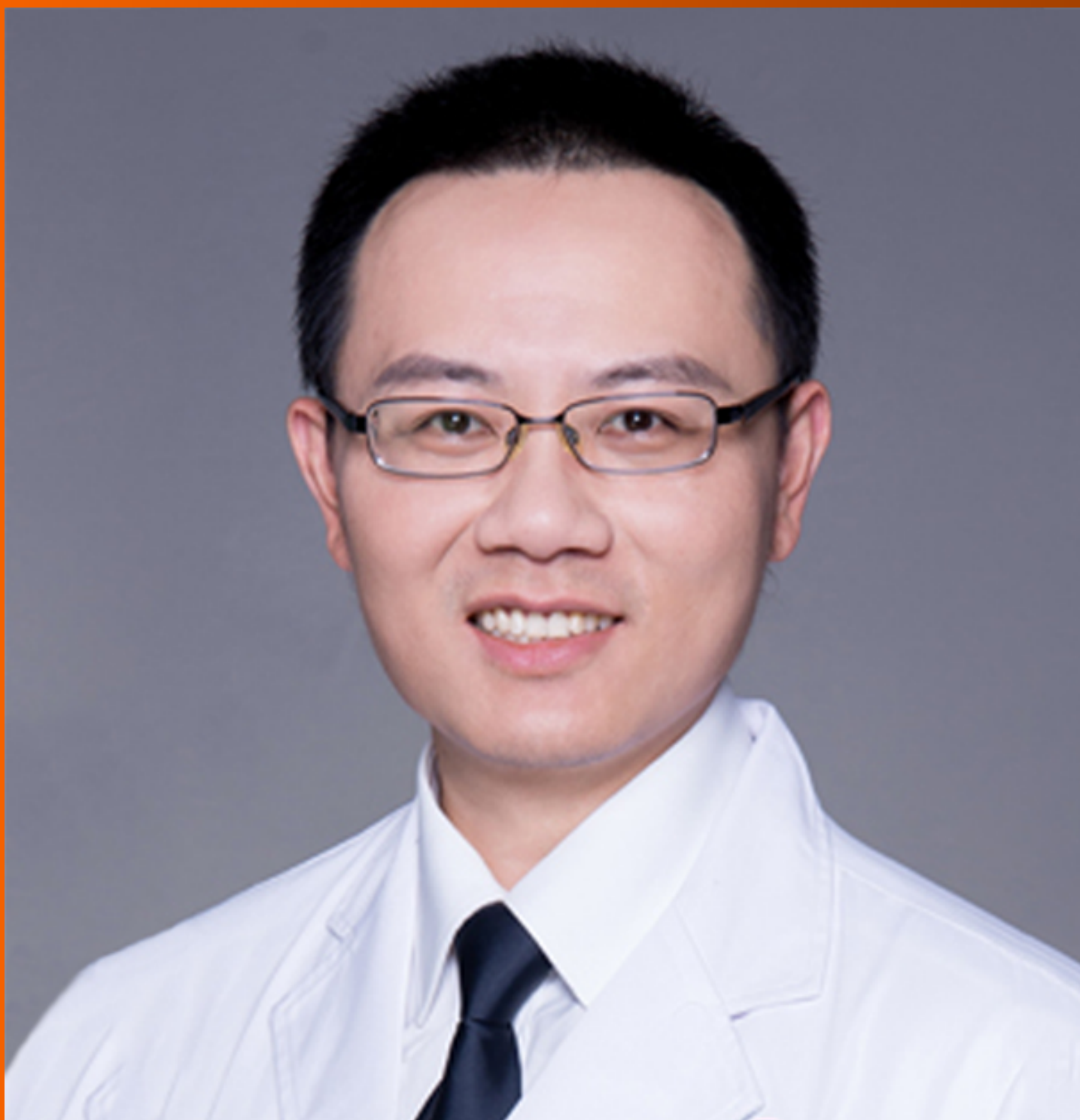


# World Journal of *Gastrointestinal Endoscopy*

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## Feasibility and safety of self-expandable metal stent in nonmalignant disease of the lower gastrointestinal tract

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### Abstract

In recent years, self-expandable metal stents (SEMSs) have been employed to treat benign gastrointestinal strictures secondary to several conditions: Acute diverticulitis, radiation colitis, inflammatory bowel disease (IBD), and postanastomotic leakages and stenosis. Other applications include endometriosis and fistulas of the lower gastrointestinal tract. Although it may be technically feasible to proceed to stenting in the aforementioned benign diseases of the lower gastrointestinal tract, the outcome has been reported to be poor. In fact, in some settings (such as complicated diverticulitis and postsurgical anastomotic

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strictures), stenting seems to have a limited evidence-based benefit as a bridge to surgery, while in other settings (such as endometriosis, IBD, radiation colitis, *etc.*), even society guidelines are not able to guide the endoscopist through decisional algorithms for SEMS placement. The aim of this narrative paper is to review the scientific evidence regarding the use of SEMSs in nonmalignant diseases of the lower gastrointestinal tract, both in adult and pediatric settings.

