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Status and Literature Review of Self-Expandable Metallic Stents for Malignant Colorectal Obstruction

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Use of colorectal stents has increased dramatically over the last decades. Colorectal stents offer an alternative way to relieve fatal intestinal obstruction and can take place of emergency surgery, which associated with significant morbidity and mortality and a high incidence of stoma creation, to elective resection. Although there remain a few concerns regarding the use of stents as a bridge to surgical resection, use of self-expandable metallic stents for palliation in patients with unresectable disease has come to be generally accepted. Advantages of colorectal stents include acute restoration of luminal patency and allowance of time for proper staging and surgical optimization, and the well-known disadvantages are procedure-related complications including perforation, migration, and stent failure. General indications, procedures, and clinical outcomes as well as recent evidences regarding the use of colorectal stents will be discussed in this review.

Key Words: Colorectal neoplasms; Obstruction; Self-expanding metallic stents

INTRODUCTION

Colorectal malignancy can cause acute intestinal obstruction, which is a life-threatening condition warranting emergency decompression. If left untreated, colorectal obstruction causes rapid distension of bowel loops, progressing from abdominal pain, nausea, and vomiting to intestinal ischemia, intestinal rupture, sepsis, and eventual death. Despite recent efforts to diagnose colorectal cancer in its early stages, 7% to 29% of patients with primary colorectal cancer present with acute obstructive symptoms.¹⁻⁶ Before the introduction of colorectal stents, surgical decompression was the mainstay of treatment. Some of the earliest endoscopic interventions included neodymium: yttrium-aluminum-garnet laser debulking and rectal tube placement. Endoluminal laser debulking for malignant rectosigmoid obstruction reportedly provides successful relief

in 85% of patients; however, this technique required several repeated sessions to obtain sufficient patency and obstructing cancer with large mass responds poorly.^{7,8} A rectal or nasogastric tube can be used to decompress the obstruction; however, placing the flexible rubbery tube past the hard obstructive segment can be very difficult.⁹ In 1991, Dohmoto et al.¹⁰ first reported the use of expandable metal stents. Three years later, in 1994, Tejero et al.¹¹ reported that colorectal stenting was useful in preoperative settings and allowed elective surgery to be performed later. Following these preliminary experiences, several studies have reported the successful management of malignant colorectal obstruction by using self-expanding metallic stents (SEMSs).¹²⁻¹⁵ With the introduction of colon-specific stents, this technique has gained popularity and has been progressively accepted as a standard modality. Currently, stenting is employed as an effective alternative to emergency surgery in the management of patients with malignant colorectal obstruction and change the role of endoscopy physician more active in this condition.¹⁶⁻¹⁹

NEED OF AN ALTERNATIVE TO SURGERY

Most patients presenting with obstructive colorectal cancer have advanced stage disease, are often elderly, and in poor

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medical condition. In addition to these factors that can adversely affect the outcomes of surgery, emergency surgery on an unprepared colon may cause significant morbidity and mortality.⁴

Over the years, the standard treatment for malignant colorectal obstruction has evolved from multiple-stage to single-stage surgery. A three-stage surgery includes the creation of a colostomy to relieve the obstruction, followed by a second surgery to resect the tumor, and then a third one for colostomy closure. This approach results in prolonged hospital stay, and the outcome is generally not favorable. Recently, a 2-stage strategy with primary resection of the tumor, closure of the rectal stump, and proximal-end colostomy (Hartmann procedure) followed by reversal of colostomy has become increasingly popular. However, the mortality and morbidity rates of emergency surgery remain high, i.e., up to 10% and 60%, respectively, and in 40% to 60% of patients, reversal of colostomy is not possible owing to advanced disease or the presence of significant comorbid conditions.²⁰⁻²² It is well known that the stoma itself causes a profound adverse effect on the quality of life of these patients.

A single-stage resection and anastomosis operation is a better strategy for patients with resectable colorectal malignancy. However, a single-stage operation is technically more difficult than a simple decompression surgery, and not all patients are suitable for this option. Apart from an unprepared colon, which can be managed with intraoperative lavage, general medical conditions associated with age and cancer stage could be obstacles to a single-stage operation.^{22,23} Based on the results of a previous survey, primary anastomosis is more likely to be performed by colorectal consultants than by general surgeons and unsupervised trainees.²⁴ Surgical experience and expertise also play a primary role in the choice of operation and its final outcome.

