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Gastrointestinal stenting: Current status and imaging features

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Abstract The use of stents in the gastrointestinal tract has been subjected to major changes. Initially, the use of stents was restricted to malignant strictures in patients with metastatic disease. But thanks to reduction of the morbidity and mortality rates, they are now used with curative intention and in patients with benign diseases after careful selection. However, for patients presenting with colon obstruction due to an advanced colon carcinoma, the mortality and morbidity are still high. The purpose of this review is to provide an overview of indications, techniques and further developments of the stents in the gastrointestinal tract and to highlight the predominant role of multidetector row computed tomography (MDCT) in the detection of potential complications.

Since 1990, stents have been used in the gastrointestinal tract mirroring prior use for hepatobiliary diseases. Initially, only malignant gastrointestinal tract strictures have been treated with stent in patients with metastatic disease. But thanks to marked drop in morbidity and mortality rates, stents have been further used for curative purpose and in benign

Abbreviations: MDCT, multidetector row computed tomography; SEMS, self-expandable metallic stent.

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gastrointestinal conditions. More recently, substantial improvements have been observed regarding gastrointestinal tract stents in order to improve technical and clinical success rates and to reduce morbidity rates.

The purpose of this review is to provide an overview of indications, techniques and further developments of the stents in the gastrointestinal tract and to highlight the predominant role of multidetector row computed tomography (MDCT) in the detection of potential complications.

Esophagus

Less than 50% of patients with esophageal carcinoma are potential candidates to surgical resection. By contrast, most of patients with esophageal carcinoma have a disease that is diagnosed at an advanced stage, being disseminated or metastatic. In such patients, dysphagia is the main clinical symptom and so that palliative treatment is required. Palliative treatment, however, can also result in prolonged survival time [1].

Indications

Malignant strictures

Currently, self-expandable metallic stent (SEMS) insertion is the most common intervention for palliation of dysphagia in inoperable patients with esophageal cancer [2,3]. SEMS is a safe and effective treatment in dysphagia palliation compared to other modalities [3]. In the same time, high-dose intraluminal brachytherapy is a suitable alternative with fewer requirements for re-intervention, additional survival benefits and a better quality of life [3,4]. The combination of stent insertion and brachytherapy seems to be a feasible and safe palliative option in patients with inoperable esophageal carcinoma [5]. There is still no evidence to recommend the appropriate timing of SEMS insertion in combination with other modalities. Non-randomized studies [6,7] have reported conflicting results regarding complication rate after SEMS insertion among patients who have undergone previous radiochemotherapy and only two studies have reported an increased rate of stent-related complications after SEMS insertion in patients previously treated with radiochemotherapy [8,9].

The use of esophageal stents in patients receiving neoadjuvant therapy before surgery have been studied but is still debated because the treatment of dysphagia is not always sufficient to improve the nutritional status of the patients and is associated with non-negligible morbidity [10]. Since the 1990s, esophageal intubation with stents has gradually developed with high rates of complete closure of tracheo/broncho-esophageal fistula and improvement in symptoms of respiratory tract and quality of life [11—13]. In a retrospective analysis, Chen et al. reported that SEMS could also significantly improve the overall survival in such patients [14]. Malignant esophageal fistula and strictures due to villous tumors with budding are the main indication of partially covered stents because migration rate is low and removal is generally not possible because of tissue embedding [15]. In case of external esophageal compression, SEMS can be performed but it is generally less effective than for intraluminal lesions [16].

Benign strictures

After preliminary experience in malignant stenosis, the use of esophageal stents have been extended to benign strictures. Benign esophageal strictures are generally caused by caustic ingestion, esophageal surgery and radiotherapy [17,18]. Stents have been proposed in refractory stenosis (*i.e.*, that remain symptomatic with dysphagia) after up to 5 repeated endoscopic dilations [19,20]. Esophageal stents are proposed especially for long stenosis (>2 cm) and stenting is based on the concept of temporary, progressive, sustained, and large diameter dilation. In case of benign esophageal strictures stents are left in place for a given period of time and systematically removed. Initially, plastic stents were used (Polyflex®, Boston Scientific, Marlborough, MA, USA), then the use of partially and fully covered SEMS was favored. Indeed stents have to be removed between 4 to 16 weeks after insertion, and between 4 to 8 weeks for fully or partially covered metallic stents in order to avoid epithelial hyperplasia and stent incarceration [21]. Uncovered metallic stents should not be used because of high risk of incarceration [22].

Stents have also been used for rupture or anastomotic leak of the esophagus after surgery and is now the treatment of choice (Fig. 1) [23—25]. Van Boeckel et al. reported a high clinical success rate for stent placement in a series of 267 patients [26]. In their study, healing of the perforation or leaking site was obtained in 85% of patients, with a mean time for healing of 7 weeks, with no differences between various type of stents (plastic, fully or partially covered stents) [26].