**Key words:** Self-expandable metal stents; Lower gastrointestinal tract; Benign strictures

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**Core tip:** Even though it may be technically feasible to proceed to stenting in nonmalignant diseases of the lower gastrointestinal tract, the outcome has been reported to be poor. In fact, in some settings, stenting seems to have a limited evidence-based benefit as a bridge to surgery, while in other settings, even society guidelines are not able to guide the endoscopist through decisional algorithms for self-expandable metal stent placement. Further studies are required to determine long-term efficacy and safety, while improvements in stent design could help to overcome the risk of adverse events, such as stent migration and perforations.

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## INTRODUCTION

Placement of self-expandable metal stents (SEMSs) represents a minimally invasive option to achieve colonic decompression in stenosing colorectal cancer (CRC)<sup>[1]</sup>. In fact, SEMSs are currently used for obstructions due to CRC in the setting of palliative care<sup>[2,3]</sup>, while their use as a bridge to surgery is still a matter of debate. To date, colonic stenting for potentially treatable conditions is only suggested for high-surgical-risk patients with left-sided obstruction<sup>[3]</sup>. Nevertheless, some studies suggest that SEMS placement could prevent proximal synchronous lesions after colonic decompression prior to curative surgery<sup>[2-6]</sup>. The growing experience in the management of malignant acute colonic obstruction with SEMSs indicates a reduction in morbidity and mortality, as well as in costs, compared to the effects of surgical treatment<sup>[4]</sup>.

Recently, SEMSs have been employed to treat benign gastrointestinal strictures secondary to several conditions: Acute diverticulitis, radiation colitis, inflammatory bowel disease (IBD), and postanastomotic leakages and stenosis<sup>[7]</sup>. Other applications include endometriosis and fistulas of the lower gastrointestinal tract<sup>[7]</sup>.

However, the use of SEMS in nonmalignant gastrointestinal tract diseases is still controversial with regard to safety and efficacy<sup>[7]</sup>. The aim of this narrative paper is to review the scientific evidence concerning the use of SEMSs in nonmalignant diseases of the lower gastrointestinal tract, both in adult and pediatric settings.

## SEMS IN THE ADULT POPULATION

### SEMS in diverticular disease

Patients with acute diverticulitis may present with colonic obstruction. The mainstay of treatment for this condition is an upfront surgical approach with resection followed by construction of an anastomosis or a defunctioning stoma<sup>[8]</sup>. Few studies have investigated the use of SEMSs in this clinical setting in recent years. Even if rates of technically successful stent placement are high in all studies, stenting a colonic obstruction due to diverticulitis carries an important risk of complications, with an incidence ranging from 6 to 43%<sup>[8,9]</sup>. Currie *et al*<sup>[8]</sup> reported a high risk of complications for diverticulitis stenting in both palliative and bridge-to-surgery patients: Out of 66 SEMS placements, 11 resulted in colonic perforation.

Similar findings were reported by Keränen *et al*<sup>[9]</sup>. Out of 10 patients undergoing SEMS placement (5 cases as bridge to surgery and 5 cases as palliation), major complications, represented by perforation, occurred in 3 patients, with resolution after surgery. In this study, both uncovered and covered SEMSs were used. Moreover, two minor complications were reported: a late colovesical fistula and one abscess. The authors concluded that stent placement for diverticular disease could be an appropriate treatment choice for patients unfit for surgery<sup>[9]</sup> and that SEMS can be used as a bridge to surgery in patients with diverticular obstruction, but there seems to be a considerable risk of complications; however, if a SEMS is placed into a diverticular stricture, the planned bowel resection should be performed within a month.

In a study by Small *et al*<sup>[10]</sup>, 16 patients, considered temporarily unfit for surgery, underwent colonic stent insertion (with uncovered stent) for diverticulitis-related obstruction to achieve bowel decompression, restore bowel function, and postpone surgical intervention. Perforation occurred in 2 patients, probably due to the severe inflammation of the bowel, while no migrations were observed. The absence of stent migration was explained by the fact that stents were surgically removed within 1 mo after placement<sup>[10]</sup>.

In the study by Forshaw *et al*<sup>[7]</sup>, 3 patients underwent uncovered SEMS placement for acute diverticulitis with impending colonic obstruction: In 1 patient, stent placement failed, and the other 2 patients experienced no clinical improvement, requiring emergency surgery for decompression.