Timing of surgery also matters in the treatment strategy for colorectal malignancy. These poor outcomes are significantly higher than those of the elective surgery, where the mortality ranges between 0.9% to 6.0%.²⁵

Given these considerations, stenting for acute colorectal obstruction has value in that it provides effective and safe decompression and patency of the bowel as well as provides time for nutritional, medico-oncological, and psychological supports to enable a safer and more effective surgical resection for obstructing colorectal cancer.

INDICATIONS FOR COLORECTAL STENTING

The two main indications for stenting in malignant colorectal obstruction are: 1) preoperative colorectal decompression

before elective surgery (the so called bridge to surgery) and 2) palliation of obstructing malignancy not suitable for curative surgical resection. In emergency settings, the use of SEMSs is proposed to provide a sufficient opening of neoplastic strictures and relieve acute obstruction.

Bridge stent to surgery

Preoperative stenting should be considered in patients with obstructive symptoms and resectable diseases. SEMS insertion relieves colorectal distension and obstruction, provides stabilization of the acute illness, and enables preoperative bowel preparation and preoperative colonoscopy to assess for synchronous cancers. Patients can undergo a single-stage operation with primary anastomosis, even with a laparoscopic approach in a more elective and better prepared condition.

Previous studies have encompassed debates and reported inconsistent findings regarding the efficacy and safety of preoperative stenting. Studies from the Netherlands and France have reported poor clinical outcomes of stenting. A group of Dutch investigators reported a higher rate of significant complications such as perforation and anastomotic leakage in the stenting group.²⁶ They used the enteral Wallstent (Boston Scientific, Natick, MA, USA), and perforation occurred in 12.8% of the stenting group patients. The study was prematurely suspended owing to a significant increase in the absolute risk in the stenting group in the interim analysis. A group of French investigators reported no advantages of the stenting group over emergency surgery patients with regard to clinical outcomes.²⁷ Stent placement was successful only in 46.7% of the patients, and perforation occurred in 6.7% of the patients. However, certain doubts have been raised regarding the validity of the results of these two studies. The technical success rate of stenting is reportedly >85% in Western reports and >95% in Korean studies.^{19,28,29} The risk of perforation does not exceed 5% in most literatures. Compared with these reports, the Dutch and French studies reported extraordinarily higher rates of stent failure and perforation occurrence. In the absence of other possible explanations, we can suppose that the investigators' expertise or the quality of the interventional endoscopists may have influenced the poor clinical outcomes. In contrast, a group of Spanish investigators have reported results opposing those reported by the above two studies.³⁰ They conducted a randomized study comparing the outcomes of the use of bridging stents and intraoperative colonic lavage with those of primary anastomosis. This study was suspended when excess morbidity was observed in the intraoperative colonic lavage group. No case of perforation was found in the stent group, and no difference in survival was observed between the two groups. The Cochrane Database has assumed a modest position regarding preoperative stenting. In this report, five randomized trials

were analyzed, and the mean success rate of stenting was found to be 86.02%. The overall complication rate of stenting was observed to be 39.22%, which is not different from the 45.71% complication rate of emergency surgery. Perforation occurred in 5.88% of the patients. The advantages of colorectal stenting include a shorter hospital stay and procedure time and less blood loss.³¹ In summary, clinical outcomes seem to depend on the technical success rate and safety of the procedure, which can vary depending on the expertise of the investigators and training systems of different regions.

Palliative stenting

Up to 19% of patients presenting with acute colorectal obstruction already have distant metastases at the time of diagnosis, and two-thirds of those patients are considered unsuitable for curative surgery.^{5,6} Use of SEMSs, instead of surgical colorectal resection or stoma creation, can provide effective decompression and restoration of colorectal luminal patency in such patients with advanced unresectable diseases or in those considered medically unfit for surgery.

Contraindications to colorectal stenting

Absolute contraindications to colorectal stenting are as follows: 1) perforation documented with free intraperitoneal air, 2) very distal rectal lesions within 5 cm from the dentate line, and 3) disseminated peritoneal carcinomatosis and multifocal enteral stenotic segments. Relative contraindications include anatomical difficulties such as a long stricture segment or strictures positioned in tortuous colorectal segments and bowel ischemia.²⁹ Uncorrectable coagulopathy is a relative contraindication for SEMS placement, and in case of prolonged bleeding times, stenting can be performed after administration of fresh frozen plasma and platelets, as necessary.