Technical considerations

Verschuur et al. showed that the Polyflex® esophageal stent was the least preferable option compared to Ultraflex® (Boston Scientific) or the Niti-S® stent (Taewong Medical, Seoul, South Korea) [27]. This is because the Polyflex® stent was more technically demanding and associated with high rate of stent migration [27].

Covered metallic stents result in effective and rapid relief of dysphagia with significantly reduced requirement for repeat interventions for recurrent dysphagia compared to uncovered metallic stents [28]. Covered metallic stents may also help maintain general patient condition and nutritional status during chemotherapy and radiotherapy. Uncovered or partially covered stents can lead to recurrent dysphagia secondary to epithelial hyperplasia [22]. In addition, epithelial hyperplasia prevents from stent removal [22].

A variety of antireflux stents are available for palliating dysphagia with complications rates and quality of life similar to those of conventional SEMS. Although some of the stents appeared effective in reducing gastroesophageal reflux, further research is required to confirm this favorable outcome [29—34].

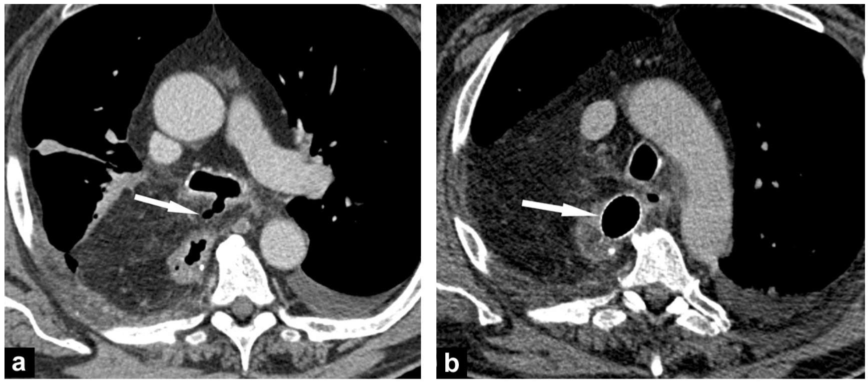

Figure 1. A 57-year-old man who developed fistula after Lewis-Santi procedure for T3 adenocarcinoma of the cardia: a: MDCT image in the axial plane shows fistula track (arrow) between the trachea and the esophagus; b: MDCT image in the axial plane shows metallic stent in the esophagus. The stent is correctly placed with satisfactory deployment (arrow).

During the start of radiotherapy, dysphagia often increases due to mucositis and esophagitis. SEMS can interfere with radiotherapy dose planning and delivery scheduling because of metallic content [35]. Because the main supporting structure of biodegradable stents lacks metallic material, they do not interfere with radiotherapy. Also the tumor may shrink with therapy so that metallic stent may migrate to the stomach and may require further procedure for removal [36,37].

Potential benefits of using biodegradable stents include the avoidance of gastrostomy or nasoenteric feeding tubes and improvement of quality of life due to possible oral nutrition. The duration of courses of radiotherapy (6—8 weeks) corresponds to the life span of the biodegradable stent [38]. However, if a biodegradable stent migrates during neoadjuvant therapy, there is no significant clinical impact due to its biodegradable properties, and if it has not migrated, it has substantially dissolved at the time of surgical resection [39].

Biodegradable stents have been proposed also for benign refractory esophageal strictures in a prospective study of 21 patients with encouraging results; indeed 45% of patients were dysphagia-free at the end of the study. These biodegradable stents allow the avoidance of stent removal and have a stable expansion force during 5 weeks [40].

Since 2001, self-expanding plastic stents have been successfully used in esophageal cancer in order to reduce the risk of stent incarceration secondary to epithelial hyperplasia. But because of its cylindric shape and smooth covering it increases the risk of stent migration compared to SEMS (29, 3 and 12%, respectively for plastic, partially or fully covered stents) [27,41]. Also, plastic stent delivery system is wider and stiffer than SEMS delivery system, often requiring a dilation before stent deployment leading to high complication rates (perforation, hemorrhage; 9% versus 3%, respectively for plastic and metallic stents) [15,41]. They exert a higher radial force than their metallic counterparts, which can lead to patient discomfort, early migration, ulceration, and rarely fistulization [42].

Results

Stent placement provides rapid and effective palliation of dysphagia, but late recurrence of dysphagia leads to future complications that require further endoscopic treatments [43,44]. Mariette et al. reported that SEMS, as a bridge to surgery, has a negative impact on outcome in patients with esophageal carcinoma, resulting in less R0 resections, earlier recurrences, a decreased 3-year overall survival, and an increased 3-year locoregional recurrence rate [45].

The technical success rate of covered stent in thoracic and abdominal esophagus is >95%. The mortality rate ranges between 0.5 and 2%.