Although not statistically significant, in all studies<sup>[7-10]</sup>, an association was reported between the high complication rate (mainly perforation and migration) and bowel wall inflammation and scarring, which makes the bowel wall friable and susceptible to local damage and acute diverticulitis-associated sepsis. Based on these results, SEMS placement may not represent a valid therapeutic option in acute diverticulitis, unless the patient is unfit for surgery<sup>[9]</sup> or surgery is performed within 1 mo<sup>[10]</sup>.

Recently, a single case of (uncovered) SEMS placement for stenosis of the descending colon secondary to acute diverticulitis in a patient who was unresponsive to the first stent (uncovered) was reported. Because the diagnosis was uncertain, a formal left hemicolectomy was performed, showing no evidence of malignancy in the surgical specimen<sup>[11]</sup>. The 2010 American Society for Gastrointestinal Endoscopy guidelines for the management of patients with colonic obstruction suggested that colonic SEMS placement could have a limited benefit as a bridge to surgery in the setting of nonmalignant colonic obstruction<sup>[12]</sup>. In contrast, the European Guidelines strongly recommend colonic stenting for diverticular stenosis<sup>[3]</sup>.

Table 1 shows the evidence from the literature regarding the use of SEMSs in diverticular disease.

### **SEMSs in benign postsurgical anastomotic strictures**

An anastomotic stricture (AS) is a late complication of colorectal surgery that occurs in up to 30% of patients and is defined as the impossibility of passing a 12-mm endoscope through the anastomotic rim<sup>[13]</sup>. Traditionally, AS has been treated by endoscopic dilation (pneumatic or mechanical), but the rate of recurrence remains high<sup>[14]</sup>. A recent systematic review<sup>[15]</sup> evaluated the role of SEMSs as a possible therapeutic strategy for complications related to colorectal surgery [such as anastomotic leakage (AL), fistula, and stenosis] to avoid further intervention. Thirty-two studies were considered, including 223 patients. In 26 studies, the clinical indication for SEMS was AS with a long-term success rate for postoperative strictures of approximately 50%<sup>[14]</sup>. For AS refractory to multiple sessions of dilation, the use of biodegradable (BD) polydioxanone stents has been proposed<sup>[14,16]</sup>. These stents are both expandable and reabsorbable (complete degradation within 4-5 mo after implantation), allowing a constant radial dilation (at least for the first 5 wk), comparable to that of metallic stents, without the need to be removed. Repici *et al*<sup>[14]</sup> treated 11 patients with AS using BD stents, with an overall success rate of 45%. Surgical resection was required in 2 patients, while early stent migration (within 2 wk) occurred in 4 patients. The unexpectedly high rate of migration was related to stent design, as it was originally intended for the treatment of esophageal strictures. However, constant dilatation ensures a patent colonic lumen over 4-5 mo (mean patency 4 mo until BD stent dissolution) due to the subsequent remodeling of the tissue around the stent<sup>[14]</sup>. These promising findings were confirmed by the study by Pérez Roldán *et al*<sup>[16]</sup> involving 7 patients with refractory AS: Technical and clinical success was achieved in 4 patients; early stent migration occurred in 1 patient, additional BD stent replacement was required in 3 patients, and stent placement failed in 1 other patient because of tight angulation. To avoid early migration, the distal extremity of the stent was fixed using either fibrin glue or metallic clips, while the proximal end (placed in the rectum or in the distal sigmoid colon) was impossible to