Colorectal stents in extrinsic compression

Extracolorectal malignancies can cause colorectal obstruction. Common origins of these conditions include gynecologic, pancreatic, bladder, and prostatic cancers, and colorectal obstruction can be caused by luminal compression or colorectal wall invasion. Compared with patients with primary colorectal cancer, those with the above conditions often have a morphologically complex anatomy and multiple stenotic segments. Patients who have undergone previous debulking surgery and/or chemoradiotherapy may have adhesion in addition to possible peritoneal carcinomatosis, and these factors in combination can result in bowel immobilization and may contribute to decreased success and increased complication rates of colon stent placement in patients with extracolorectal malignancies.^{32,33} It is reasonable that colorectal stenting in this condition should be considered only in those patients in whom de-

compressive surgery is not feasible or alternative therapies have failed. An underlying extracolorectal malignancy is a predictor of failure in colorectal stent placement, and a history of radiation therapy is the sole predictor of complications.³⁴

TYPES AND MATERIALS OF COLORECTAL STENTS

Since the development and testing of the first stent designed for colorectal application in 1998,³⁵ many types of stents have been examined specifically for their use in the lower gastrointestinal tract, and these stents are available in a variety of lengths and diameters; therefore, an appropriate stent can be selected on the basis of factors such as the length of the obstructed segment and structural features of the obstruction.

The framework of a colorectal stent is made up of stainless steel, Elgiloy, or nitinol, and the stent is structured into a mesh tube. Once deployed, the mesh structure of the stent expands over 24 to 72 hours to become incorporated into both the tumor and the surrounding tissue by pressure necrosis, thereby anchoring the stent. Stents designed to resist tumor ingrowth and tissue hyperplasia are covered with a polyurethane, polyethylene, or silicone coating.

Nowadays, stainless steel and Elgiloy stents have been almost completely replaced by nitinol stents, which are magnetic resonance imaging compatible and allow improved elasticity and conformability. Computed tomography (CT) colonography may be safely used for the preoperative examination of the proximal colon after metallic stent placement in patients with acute colon obstruction caused by cancer.³⁶

Delivery systems and techniques

According to the type of delivery system, stents are classified into through-the-scope (TTS) type and over-the-wire (OTW) type stents. In TTS type stents, the stent mesh frame is folded and mounted on a small-sized catheter that can pass through an endoscope with a working channel. Endoscopes by Olympus (Tokyo, Japan) have working channels of 2.8 mm for gastroscopes, 3.2 mm for colonoscopes, and 3.7 mm for therapeutic endoscopes. Because nitinol SEMSs are very flexible and 2.0- to 2.5-cm-diameter mesh frames can be mounted on small-caliber delivery systems, stents with <11 Fr diameters can be delivered through the scope to the sites of obstruction, including those in the ascending colon. Stents with >3.0-cm diameters are mounted on larger delivery systems and cannot pass through the working channel of the endoscopes. Stents with ≥11 Fr diameters are inserted using the OTW technique. Even a TTS type stent can be inserted using the OTW technique if the therapeutic scope cannot reach the stenotic segment. The decision regarding what size stents should be used

can be based on the premise that stents with larger diameters are supposedly better suited to accommodate in the left colon. However, there is no evidence suggesting that the stent diameter influences the outcomes after stenting, and a stent with a larger diameter is not associated with an increased risk of complications even in patients undergoing chemotherapy.³⁷

Covered and uncovered stents

The mesh frame of SEMSs can be bare or covered with thin walls. Uncovered stents have bare spaces between the meshwork, and when deployed in stenotic segments, both the cancerous and the surrounding tissue get incorporated into the mesh wires. This effect enhances the fixation of the stent at the site and decreases the risk of stent migration. In contrast, covered stents have closed spaces between the mesh wires and are resistant to tumor ingrowth inside the stent. Covering of the stent results in a decreased incidence of tumor ingrowth and in stent restenosis but leads to an increased tendency of migration.^{38,39}