Stents in cervical esophagus have usually been associated with high risks of perforation, inhalation, proximal stent migration, and poor tolerance. However, Verschuur et al. found similar morbidity and recurrent dysphagia in patients with cervical and thoracic/abdominal esophageal stents [46]. Specific stents have been designed for the cervical esophagus, for example the ''Ultraflex'' (Boston Scientific) with a low radial expansion force [47], with a small proximal collar (5 mm) to reduce gastroesophageal reflux [48], or with a proximal delivery system in order to secure correct positioning of the stent (MITech Co, Pyontack, South Korea) [49]. Only a few rare cases of tracheal compression due to esophageal stent have been reported [50]. It has been suggested that high radial force and anatomic location of the stent above the carina are favoring factors for tracheal compression.

The use of plastic stents (Polyflex®) for benign stenosis have also been reported in many studies with more than 160 patients [19]. The technical success rate was about 95%, either for insertion and removal.

Complications

Early morbidity rate of esophageal stent placement is about 20% and may be due to technical problems in 5.3% of cases (misplacement 0.3%, expansion/deployment failure in 3.9/0.8%, stent migration in 0.3%) or related to patients in 14.6% of cases (pain 12%, perforation 0.6%, hemorrhage 0.6%, mortality 1.4%). Late morbidity can also be due to technical problems (stent occlusion secondary to tissue in- and/or overgrowth in 11.3%, stent migration in 7%) or related to patients (gastroesophageal reflux in 3.7%, recurrent dysphagia in 8.2%, esophageal fistula in 2.8%, hemorrhage in 3.9%, esophageal perforation in 0.8% and thirty day mortality in 7.4%) [51,52]. Esophageal stent migration is more common when stents are placed near the gastroesophageal junction [53]. The actual mechanism of hemorrhage after placement of esophageal stent is controversial (pressure necrosis of the tumor and of the esophageal wall is one of these). Some authors found that bleeding occurred more frequently in patients whose stents extended to or above the level of the aortic arch, because at this level the left subclavian artery and the aortic arch have close relationships with the posterior wall of the esophagus [54]. In case of dysphagia and trachea-esophageal fistula, the technical success of stenting ranges between 70 to 100% [46]. Epithelial hyperplasia is very low with plastic stents, facilitating its removal, but high rates of migration have been reported (between 47 and 64%) especially for proximal or distal stent location and peptic stenosis [42,55]. Some authors reported a low migration rate after slight oversizing of stent diameter [56]. Others authors proposed a proximal fixation of the stent on the esophageal mucosa by a clip to prevent stent migration [57]. Delayed migration could be, at least in some cases, the inevitable consequence of the dilating efficacy of the plastic stents [58]. Dysphagia is generally improved rapidly but long-term efficacy is small (between 6 to 40% at 1 year) especially for anastomotic strictures [59].

A meta-analysis found that clinical success (for dysphagia) was about 46.2% with a median follow up of 74 weeks, and was better for plastic stents (55% versus 21%, $P = 0.02$) but only two studies used metallic stents for caustic stenosis [21]. The migration rate was about 26.4%, with a mean delay of 17 days, and 87% of stents were removed between 4 to 8 weeks. The perforation rate was 1.5% [21].

Imaging features

MDCT is usually performed using oral water. The use of oral positive contrast material is restricted to patients with clinical suspicion of esophageal perforation, fistula of extraluminal collection [60]. Usually, unenhanced MDCT examination of the thorax and abdomen is performed first to best evaluate stent position and location. Then MDCT is obtained with intravenous administration of iodinated contrast material and oral contrast (Fig. 2). The use of automated exposure control and iterative reconstruction is recommended to minimize radiation dose [61—64].

Complications of esophageal stenting can be classified into early (*i.e.*, occurring less than 7 days following the procedure) and late (*i.e.*, occurring more than 7 days after the procedure) complications [60]. Complications include stent misplacement, hemorrhage, perforation, tracheal compression [54], stent migration, stent fracturing, tumor ingrowth and tumor overgrowth, fistula formation and bolus impaction.

Esophageal perforation on MDCT manifests as periesophageal gas bubbles, mediastinal fluid collection and extraluminal leakage of oral contrast material [60,65]. Left pleural effusion is often present and does not necessarily indicate esophageal perforation.

More rarely, pneumomediastinum is observed. Pneumomediastinum indicates esophageal perforation. It is more frequently observed after esophageal balloon dilation and can be associated with subcutaneous emphysema that is best evidenced on MDCT.

MDCT helps detect esophageal stent leak that presents as presence of contrast material beyond the stent wall. Similarly, MDCT readily reveals stent fracture that often results in buckling and incomplete or complete esophageal obstruction [60]. MDCT reveals esophageal perforation with distal tip of the stent projecting outside the esophageal lumen. Tracheal compression by esophageal stent is evidenced by MDCT [54].