**Table 1 Stenting in diverticular disease**

Ref.	Number of patients	Type of study	Single vs multicenter	Mean age (range)	Site of obstruction	Stent type	Early adverse events	Duration of stenting	Outcome
Baron <i>et al</i> <sup>[28]</sup> , 1998	3	Prospective	Single center	63 yr (19-89)	Sigmoid colon	Wallstent <sup>1</sup>	2 migration	Not stated	3 BTS
Tamim <i>et al</i> <sup>[63]</sup> , 2000	3	Prospective	Single center	Not stated	Sigmoid colon	Wallstent <sup>1</sup>	None	Not stated	2 BTS, 1 declined surgery
Meisner <i>et al</i> <sup>[64]</sup> , 2004	5	Retrospective	Single center	Not stated	Sigmoid colon	Wallstent, Ultraflex <sup>1</sup> , Memotherm <sup>2</sup>	1 migration, 1 fistula	Not stated	1 Hartman after migration, 2 BTS, 1 early removal, 1 death
Suzuki <i>et al</i> <sup>[47]</sup> , 2004	6	Retrospective	Single center	67 yr (43-91)	Sigmoid colon	Ultraflex, Wallstent <sup>1</sup> , Memotherm <sup>2</sup>	2 migration, 1 reobstruction	7.5 mo	6
Syn <i>et al</i> <sup>[65]</sup> , 2004	3	Prospective	Single center	75.2 yr (42-92)	Sigmoid colon/Rectum	Uncovered; Ultraflex, Wallstent <sup>1</sup>	None	3-24 d	1 unable to pass wire: Colostomy, 2 BTS
Stefanidis <i>et al</i> <sup>[66]</sup> , 2005	1	Retrospective, case report	Single center	63	Sigmoid colon	Wallstent <sup>1</sup>	1 reobstruction	139 d	BTS but stoma
Athreya <i>et al</i> <sup>[67]</sup> , 2006	3	Retrospective	Single center	75 yr (46-102)	Sigmoid colon	Ultraflex, Wallstent <sup>1</sup> , Memotherm <sup>2</sup>	None	Not stated	3 palliation
Jost <i>et al</i> <sup>[68]</sup> , 2007	7	Prospective	Single center	67.3 yr (25-93)	Sigmoid colon/Descending/Rectum	Wallstent <sup>1</sup>	1 migration, 1 reobstruction, 2 perforation	Not stated	7 BTS
Small <i>et al</i> <sup>[10]</sup> , 2008	16	Retrospective	Single center	66 yr (41-97)	Sigmoid colon/Descending/Rectum	Ultraflex, Wallstent <sup>1</sup>	2 perforation, 4 reobstruction	30 d	14 BTS, 2 declined surgery
Pommergaard <i>et al</i> <sup>[69]</sup> , 2009	7	Retrospective	Single center	76.6 yr (46-97)	Sigmoid colon/left flexure	Ultraflex, Wallstent <sup>1</sup>	1 migration, 1 reobstruction, 3 perforation, 2 mortality	8 d (BTS) 91 d (palliation)	5 BTS, 2 palliation
Forshaw <i>et al</i> <sup>[7]</sup> , 2010	3	Retrospective	Single center	67 yr (47-89)	Sigmoid colon	Wallstent <sup>1</sup>	1 migration, 1 failure to decompress	17 d (range 5-30)	2 BTS, 1 failure of stent placement
Keränen <i>et al</i> <sup>[9]</sup> , 2010	10	Retrospective	Single center	72 yr (58-89)	Not indicated	Uncovered and covered. Ultraflex, Wallstent <sup>1</sup>	3 perforation, 1 colorectal fistula, 1 abscess	21 d	2 BTS, 5 palliation 3 emergent surgery for perforation
Arya <i>et al</i> <sup>[70]</sup> , 2011	2	Retrospective	Single center	69.4 yr (46-85)	Sigmoid colon	Wallstent <sup>1</sup>	None	Not stated	2 BTS

<sup>1</sup>Wallstent, Wallflex, Ultraflex, Boston Scientific;<sup>2</sup>Memotherm, Bard, Angiomed, Karlsruhe, Germany. BTS: Bridge to surgery.

reach and fix because of the stiffness of the 8 mm positioner, which was unable to pass through the sigmoid colon<sup>[16]</sup>.

### SEMS in benign postsurgical anastomotic leakage

AL and anastomotic fistulas (AFs) are potential complications in patients undergoing colorectal surgery, with a prevalence ranging from 3% to 22%<sup>[17]</sup> and a reversal rate of diverting stoma lower than 50%<sup>[15]</sup>. A systematic review by Arezzo *et al*<sup>[15]</sup> analyzed 17 studies, including 68 patients treated with SEMSs for AL and AF, and demonstrated a high success rate with healing in approximately 75% of the patients. The use of SEMSs for AL and AF should be carefully evaluated and should take into account some important recommendations: (1) The use of SEMSs should be avoided when sepsis is present; (2) Patients with low AL (< 1 cm above the dentate line) are not suitable for the procedure because of patient discomfort and significant risk of migration<sup>[15,17]</sup>; and

(3) Uncovered metal stents should not be used because of ingrowth and risk of perforation<sup>[15]</sup>. When a perirectal abscess is present, it must be drained before stent placement, as the stent impairs the drainage of the purulent material into the lumen. In a case series by Lamazza *et al*<sup>[17]</sup>, 22 patients underwent SEMS placement for symptomatic anastomotic leakage (at least 30% of the anastomotic circumference) after CRC resection. In 19 patients (86%), the leak was resolved, and the diverting ileostomy could be closed, restoring the physiological bowel transit. Therefore, the use of SEMS in this setting seems very promising and encouraging.

### **SEMS in fistulas of the lower gastrointestinal tract**

Colovaginal fistulas most frequently result from obstetric trauma but may also occur after difficult hysterectomy or secondarily to the extension or rupture of perirectal, perianal or Bartholin's abscesses; to any surgical procedures involving the posterior vaginal wall, the perineum, or the anorectal region; and to radiation damage<sup>[19]</sup>. Crohn's disease (CD) also represents a relevant cause<sup>[18]</sup>.