This difference is especially important in settings for different stent purposes. In patients requiring preoperative bridging, stents with reliable localization and adequate patency should be preferred. Because tumor ingrowth occurs over time, and if surgery is planned within a few weeks, uncovered stents are better to use than covered stents. For definitive palliation, covered stents are preferred as they can be used for long periods and have the potential advantage of preventing tumor ingrowth and reobstruction. Comparative studies and retrospective analysis of published data seem to indicate that this potential advantage is offset by the tendency of covered stents to migrate more commonly.³⁸ However, in actual practice, available studies comparing the performance of different stents suggest that there is no clear cut advantage of the use of covered SEMSs over that of uncovered SEMSs in patients with malignant colorectal obstruction in either preoperative or palliative settings.²⁸ In a Korean study³⁹ comparing the use of uncovered and covered SEMSs (Niti-S, Colon TTS; Taewoong Medical Co., Seoul, Korea) in 80 patients with malignant colorectal obstruction, there was no obvious advantage of the use of covered stents over that of uncovered stents in the treatment of patients in either preoperative or palliative settings. In the covered stent group, there were nine late complications, including six episodes of stent migration, one reported tumor overgrowth, and two cases of stool impaction. In the uncovered stent group, tumor ingrowth was reported in only three patients. This result is outstanding compared with the results of an old Western pooled analysis²⁸ of colorectal SEMSs that included 54 studies, in which 170 covered SEMSs were placed and 52 (30.5%) were reported to migrate on subsequent follow-up examinations.

PREPARATION AND PROCEDURES FOR STENTING

Before stenting is performed, radiological evaluation with a thin-section CT scan and sagittal-and-coronal-direction reconstructions can be helpful to recognize accurate delineation of relevant anatomy and morphology of the obstruction as well as to detect any extraluminal spread or metastasis of the disease.

Prophylactic antibiotics could be considered in patients with obstruction, as the stenting procedures may cause perforation and bacteremia. To improve endoscopic visualization, use of one or two generous cleansing enemas is usually suggested. However, if there are signs of a septic condition or the impending rupture of the colon, voluminous bowel preparation should be avoided because it may promote worsening of the obstructive symptoms.

Regarding the use of sedatives and analgesics, a combination of a meperidine and a short-acting benzodiazepine is commonly administered in practice. Because abdominal distension due to colorectal obstruction could worsen respiratory suppression by sedatives, proper monitoring is mandatory. In general, colorectal stenting is a well-tolerated procedure with minimal patient pain and discomfort especially if the lesion is located in the distal part of the colon.

Balloon dilatation of stenotic segments after stenting is not recommended because this significantly increases the risk of colorectal perforation.⁴⁰ An experimental study on freshly excised human colon cancer specimens has confirmed that dilation of colorectal cancer strictures is associated with a high risk of perforation.⁴¹ Stricture severity, peritumoral collagen fiber proliferation, an annular growth pattern, and fewer residual proper muscle fibers are predictors of dilatation-associated perforation. Slow SEMS expansion over 1 to 3 days is preferred instead of rapid expansion with balloon dilation.

OUTCOMES FOLLOWING COLORECTAL SEMS PLACEMENT

Twenty years since its introduction to clinical practice, colorectal stenting has evolved, and favorable outcomes following two different indications have been reported by many investigators from different institutions during different periods. Technical success can be defined as the correct opening of the stent across the stricture with the passage of fecal material and absence of perforation. The definition of clinical success varies, but it is most frequently outlined as colorectal decompression with resolution of obstructive symptoms within 72 hours of stent placement. The median technical success rates, which are not strictly related to stent indication, are reportedly

96.2%, ranging from 66.6% to 100%.^{19,28,29} The median rate of clinical success in a recent systematic review was 92%, ranging from 46% to 100%, with extremely variable definitions of clinical success among more than 80 different studies evaluated.¹⁹