Stent migration is best evidenced on MDCT. In rare occasions, esophageal stent may migrate into the duodenum. This is more frequent for stents placed in the gastroesophageal junction [66]. Stent migration may result in gastrointestinal perforation either at the level of the esophagus or more distally in the duodenum [66]. Valenzuela et al. have reported esophageal stent migration into the pleural space [60].

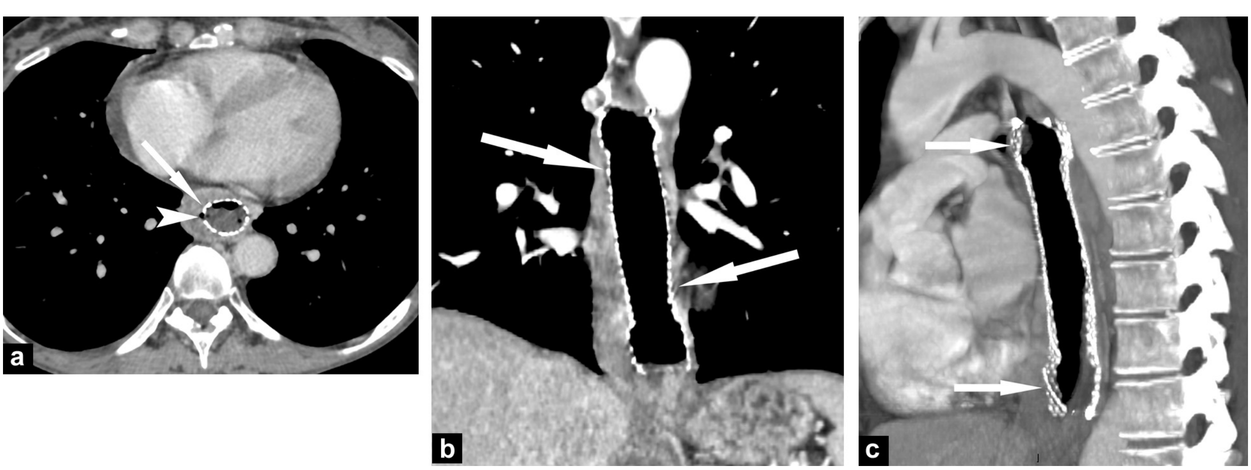

Figure 2. A 53-year-old woman with unresectable epidermoid carcinoma of the lower third of the esophagus. The patient was treated with endoluminal stent placement and systemic chemotherapy: a: MDCT image in the axial plane shows metallic stent in the esophagus. The stent is correctly placed with satisfactory deployment (arrow); b: MDCT image in the coronal; c: in the sagittal plane shows metallic stent in the esophagus. The stent (arrows) is correctly placed with satisfactory deployment.

Gastroduodenal stents

Indications

Malignant strictures

SEMS represent the treatment of choice of gastroduodenal malignant strictures when curative surgery is not possible (Fig. 3) [67]. The most frequent indication for SEMS placement is duodenal obstruction secondary to a pancreatic cancer (up to 10 to 20% of cases), usually at an advanced stage [68—70]. SEMS are also used in patients with gastroduodenal obstruction due to surrounding tumor [71]. Because of rapid efficacy, reduced morbidity and low cost compared to palliative surgery, SEMS are also used as an alternative to surgery for palliation in patients with poor life expectancy [72,73]. Mehta et al. in a prospective randomized trial found that duodenal stenting was superior to laparoscopic gastrojejunostomy for malignant gastric outflow obstruction in terms of morbidity, postoperative pain, hospital stay and 1-month quality of life [74]. These results were confirmed in a decision analysis by Siddiqui et al. who reported lower mortality/morbidity rates and a cost/benefit analysis in favor of duodenal stents compared to surgery [75]. Contraindications for duodenal SEMS include multiple stenoses or stenosis that is beyond the reach of the endoscope (for example in patients with peritoneal carcinomatosis or who had previous surgery), massive gastrointestinal bleeding, suspicion of perforation and hemodynamic instability.

Benign strictures

No clear information is available concerning the use of SEMS in benign gastroduodenal stenoses, but it may be assumed that biodegradable or extractable stents would represent a good alternative in their management.

Results

Reported technical success rate is about 94% and the clinical success rate (defined by relief of obstructive symptoms and reintroduction of oral feeding) is about 84% [70,76,77].

Clinical success is defined by relief of clinical symptoms of obstruction, the reintroduction of oral feeding, improvement of nutritional status and a better quality of life. Clinical success of gastroduodenal stents is between 79 and 91%, with fast recovery because 60 to 90% of patients are able to have oral solid food one day after stent insertion [70,76]. This clinical success is prolonged with time since 90 to 100% of patients are still able to have oral feeding 3 and 6 months after stent insertion, respectively [78], with a median stent patency of 219 days [76]. Moreover, it is possible to insert a second stent in a first one in case of first stent obstruction [76,79]. Predictive factors of stent patency are chemotherapy and covered stent [80]. Studies comparing stenting with surgery for malignant stenosis of the gastroduodenal tract showed that stent was associated with a reduced time for oral nutrition, a reduced hospital stay, a reduced cost but with a short time for recurrent obstruction and second endoscopic treatment [72,81—83]. Indeed long-term efficacy seems to be better with surgery, which is preferred in case of life expectancy of more than 2 months [83].

