterogeneous group of stricturing disease from a number of different colorectal surgeries, including low anterior resection, sigmoidectomy, and ileal-anal pouch creation [61].

Pathophysiology

Similar to the previously aforementioned esophageal and gastric anastomotic strictures, colorectal anastomotic strictures are not fully understood but important factors include continued inflammation with ischemia, leakage, and in some cases, radiotherapy [62]. For unclear reasons, it is reported that the rectum is the most common site for stricturing disease [61]. Other possible proposed factors include discrepancies in size between the two ends of the anastomosis and an abnormal collagen synthetic reaction [63].

Incidence and Risk Factors

The incidence of benign colorectal anastomotic strictures ranges between 3 and 30%, yet only 5% of patients become symptomatic [28, 61, 62, 64]. Risk factors can be separated into four categories: patient factors, surgical technique (stapled anastomosis [62], smaller stapler diameter [62], temporary diverting loop ileostomy [62]), and complications (anastomotic ischemia and leak [61], pelvic sepsis [3, 61]) and adjuvant therapy (radiation [3, 61]).

Treatment

The mainstay of therapy is endoscopic balloon dilation. Dilation is favored over bougienage for the simple fact that it causes less traumatic injury [65]. While dilation is generally successful, frequently repeated dilation sessions are usually required. Stents, steroids, and incisional therapy with electrosurgery, laser, or argon are less commonly implemented and are reserved for combination treatment adjuncts or for dilation failures.

Balloon Dilators

The TTS balloon dilation is as described previously. For narrow lumen stenotic strictures or angulated intestines a technique called over-the-wire (OTW) dilation is preferred over TTS, which uses an endoscopically placed guidewire to allow for more successful proximal placement of the balloon [27, 62]. OTW uses the Seldinger technique for balloon insertion and generally has larger diameter balloons than the TTS type. Balloon dilation, including both TTS and OTW, has been shown to be efficacious with medium-term success rates reported between 33 and 86%, however, recurrence rates after initial dilation are reported to be quite high at 30–88% [61, 62, 65]. The large disparity in success rates speaks to the high heterogeneity amongst the results of the studies; this is likely in keeping with difference in technique, especially in the diameter of the balloon used for dilation.

Di et al. reported improved results for the use of second, simultaneous balloon dilation for colorectal strictures [28]. In double balloon dilation, two guidewires are employed, each passed separately through the endoscope. The first balloon, usually a 20-mm, is used for initial stricture dilation under fluoroscopic surveillance for 1–3 min [65]. Then a second guidewire is passed alongside with a smaller balloon, usually 10–15-mm, and then the two balloons are inflated simultaneously [28]. At the end of the procedure, water-soluble contrast medium is injected into the rectum to rule out perforation [65]. 71–100% of patients reported long-term success in the management of symptomatic colorectal anastomotic strictures post-double balloon dilation [65]. This reported improvement with double balloon dilation could be explained by the fact that balloon size appears to be the most important factor regarding dilation efficacy for colorectal anastomotic stricturing disease [3]. Therefore, the additional benefit in diameter from the second balloon accounts for its success

[65]. The largest balloon diameter reported in the literature for this population is 40-mm. Increased balloon diameter appears not to be correlated with an increased complication rate [65]. The balloon dilation procedure is relatively safe with minimal morbidity and complications [3, 62].

Other Endoscopic Procedures

Rigid Dilators

The Savary-Gilliard bougies have been shown to have similar success rates, approximately 80%, to balloon dilators with the added advantage of being less expensive, as the bougies are reusable [66].

Stents

Stents for colorectal strictures are reserved for patients with recurrent symptoms after failed initial dilation treatment. Success rates range between 70 and 80% [63, 67].

SEMSs' role in malignant colonic unresectable strictures is well established but in benign disease its role is yet to be defined [63]. SEMS, once again, can be covered or uncovered, with the uncovered stents promoting tissue hyperplasia and embedding and therefore are harder to remove. This characteristic can lead to possible re-occlusion but have lower migration rates as a result, with uncovered stents being the opposite [63, 64].

Biodegradable stents have gained popularity of late as a management option for colorectal anastomotic strictures. Building upon the limitations of SEMS and SEPS, avoiding a second endoscopic removal procedure and its gradual expansion and dilatory effect gives these stents inherit advantages over both [64, 67]. Repici et al. reported suboptimal efficacy of these stents with stricture resolution in only 45% of patients and surprisingly high stent migration rates of 36%. The authors attributed these poor results to the fact that colorectal specific biodegradable stents are not yet available; therefore, the stents, originally meant for esophageal strictures, were too small in diameter to be adequate for colonic strictures [64]. At this time, clinical availability of biodegradable stents is dependent on varying regulatory approvals throughout the world.

Electrosurgical Coagulation

Electrosurgical coagulation and other less commonly described incisional procedures like laser stricturotomy, microwave coagulation therapy, and argon plasma coagulation can be performed independent or in conjunction with balloon dilation [62]. These adjunct therapies involve radial incisions at multiple locations around the stricture just prior to the planned dilation. These procedures have shown synergistic results when combined with balloon dilation, especially for high-grade stenosis (<7-mm lumenal diameter) [68].

Endoscopic stricturotomy (ES) using the needle knife is a promising novel treatment for treating of anastomotic strictures in inflammatory bowel disease (IBD)[69]. In a case series by Lan and Shen, ES resulted in lower rates of subsequent surgery when compared to balloon dilation (9.5 vs 33.5%) in Crohn's patients [70]. However, there were much higher rates of bleeding requiring transfusion in the ES cohort (8.8 vs 0%). In another case series, ES appeared equally efficacious for non-IBD related strictures [71].

Endoscopic Transanal Resection of Strictures (ETAR)

ETAR entails resecting the anastomotic stricture. The procedure involves the insertion of a urologic resectoscope into the rectum and using a loop-cutting electrode to resect the lesion superficial to the muscular wall [72]. The incision by the loop-cutting electrode is in the posterior part of the stricture, where the peri-rectal fat and fibrosis limit the morbidity of intraperitoneal wall perforation [68]. The incision into the posterior wall opens up the stricture, allowing a channel to be created by the incision [68]. The site is then sealed using a Foley balloon catheter, which is removed the following day. A limited, small case series on its use in anastomotic strictures report success rates ranging from 84 to 100% [68, 72, 73]. This procedure is reserved for distal, low-lying strictures, up to 15 cm, that are accessible with a resectoscope [73].

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