Palliative stenting

Use of SEMs for palliative purposes has recently been accepted as a proper alternative to surgical diversion in patients with unresectable disease or inoperable medical conditions. The efficacy of colorectal stenting for palliation in patients with locally advanced or metastatic disease has been well investigated. Xinopoulos et al.¹⁴ conducted randomized controlled trials (RCTs) comparing colostomy with the use of SEMs for palliation of malignant colorectal obstruction. Thirty patients were enrolled, and palliative stenting was successful in 93.3% of the patients (14/15 patients), with no stent-related mortality reported. In 57% of the patients (8/14) in whom the stent was successfully placed, stenting provided long-term colorectal patency until death. Mean survival was 21.4 months in the SEM group and 20.9 months in the colostomy group. Mean hospital stay was significantly higher in patients undergoing colostomy than in those undergoing SEM placement (60 days vs. 28 days). Fiori et al.⁴² reported another RCT in which 22 patients were randomized to either colostomy or SEM placement. Mortality was 0% in both groups, and morbidity was not different between the groups. Compared with the colostomy group, the stent group experienced a shorter time to resumption of oral intake and restoration of colorectal patency and a reduced hospital stay. Both studies suggest superior, or at least not inferior, clinical efficacy and safety of stenting to surgical colostomy.^{14,42} On contrarily, one report by the Dutch Stent-in I multicenter RCT which randomized patients with incurable colorectal cancer to SEM or surgery. WallFlex stents (Boston Scientific) were chosen for use in the stenting group. The study was terminated prematurely after enrolling 21 patients because of a high rate of stent-related perforations, resulting in six perforations and three deaths among 10 patients in the SEM group.^{26,43} However, there is no clear explanation for such a high perforation rate. The investigators expressed certain doubts regarding the safety of WallFlex stents. However, neither consistent results nor supporting data have been reported by other studies using WallFlex stents. Studies using the same WallFlex stents for palliative management of colorectal obstruction have reported a perforation rate of approximately 5%,⁴⁴⁻⁴⁶ and this fact raises operator factor as another possibility for devastating report by the Dutch study group. To date, except for the Dutch Stent-in I multicenter RCT, a few prospective trials and many recent retrospective series have reported findings demonstrating the usefulness of SEMs for definitive palliative treatment of malignant colorec-

tal strictures.⁴⁶⁻⁵⁰

Regarding the economic aspects, a retrospective analysis of the Medicare Provider Analysis and Review dataset was conducted to compare the economic outcomes between patients undergoing colostomy and those undergoing stent placement.⁵¹ The median hospital stay (8 days vs. 12 days; $p < 0.0001$) and the median cost per subject (\$15,071 vs. \$24,695; $p < 0.001$) were significantly lesser for the stent placement group than for the colostomy group. Quality of life and symptom control in patients with colorectal strictures were also investigated in prospective settings.⁵² Patients responded that both SEM placement and surgical diversion provided durable improvement in the symptoms of large bowel obstruction; however, patients with stent placement reported better overall quality of life scores and gastrointestinal symptom-specific quality of life scores.

Bridge to surgery

Mortality and morbidity rates are known to be significantly higher for colorectal surgery in an emergency situation than for elective operation.^{6,53} In patients with malignant colorectal obstruction and resectable disease, colorectal SEM placement can allow colorectal decompression without the morbidity and mortality of urgent surgery. Preoperative SEM placement results in lower procedure-related complication rates, shorter hospital stays, higher rates of primary anastomosis, and lower rates of colostomy compared with urgent surgery.⁵⁴ Mortality with SEM placement is similar to that with emergency surgery, and the complication rate is usually $< 5\%$.^{29,55} The strategy of SEM placement followed by laparoscopic 1-stage resection reportedly results in good patient comfort, a rapid postoperative recovery, and a short hospital stay.⁵⁵⁻⁵⁷ An RCT comparing a bridging SEM-laparoscopic approach (24 patients) with conventional open surgery (24 patients) was published by Cheung et al.⁵⁸ Bridging SEM placement was attempted within 24 to 30 hours of admission, and an elective laparoscopic-assisted resection was performed within 2 weeks of SEM placement. Patients who were randomized to the open surgery group underwent an emergency Hartmann procedure or colectomy with intraoperative irrigation on the same day of admission. In the bridging SEM-laparoscopic group, no stent-related complications occurred. Technical failure occurred in four patients owing to cannulation failure, and SEMs were successfully implanted in the remaining 20 patients (technical and clinical success rates of 83%). Patients in the bridging SEM-laparoscopic group successfully underwent a single-stage operation compared with those in the conventional surgery group (16 vs. 9; $p = 0.04$). None of the patients in the bridging SEM-laparoscopic group had a permanent stoma compared with six patients in the emergency open surgery

group ($p=0.03$).