In patients, with obstructive jaundice, biliary drainage can be performed endoscopically before duodenal stent placement [84,85].

Complications

The morbidity rate of gastroduodenal stents is between 11 and 43% [78]. Early complications include migration, obstruction, biliary obstruction (in case of a covered stent), perforation, hemorrhage (Fig. 4), and misplacement [86]. Delayed complications include migration, perforation, obstruction, duodenal fistula or stent fracture, and can be treated with a new stent. Migration rate for covered stent is about 25% [76], and obstruction of non-covered stent is about 15% [87]. Risk factor for early uncovered stent obstruction is stenosis of a gastrojejunal or a gastroduodenal anastomosis [88]. Risk factors for perforation are previous dilation, attempt to pass the stenosis with the endoscope, use of rigid guide wire, concomitant corticosteroid therapy/chemotherapy/radiotherapy.

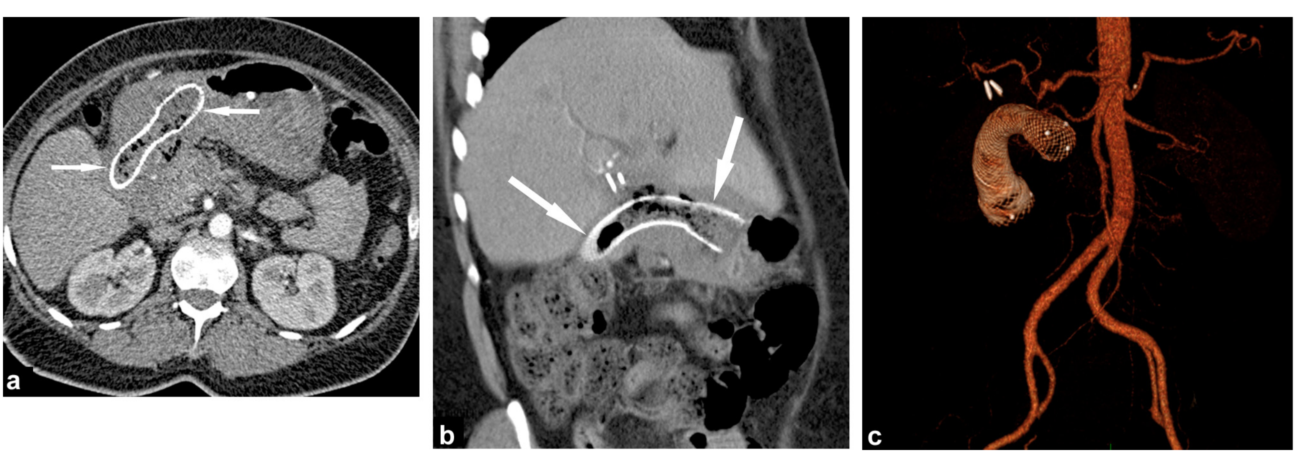

Figure 3. A 56-year-old woman with unresectable gastroduodenal adenocarcinoma: a: MDCT image in the axial plane shows metallic stent (arrows). The stent is correctly placed with satisfactory deployment (arrow); b: MDCT image in the oblique plane confirms satisfactory stent (arrows) deployment; c: 3D reconstruction confirms optimal placement and satisfactory deployment.

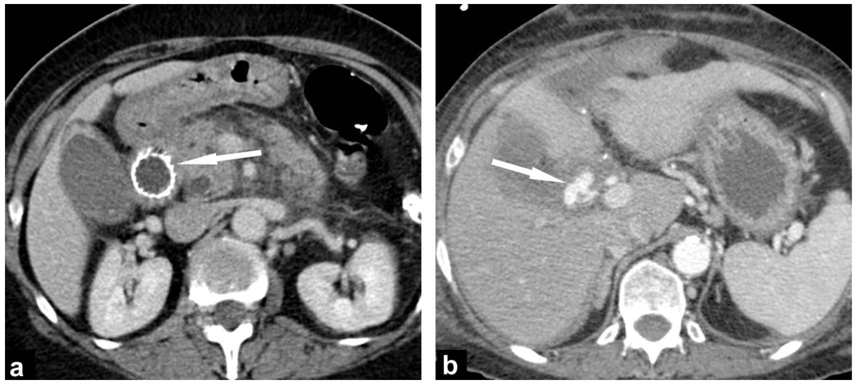

Figure 4. A 70-year-old woman with unresectable adenocarcinoma of the pancreatic head responsible for major dilatation of the jejunum. The patient was palliated with non-covered self-expandable metallic stent (Hanarostent): a: MDCT image in the axial plane shows metallic stent (arrow) in the duodenum. The stent is correctly placed with satisfactory deployment (arrow); b: CT image obtained 17 days after stent placement because of hematemesis shows extravasation of iodinated contrast material (arrow) originating from the right branch of the hepatic artery indicating arterial injury due to stent placement.