Especially in older women, colovaginal fistulas can represent a complication of diverticulitis, CRC or fecal impaction. Even treatments for pelvic organ prolapse, such as pessaries<sup>[20]</sup> and various mesh repair procedures, have been associated with fistulas<sup>[21]</sup>.

Many surgical options and techniques are available to treat benign colorectal fistulas. However, for patients who were not treated successfully with prior operative interventions, namely, patients with an unfavorable abdomen or pelvis or severe comorbidities or patients trying to avoid fecal diversion, endoluminal therapies may be a suitable alternative. SEMS placement for the treatment of enteric fistulas in patients with malignancies has been reported, with the resolution of the fistula in all cases<sup>[22,23]</sup>. In 2008, Abbas *et al*<sup>[24]</sup> reported 2 cases of benign colovaginal fistula, one occurring after sigmoid resection for diverticulitis and one following hysterectomy and radiation therapy for cervical cancer. Technical and clinical success was obtained only in the first patient (through the placement of a covered stent), whereas in the second patient, stenting failed due to the high grade of associated fibrosis and inflammation and the sharp colonic angulation that hindered a safe advancement of the endoscope<sup>[24]</sup>. The latter may constitute a technical limitation to the procedure. In many patients, fistulas are associated with strictures, and often, the narrowed lumen can only be traversed with a wire under fluoroscopic guidance, making it difficult to assess the exact location of the fistula within the stricture due to the lack of direct endoscopic visualization. The accurate localization of the fistula is crucial for the proper positioning and deployment of the covered stent.

Currently, there are no society guidelines regarding SEMS placement in this context.

### **SEMS in endometriosis**

Endometriosis is a disorder characterized by the growth of endometrial tissue outside the uterus (most frequently involving the adnexa of uterus) and is diagnosed in up to 15% of premenopausal women<sup>[25,26]</sup>. The bowel is involved in 5%-15% of patients, with a rectosigmoid location in 90% of cases. Nevertheless, stricture formation is rare, and an acute obstruction of the large bowel requiring intervention is reported in less than 1% of cases<sup>[25,26]</sup>. Regarding acute obstruction by malignant stenosis, emergency surgery is associated with higher rates of mortality and stoma creation. Furthermore, abdominal surgery in these patients may be complex due to concomitant pelvic endometriosis, requiring a multidisciplinary approach and the presence of both the colorectal surgeon and the gynecologists in the operating room<sup>[26]</sup>. For these reasons, SEMSs may allow for multidisciplinary team evaluation, providing a safe option as a bridge to elective and definitive surgery<sup>[25-28]</sup>, even if a laparoscopic approach (with the ablation of endometriosis nodules) and hormonal therapy are actually the standard of care in this setting. No society guidelines exist for SEMS placement in the context of endometriosis.

### **SEMS in radiation colitis**

A case of radiation-induced colonic stricture treated with a SEMS was first reported by Yates *et al*<sup>[29]</sup> in 1999. A 73-year-old man affected by a sigmoid stricture secondary to pelvic irradiation for prostate cancer ten years earlier underwent SEMS placement with resolution of the acute colonic obstruction. However, the authors reported stent dislodgment 19 d later associated with bleeding due to the telangiectatic sigmoid mucosa.

Since then, few cases of SEMS placement for radiation colitis have been reported. The largest series included 3 patients from a 7-year prospective database of benign colonic stricture<sup>[10]</sup>. Unfortunately, 1 patient was lost to follow-up, while the other 2 developed complications, namely, immediate perforation of the cecum (probably due



to overdistension) and small bowel obstruction two months later due to collapse of an ileal stent (placed because of the coexistence of small and large bowel obstruction). The small numbers of other cumulative case series<sup>[8]</sup> do not allow us to draw any definitive conclusion regarding the use of SEMS in this setting. Furthermore, concerns arise from the specific characteristics of the irradiated colon: The mucosa is friable and thus more prone to bare metal wire damage and subsequent bleeding<sup>[10,29]</sup>; the atrophic mucosa may prevent the embedment of the stent, promoting its migration<sup>[7]</sup>; last, the radiation damage may result in the stricture being particularly stiff, hampering the clinical success of SEMS<sup>[30]</sup>. No guidelines exist for SEMS placement in the context of radiation colitis.

### **SEMS in ischemic colitis**

The use of SEMSs in the setting of ischemic colitis has not been widely reported. In a study by Forshaw *et al*<sup>[7]</sup>, one patient with suspected ischemic stenosis was treated with uncovered SEMS placement. After five months, the stent migrated distally and was removed; the patient remained asymptomatic thereafter<sup>[7]</sup>.