In contrast, two other RCTs by French²⁷ and Dutch²⁶ investigators reported that preoperative SEMS placement had no advantages over emergency surgery and that the SEMS group had a higher procedure-related complication rate, including perforation, than did the emergency surgery group. Both studies show a similarity in the extraordinarily low success rates of SEMS placement (46.7% to 70%).^{26,27} This fact suggests that lower technical success rates of SEMS placement may be related with higher complication rates and unfavorable long-term outcomes. These conflicting results of studies from Asia and Europe highlight the need for in depth consideration of operator expertise in SEMS placement and crossover studies such as those with Asian operators on European patients.

Concerns regarding the mechanical effects of SEMSs on cancer have been discussed by cancer physicians and surgeons. Subclinical perforation may occur during stent insertion, and SEMS squeezing of the tumor may lead to tumor cell spillage. Increased levels of carcinoembryonic antigen mRNA and cytokeratin 20 mRNA in peripheral blood were observed in patients who underwent SEMS insertion.⁵⁹ The impact of such events on long-term oncologic outcomes is unknown and deserves further investigation. Fortunately, there has been no report of shortened survival in patients undergoing preoperative SEMS placement compared with those undergoing emergency surgery. An English study noted a 3-year survival rate of 80% in 10 patients who underwent SEMS insertion as a bridge to potentially curative resection compared with 74% in 15 patients who underwent emergency resection, after a mean follow-up period of 21 months.¹⁸ The colorectal obstruction itself is well known as poor prognostic factor. In a recent Korean study, the 5-year survival rate was 44% in 24 patients with stage II and III colorectal cancer after SEMS placement as a bridge to surgery compared with 87% in 240 patients who underwent elective surgery for nonobstructing left-sided colorectal cancer.⁵

The cost-effectiveness of SEMSs is another important issue to be evaluated because SEMSs are expensive. It is debated that their high cost may be offset by a shorter length of hospital stay and lower rate of colostomy formation in patients. Analysis studies from European and Western countries such as the USA, Canada, the UK, and Switzerland have reported that preoperative SEMS placement followed by elective surgery is significantly more effective and cost efficient than emergency surgery as a result of reduced complication rates and hospital stay lengths irrespective of the nation's medical expenditure system.⁶⁰⁻⁶³ Preoperative SEMS placement reduced the cost of treatment by £685 in a UK study,⁶² 136 Euros in a European study,¹⁴ and 19.7% in a Swiss study.⁶³

Complications of colorectal SEMS placement

Colorectal SEMS placement is a low-risk procedure with a mortality rate of <1%.^{29,44,46} Complications are defined as early and late, i.e., occurring <30 or ≥ 30 days after the procedure, respectively. Perforation, bleeding, and misplacement occur commonly as early complications. Stent migration, reobstruction, tenesmus, and perforation occur more commonly as late complications.

Stent reobstruction is usually caused by tumor ingrowth or overgrowth and is considered an important factor in the long-term outcomes of SEMS placement. The likelihood of stent occlusion by tumor growth increases with the time elapsed after stent placement because of the natural tendency of cancer to invade local tissues; thus, stent reobstruction occurs more frequently in the setting of palliation of malignant strictures. A systemic review of published data showed a 16% rate of stent reobstruction (49/302) in patients with a palliative SEMS.⁶⁴ In a multicenter European study using Ultraflex precision stents for palliation, the clinical success rate was maintained at 81% at 6 months.⁶⁵ Tumor ingrowth can be overcome by insertion of an additional stent. Stent in stent strategy is becoming the standard treatment for tumor ingrowth or overgrowth.⁶⁶ In a recent Korean study,⁶⁷ factors associated with a favorable outcome in colorectal SEMS placement were identified. Patients with shorter stents (<10 cm) had better outcomes than those with longer stents (≥ 10 cm; $p=0.008$), and patients with a distal obstruction had better outcomes than those with a proximal obstruction ($p=0.015$). Most patients who experienced stent reobstruction were treated successfully by placement of an additional stent.⁶⁷

Stent migration may be asymptomatic or may cause the recurrence of obstructive symptoms or bleeding and/or tenesmus if the stent affects the anorectum. Removal of distally migrated stents from the rectum is not technically difficult and can often be performed manually without the use of an endoscope. The migration rates for uncovered stents range from 3% to 12%, whereas the migration rates for covered stents are reportedly as high as 30% to 50%.⁶⁶ Migration occurs more frequently after chemoradiotherapy because of tumor shrinkage. Other factors that may promote stent migration include stent placement within partially obstructed lesions (those caused by benign disease or extrinsic compression), use of inadequately sized stents, and fecal impaction. Stent migration may also be treated with the insertion of a second stent, or if patency is restored without stent use, a clinical observation strategy can be adopted in specific situations.