Imaging features

MDCT is usually performed using oral water. The use of oral positive contrast material is restricted to patients with clinical suspicion of gastroduodenal perforation, fistula of extraluminal collection [60].

Duodenal stent placement may result in perforation that manifests as retroperitoneal or intraperitoneal free air depending on the site of perforation. Rarely, perforation may manifest with more subtle findings and free gas is only observed adjacent to the distal tip of the stent. Extraduodenal leak of contrast material is a specific finding for the diagnosis of duodenal perforation. Similar to esophageal stent, other complications of duodenal stents include stent misplacement, hemorrhage, perforation, stent migration, stent fracturing, tumor ingrowth and tumor overgrowth, fistula formation and bolus impaction.

MDCT helps detect duodenal stent leak that presents as presence of contrast material beyond the stent wall. Similarly, MDCT readily reveals stent fracture that often results in buckling and incomplete or complete duodenal obstruction [60]. MDCT reveals duodenal perforation with distal tip of the stent projecting outside the duodenal lumen. MDCT is also useful for elucidating the cause of duodenal bleeding after duodenal stent placement (Fig. 4) [89].

Colonic stents

Intestinal obstruction may be the revealing symptom of colorectal cancer in up to 30% of patients. Previous studies have reported poor outcome and increased postoperative mortality for patients with obstructive colorectal cancers [90—92]. Emergency surgery, though controversial, is an option in this situation but conveys high morbidity (40 to 60%) and mortality (8 to 20%) [93,94]. Moreover, in case of left colonic obstruction, up to 40—60% of patients will have a permanent stoma [92]. In order to improve these results, SEMS have been proposed since 1990s, first as a palliative treatment then as a bridge to surgery [95,96].

Indications

Palliative treatment in malignant stenosis

Two clinical situations must be distinguished: first patients with very poor life time expectancy whatever the cancer stage who will require only comfort care, and patients with late stage cancer who are not eligible for surgery and who will receive chemotherapy. For patients with very poor lifetime expectancy, stent insertion is associated with a better quality of life and less unnecessary surgery. For patients with longer lifetime expectancy who will receive chemotherapy, SEMS can avoid stoma, which is generally permanent, and is associated with lower morbidity rate, shorter time to first chemotherapy, better quality of life and similar survival compared to surgery [97—100]. Two randomized controlled trials reported lower stoma rate, better quality of life [101] and shorter hospital stay [73] with SEMS compared to surgery. A third randomized controlled trial was terminated prematurely because of safety considerations related to high colonic perforation rate in the SEMS group [102], especially delayed perforations in patients treated with chemotherapy and bevacizumab [99]. Some authors reported that adjuvant bevacizumab therapy nearly tripled the risk of colonic perforation in case of stent placement [103]. Authors claimed that surgery was probably necessary after SEMS insertion in metastatic patients (as for bridge to surgery) when a prolonged chemotherapy is considered with potential curative treatment of metastases. Regarding cost-benefit analysis, SEMS seems to be better than surgery in most of the studies [97,98,104]. In conjunction with shorter hospital stay and lower complications, cost reductions of 20 and 30% have been reported in the palliative and bridge to surgery groups, respectively [105]. In case of palliative treatment, risk factors for complication after stent insertion include proximal location of the stricture (right colon), extrinsic lesions, history of radiation and chemotherapy with bevacizumab [103,106,107].

SEMS as a ''bridge to surgery''

SEMS as a bridge to surgery is used as a preoperative measure to temporarily relieve obstruction before definitive ''elective'' one-stage surgical therapy 8 to 10 days later in patients with malignant stenosis (Fig. 5). Several retrospective studies have compared the combination of SEMS with surgery to surgery alone and found that the combination of SEMS with surgery was associated with less stoma rate, less operative time, low morbidity rate, low intensive care stay and sometimes low early mortality rate than surgery alone [97,98].

One randomized controlled trial reported that SEMS as a bridge to surgery was associated with more one step surgeries, less permanent stoma rate, low morbidity rate (less blood loss, less anastomotic fistulas or wound infection) [108]. Also, in a meta-analysis, SEMS as a bridge to surgery was found to have a high successful primary anastomosis and low overall stoma rates, with no significant differences in complications and mortality rates [93]. This approach is now validated in the NICE (National Institute for Clinical Excellence) process [93,109,110]. Moreover, a recent meta-analysis showed that SEMS as a bridge to surgery was equivalent to emergency surgery with respect to overall survival, disease-free survival, and recurrence [111].