In 2009, another case was reported as bridge to surgery in a 76-year-old woman affected by colonic obstruction due to radiation. The outcome was satisfactory, and the obstruction resolved without complications, allowing for elective colonic resection without the need for a stoma. The diagnosis of chronic ischemic colitis is made based on clinical, endoscopic and pathological findings<sup>[31]</sup>. Despite the scarceness of published cases and the subsequent lack of recommendations from society guidelines, endoscopic stenting may be considered a bridge to surgery for ischemic colitis to reduce the need for emergency surgery and stoma creation, as shown in other forms of colorectal benign obstruction.

### **SEMS in IBD**

Stenosis is a frequent complication of CD, occurring in one-third of patients within 10 years after the diagnosis<sup>[32]</sup>. After initial ileocolic resection, over 40% have recurrent obstructive symptoms after 4 years<sup>[33]</sup>. CD strictures occur more frequently in the small intestine than in the colon (64% *vs* 5%, respectively). Stenosis recurrence after stricturoplasty occurs in 2.8%-5% of cases<sup>[34,35]</sup>. The high rate of recurrence suggests that, when possible, conservative treatment should be preferred to avoid repeated surgery. Currently, the treatment of choice is endoscopic balloon dilatation (EBD)<sup>[36]</sup>. Uncontrolled observational studies report that EBD is a safe and effective alternative to surgery in selected patients, with success rates ranging from 44% to 58%<sup>[37-42]</sup>.

In the latest European Crohn's and Colitis Organization guidelines, EBD is the recommended treatment in patients with short ileocolonic strictures (< 4 cm) and anastomotic stenosis, while no mention is made about the use of stents<sup>[43]</sup>. Information regarding the efficacy and safety of SEMSs in the context of CD strictures is limited and inconclusive. Since 1997, various case reports (with a total of 12 patients) and 4 small case series (ranging from 5 to 17 patients) have been published<sup>[9,10,44-55]</sup>. Covered colonic metallic stents were mainly used. The most frequent indication for stent placement was a bridge to surgery. For these reasons, it is difficult to draw conclusions regarding the use of stents in this clinical context and to predict long-term outcomes<sup>[9,10,44-51]</sup>.

In 2012, Loras *et al*<sup>[55]</sup> published a retrospective multicenter cohort study involving CD patients treated with SEMSs. Seventeen patients affected by stenosis shorter than 8 cm were treated with the placement of 25 stents (4 partially- and 21 fully-covered SEMS): in 1 case, 2 stents were placed for the treatment of 2 locations of colonic stenosis; in 5 cases, due to stent migration or impaction, another SEMS had to be placed. Clinical success was achieved in 64.7% of patients with a mean follow-up of 67 wk. In 4 patients (16%, 50% partially covered stents), stent removal was technically difficult due to stent adherence to the bowel wall. Over half of patients (52%) presented spontaneous distal stent migration secondary to the resolution of the stenosis (11 of the 13 patients). Endoscopic treatment of a short CD stricture could prevent or delay the need for surgical resection, and both EBD and SEMSs may be considered before surgery is performed. In particular, SEMS could be considered in patients who are not good candidates for EBD because of the presence of stenosis longer than 4 cm or complex strictures or due to the presence of a fibrotic stricture rather than a mixed fibrotic/edematous stricture. The use of fully-covered SEMSs could prevent adherence to the bowel mucosa and therefore facilitate removal; however, the likelihood of distal stent migration is higher. In contrast, partially-covered SEMSs can prevent distal stent migration but have an increased risk of adherence to the bowel mucosa, with consequent removal difficulties. The very limited experience with BD stents hampers a correct assessment of the outcome in this clinical condition. However, this could represent a promising option since removal is unnecessary and a longer effect is possible<sup>[56,57]</sup>. Another field of application of fully-

covered SEMSs in IBD patients is the treatment of iatrogenic perforations. In a prospective cohort study, 9 patients [of whom 2 were ulcerative colitis (UC) patients] underwent fully-covered SEMS placement for perforation, postoperative fistula or leakage, or complete anastomotic disunion. Clinical success with evidence of significant healing of the bowel wall occurred in all patients after 3-8 wk of follow up, and no patients required surgery<sup>[58]</sup>.

Interestingly, Di Mitri *et al.*<sup>[59]</sup> proposed colonic stenting as an endoscopic rescue treatment in a pregnant patient affected by UC and colonic stricture, allowing us to bring the pregnancy to term without the need for surgery. It is important to stress that a colonic stricture in the context of UC should be considered malignant until histology excludes the presence of tumor; if adequate biopsy sampling is not possible or inconclusive, surgery should be considered as the standard of care<sup>[60]</sup>. No guidelines exist for SEMS placement for IBD patients.

Table 2 shows the evidence from the literature regarding the use of SEMSs in IBD.