Perforation is the most dangerous complication of SEMS placement in patients and can be very alarming for physicians. Perforation can occur at different stages of the procedure or after stent placement. Procedure-related perforation accounts

for 15% to 20% of the cases and is usually related to wire or catheter misplacement or stricture dilation. Overdistension of air in an already dilated proximal bowel may result in a closed-loop perforation away from the site of the lesion. Stent-related perforation may occur because of tumor fracture caused by the radial force of the stent or because of the pressure of the stent ends on the friable mucosa at the border of the tumor.⁴⁶ Overall, the risk of perforation has been estimated to be within 5%.^{6,29,37,40,68} Exceptionally, Dutch prospective trials using Wall-Flex stents reported an unexpected high rate of perforation;^{26,43} however, the underlying reason was unclear. A review on stent-related perforation analyzed a total of 2,287 patients from 82 articles and reported an overall perforation rate of 4.9%.⁶⁹ The perforation rates for palliation and bridge to surgery were not different (4.8% vs. 5.4%; $p=0.66$). More than 80% of the events occurred within 30 days of stent placement, with half of them occurring during or within 1 day of the procedure. Mortality related to perforation was 0.8%, but the mortality rate of patients experiencing perforation was 16.2%. There was no difference in the mortality rates between the palliation and the bridge to surgery groups. Concomitant chemotherapy, use of corticosteroids, and radiotherapy increased the risk of perforation. The overall perforation-related mortality was far lower in these patients than in patients undergoing emergency surgery for bowel obstruction. Bevacizumab-based chemotherapy is emerging as a major risk factor for poststenting perforation.⁴⁰ Several studies have found that bevacizumab therapy nearly triples the risk of perforation and significantly shortens the mean time to delayed perforation.^{40,43,70} The anti-angiogenic effect may weaken the bowel wall and might promote perforation at the site of SEMs pressure. However, this risk could be independent from stenting itself because the addition of bevacizumab to chemotherapy significantly increases the risk of spontaneous gastrointestinal perforation in these patients compared with the controls.⁷¹

Risk factors for technical and clinical failures and complications associated with colorectal SEMs placement include the presence of extrinsic compression, carcinomatosis peritonei, proximal location of obstruction, and stenoses longer than 10 cm.^{47,72} Male sex and completeness of obstruction are also recognized as risk factors for technical failure.⁴⁰ More importantly, operator expertise should be considered an influential factor for successful SEMs placement. Endoscopists who are familiar with wire and catheter manipulation and fluoroscopic image interpretation and are able to advance an endoscope through tortuous and fixed bowel loops are more likely to achieve technical and clinical success without complications.

CONCLUSIONS

With advances in endoscopic and mechanical techniques, use of colorectal SEMs has come to be accepted as an effective and safe therapeutic alternative to surgery for obstructive colorectal malignancy. Although debates continue, colorectal SEMs placement, when performed by endoscopists having sufficient expertise in interventional and therapeutic procedures, is considered to provide reliable colorectal decompression and has lower procedure-related mortality and morbidity than emergency surgery. Colorectal SEMs can be used both for the definitive palliative treatment of patients with unresectable disease and for preoperative bridging to surgery in patients with resectable disease and in those who are considered medically unfit for surgery. Colorectal SEMs placement provides reliable decompression and allows time for preparation for elective surgery. With preoperative bridging SEMs placement, patients with resectable disease can undergo surgery in more favorable medical and surgical conditions. Although SEMs are expensive, economic analyses have proven that the high cost of SEMs is offset by shorter hospital stay lengths and lower rates of colostomy formation in patients. Regarding procedure-related complications, the use of bevacizumab should be considered a risk factor.

Conflicts of Interest

The authors have no financial conflicts of interest.

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