To tone down some encouraging results, two randomized controlled trials have been terminated prematurely because of safety considerations related to colonic perforations and morbidity [112,113]. Also, oncological safety of SEMS continued to remain uncertain and thus a matter of concern. SEMS is associated with a high incidence of clinical and ''silent'' perforations, with an estimated incidence of 10 to 20% [114,115]. Clinical perforation of a tumor is considered as favoring factor for the development of peritoneal carcinomatosis after curative surgery for colon cancer, as is pointed out in a recent and exhaustive review [116]. Another putative risk comes from stent insertion itself and its subsequent expansion within the tumor. The problems resulting from stent insertion include tumor perforation, altered pathology and tumor cell dissemination [114,117]. Indeed in a recent report, some authors have shown a lower overall and disease-free survival associated with shorter recurrence time in the stent group compared to surgery group [118]. Others authors claimed that stenting was associated with higher local recurrence rate compared to emergency resection ($P = 0.038$). None of these studies were however randomized trials and therefore their results must be taken with caution.

External malignant colonic stenosis

Colonic stenosis due to external compression by an advanced locoregional tumor or a peritoneal carcinomatosis is usually associated with failure of SEMS insertion. Indeed these stenoses are generally long and multiple resulting in a high clinical failure rate of approximately of 60% [106]. Only transverse colonic stenoses due to gastric cancer compression seems to be associated with higher clinical success rates of approximately 80% [119].

Benign colonic strictures

Use of SEMS in benign colonic obstruction is controversial and limited to patients with tight strictures that recur after repeated dilations and in patients who refuse or who are not candidate to surgery [120—122]. Only retrospective studies and case reports are available concerning anastomotic stenoses, diverticular stenoses, radiation-induced colonic stenoses and Crohn's disease stenoses [123]. Even if the rate of technical success ranges between 90 and 100%, clinical success rate is lower whatever the type of colonic stent (uncovered, fully/partially covered stents) due to high morbidity, with a high rate of delayed complications [123]. Indeed stent migration is observed in about 40% of patients, especially in anastomotic stenoses or when covered stents are used. Perforation rate in inflammatory stenosis is about 20%, especially in diverticular diseases. Also, clinical success is low in radiation-induced stenosis because of marked stiffness. If several studies tend to prohibit the use of SEMS in diverticular or radiation-induced stenoses, its use in anastomotic stenoses seems to be promising especially with covered stents that can be easily removed or biodegradable stents.

Results

Technical success (defined as successful insertion of the stent across the stricture) has been reported in 90% of cases [79,97,98]. Technical failure of SEMS placement is most commonly due to the inability to pass the guide wire across the stricture, especially in cases with tortuous angulated anatomy, poor preprocedure bowel preparation, intense enteral peristalsis, or very tight strictures [98,124,125].

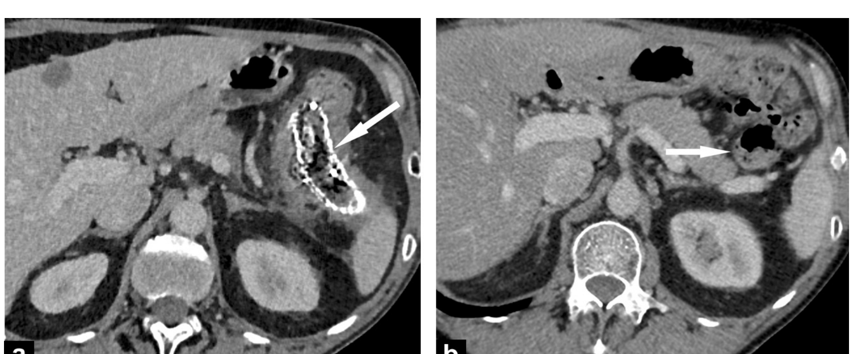

Figure 5. A 61-year-old man with T4 adenocarcinoma of the left colon presenting with acute colonic obstruction: a: MDCT image in the axial plane shows metallic stent (arrow) in the left colon. The stent is correctly placed and allows relief of obstruction; b: MDCT image in the axial plane after systemic chemotherapy and stent removal shows complete disappearance of tumor (arrow).

Clinical success (defined by relief of obstructive symptoms and adequate bowel decompression within 72 hours) is observed in up to 80% of patients [97,98].

Complications of colonic stenting

Colonic stenting is generally considered as a low risk procedure with a mortality rate of approximately 1% [126,127].

Complications associated with colonic SEMS can be classified as early complications, including perforation, bleeding, and misplacement, and late complications including mainly stent migration, reobstruction, and erosion or fistulation of the intestinal wall [125,128]. Risk factors of complications are male gender, stent diameter below or equal to 22 mm, complete colonic obstruction, operator experience, and stricture dilation during SEMS insertion [103].

Self-limited hemorrhage occurs in 0—5% of the cases and is generally a minor complication, most likely related to the tumor itself and does not require a specific treatment [122,125,129].