## SEMS IN THE PEDIATRIC SETTING

Evidence regarding the use of endoscopic stents for colonic strictures in children is very scarce. Furthermore, there are no commercially available colonic stents for pediatric patients, and therefore, stents approved for other gastrointestinal districts have been used, according to the child's age<sup>[61]</sup>. Both plastic self-expandable stents and SEMSs (2 cases) have been used for AS following surgery for Hirschsprung's disease or total colonic aganglionosis (Zuelzer-Wilson syndrome)<sup>[61,62]</sup>. Stent migration was frequent and required repeated stent placement. Moreover, tenesmus was a common complaint since the stents were located in close proximity to the dentate line due to the sensitive mucosa of the anal verge. No guidelines exist for SEMS placement in pediatric patients.

## CONCLUSION

The present review aimed to assess the evidence regarding the use and expected benefits of SEMSs in nonmalignant diseases of the lower gastrointestinal tract. Literature concerning this approach is missing, and robust data from randomized trials or large prospective studies are still lacking.

Because of such scarceness of data, the available international guidelines for specific settings (such as endometriosis, IBD, radiation colitis) do not consider the use of SEMSs and are not able to guide the endoscopist with a decisional algorithm for SEMS placement.

Although it may be technically feasible to proceed to stenting, the use of SEMSs is usually indicated after the failure of other endoscopic or nonendoscopic treatments and in carefully selected patients (such as patients unfit for surgery).

Nevertheless, the use of SEMSs has been investigated and seems promising in specific settings, such as CD-related strictures, AF, AL, and endometriosis.

In other settings, including AF, AL, and ischemic and radiation colitis, the number of patients enrolled in published studies is too low to draw firm conclusions.

In CD strictures, data arising from the literature show that endoscopic stenting should be considered in patients with stenosis not suitable for EBD (strictures longer than 4 cm or complex and fibrotic strictures, rather than mixed fibrotic/edematous strictures) and could prevent or delay the need for surgical resection in surgical candidates.

In AF and AL after colorectal surgery, the use of fully-covered SEMS leads to healing and resolution without the need for subsequent surgery in approximately 75% of patients. Requirements for a successful procedure included previous drainage of perirectal abscesses, absence of systemic infection (*i.e.*, sepsis) and localization of the lesions > 1 cm above the dentate line<sup>[13]</sup>.

The use of SEMSs has been evaluated in endometriosis stenosis, a rare manifestation of the disease that usually requires emergency surgery and that is associated with high rates of mortality and stoma creation. As demonstrated by several case reports, the stenting of the stricture provides a safe bridge to elective and definitive surgery, avoiding stoma creation and its inevitable subsequent psychological drawbacks, even if a laparoscopic approach (with the ablation of endometriotic nodules) and hormonal therapy are actually the standard of care in this setting.

In AS, the placement of SEMSs leads to clinical success in approximately half of patients and seems to be a reasonable choice for refractory AS. In this field, the use of

Table 2 Stenting in inflammatory bowel diseases

Ref.	Number of patients	Type of study	Single vs multicenter	Mean age (range)	Site of obstruction	Stent type	Early adverse events	Duration of stenting	Outcome
Keränen <i>et al</i> <sup>[9]</sup> , 2010	2 (1 BTS 1 refused surgery)	Case series	Single center	41 yr (36-47)	Crohn's anastomotic stricture	1 covered 1 uncovered; Wallstent, Ultraflex <sup>1</sup>	None	30 d (pt 1), 4 yr (pt 2)	BTS (pt 1), refused surgery, ileostomy after perforation (pt 2)
Matsushashi <i>et al</i> <sup>[45]</sup> , 2000	2	Case series	Single center	28 yr (27-29)	1 descending colon 1 ileo-colonic anastomosis	Covered steel Z-stent Gianturco Rosch <sup>5</sup>	1 migration	30 d (pt 1), 150 d (pt 2)	Both
Wholey <i>et al</i> <sup>[46]</sup> , 1998	1	Case report	Single center	Not indicated	Anastomotic stricture in the descending colon	Wallstent <sup>1</sup>	None	21 d	Elective surgery 3 wk after stent placement
Suzuki <i>et al</i> <sup>[47]</sup> , 2004	2	Case series	Single center	Not indicated	Not indicated	Wallstent, Ultraflex <sup>1</sup> , Memotherm <sup>2</sup>	1 reobstruction (pt 1)	30 d (pt 1), 90 d (pt 2)	Colostomy and stent removal in pt 2 for abscess after 3 mo
Wada <i>et al</i> <sup>[48]</sup> , 2005	1	Case report	Single center	25 yr	Sigmoid colon	Covered metallic Gianturco Rosch <sup>5</sup>	None	32 mo	Perforation of the stent and ileosigmoid fistula: Ileostomy and resection
Bickston <i>et al</i> <sup>[49]</sup> , 2005	1	Case report	Single center	49 yr	Terminal ileum (refractory to balloon dilation)	Wallstent <sup>1</sup>	None	60 d	Yes
Dafnis <i>et al</i> <sup>[50]</sup> , 2007	1 (unfit for surgery)	Case report	Single center	65 yr	Recto-sigmoid junction	Uncovered; Wallstent <sup>1</sup>	None	126 d	Second and third coaxial uncovered walls tent for ingrowth (after 126 and 267 d)
Martines <i>et al</i> <sup>[51]</sup> , 2008	1 (BTS)	Case report	Single center	45 yr	Ileocolic anastomosis	Covered; Niti-S <sup>3</sup>	None	7 d	Scheduled surgery
Levine <i>et al</i> <sup>[52]</sup> , 2012	5	Retrospective	Single center	49 yr (29 - 67)	4 ileocolic anastomosis 1 ileosigmoid anastomosis	Uncovered; Wallflex, Wallstent <sup>1</sup>	1 reobstruction at 3 wk	34.8 mo (4.5-109)	Yes
Attar <i>et al</i> <sup>[53]</sup> , 2012	11	Prospective	Single center	34 yr (18-66) refractory to previous balloon dilation	8 ileocolic anastomosis 1 ileosigmoid anastomosis 2 terminal ileum	7 Hanarostent <sup>4</sup> , 4 Niti-S <sup>3</sup>	1 failure due to angulation 1 ingrowth 8 migration	15 d (1-35)	5 surgery 5 scheduled remotion of stent
Branche <i>et al</i> <sup>[54]</sup> , 2012	7	Prospective	Single center	50 yr (36-59)	5 ileocolic anastomosis 2 ileosigmoid anastomosis	Partially Covered; Hanarostent <sup>4</sup>	None	7 d	Yes
Loras <i>et al</i> <sup>[55]</sup> , 2012	17	Retrospective	Single center	45.7 yr (21-62) refractory to previous balloon dilation	Colon and ileocolic anastomosis	4 partially covered and 21 fully covered (Hanarostent <sup>4</sup> and Niti-S <sup>3</sup> ) (5 for stent migration, 2 stents for 1 stenosis)	1 proximal migration requiring surgery 13 spontaneous migration (11 after resolution of stenosis)	28 d (range 1-112)	Treatment was successful in 11 of 17 patients (64.7%)

Rejchrt <i>et al</i> <sup>[36]</sup> , 2011	11	Prospective	Single center	43 yr (32–58)	2 colon, 1 ileum, 8 ileocolic anastomosis	Biodegradable stent; SX-ELLA <sup>5</sup>	1 failure to release, 3 spontaneous migration	4 wk for degradation	After median of 16 mo symptom free if no migration occurred
Di Mitri <i>et al</i> <sup>[59]</sup> , 2017	1	Case report	Single center	28 yr	Sigmoid colon (UC 29 wk of pregnancy)	Covered; Niti-S <sup>3</sup>	None	75 d	Removed after delivery

<sup>1</sup>Wallstent, Wallflex, Ultraflex, Boston Scientific;<sup>2</sup>Memotherm, Bard, Angiomed, Karlsruhe, Germany;<sup>3</sup>Niti-S, Taewong Medical, Korea;<sup>4</sup>Hanarostent, M.G. Lorenzatto, Italy;<sup>5</sup>SX Ella, Ella S.C., Czech Republic;<sup>6</sup>Gianturco-Rosch stent, Co. BTS: Bridge to surgery; UC: Ulcerative colitis.

BD stents is promising, as confirmed by preliminary results in the literature<sup>[14,16]</sup>.

A greater amount of data is available regarding the role of SEMSs in acute diverticulitis. The high rate of complications associated with bowel inflammation (migration, perforation) generally contraindicates stenting, and this is also supported by the ESGE guidelines<sup>[9]</sup>. However, among patients unfit for surgery<sup>[9]</sup> or undergoing surgery within 1 mo<sup>[10]</sup>, placement of a stent could represent exceptions and possible indications in the presence of a fibrotic stricture.

In conclusion, stenting may play a role in the palliative management of benign colorectal strictures in selected cases, both as a palliative measure and a bridge to surgery, but it should be preceded by careful patient counseling regarding the expected benefits, as well as the possible adverse events. Because of the limited evidence available, SEMS placement in the context of benign disease should currently be considered “off-label” and should be considered as an alternative treatment after multidisciplinary evaluation and, when possible, in the setting of clinical trials. Evidence of the long-term efficacy and safety of such interventions requires further study. Improvement in stent design, to overcome the risk of adverse events, such as stent migration and bowel perforation, is mandatory.

In the near future, the evolution of materials and devices, as well as the creation of a database specifically targeting colonic pathology, may bring about changes to what is stated in this review.

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