Colonic perforation is the most serious complication and occurs in about 5% of procedures (range: 0—83%) [98,126] with a 10% mortality rate [126]. In a systematic review, Khot et al. have reported 3 deaths in a total of 565 colonic stent placements; two of them were due to colonic perforation [126]. Colonic perforation is predominantly observed in patients who had balloon dilation of the colonic stenosis or incomplete initial stent deployment [126,130,131]. Risk factors for early perforation following stent insertion are stenosis dilation prior to stent insertion, try to pass the stenosis with the endoscope or excessive manipulation of guide wires, especially in the presence of diverticular disease or early wall ischemia [131]. Type and size of the stent have to fit stenosis and colonic features in order to avoid stent incarceration. Late perforations are generally associated with chemotherapy and thus imply surgery 3 to 6 months after stent insertion.

Migration rate of colonic stents is about 11% (range: 0 to 50%) [98,104]. Most of the stents migrate distally and are automatically expelled through the anus, while symptomatic stents may be removed endoscopically. It can be associated with chemotherapy due to tumor shrinkage, or in case of prior laser debulking or balloon before dilation and lead to secondary obstruction [125]. Others factors that predispose to stent migration include treatment of partial obstructions or extrinsic compressions, small stent diameter, colonic angulation, insufficient length to allow stent flaring, postoperative radiotherapy, and benign lesions [122,128,130]. Stent migration occurs also three times more frequently in the distal rectum compared to the left colon [132]. Use of non-covered or longer/larger diameter stents seems to reduce the risk of migration.

Stent obstruction is most frequent in palliative stent patients and occur in about 10% of patients [127]. Tumor overgrowth is the most common cause (Fig. 6), ingrowth through the stent lattice, mucosal prolapse, stent fracture and fecal impaction are less frequent [98,126,131]. In case of stent obstruction due to cancer progression, laser/argon therapy, stent in stent, or surgery can be done [79,127]. In case of stool impaction, medical or endoscopic desobstruction is mandatory. This can be precluded with low-residue diet and use of osmotic laxative.

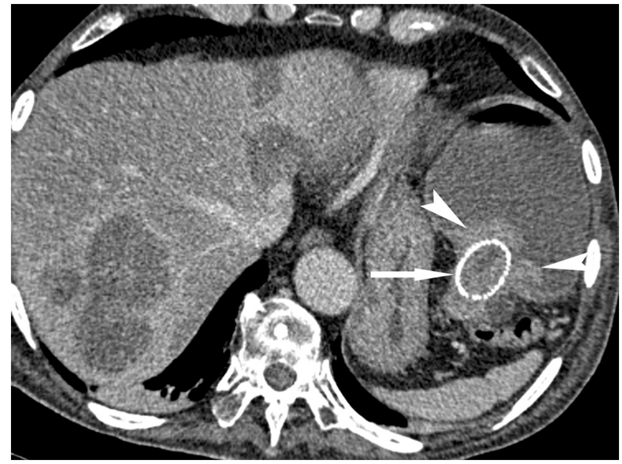

Figure 6. A 66-year-old man who had endoscopic metallic stent placement for T4 adenocarcinoma of the left colon. MDCT image in the axial plane four months after stent placement shows tumor ingrowth (arrowhead) within stent lumen. The stent (arrow) shows normal deployment and no migration.

Imaging features

Whereas X-ray imaging using barium enema has been used in the past to assess the degree of luminal stenosis and the length of the stenosis, currently, MDCT using water enema is the favored imaging technique for a comprehensive evaluation before colonic stent placement [133]. One advantage of MDCT is that it helps determine the cause of colonic obstruction. In this regard, obstruction can be due to intraluminal tumor process but also to extraluminal compression by pelvic neoplasm or peritoneal carcinomatosis. MDCT with water enema is also used to determine the site of the obstruction and the number of sites of obstruction. It is currently acknowledged that multiple sites of obstruction render the patient unsuitable for stent placement [131].

In patients with suspected complications following colonic stenting, MDCT is usually performed using oral water. The use of oral positive contrast material is restricted to patients with clinical suspicion of perforation or fistula [60].

Before stent placement, colon perforation must be excluded. This is best depicted using MDCT. After stent placement, X-ray pelvic radiography is performed to ensure correct placement and optimal expansion. This is also helpful for further comparison should stent migration be suspected [131]. However, X-ray pelvic radiography may show initially incomplete stent expansion that subsequently becomes complete during the following days.

Following colonic stent placement in patients with major colonic dilatation, MDCT can reveal presence of marked colonic edema, which is assumed to indicate colonic ischemia [131].

Colonic perforation due to stent placement is confirmed by MDCT. MDCT shows pneumoperitoneum and pericolic fluid accumulation. Infection of pericolic fluid collection can be managed percutaneously using drain placement.

Finally, MDCT is often performed in patients who had stent placement and symptoms suggestive of colonic obstruction. MDCT can reveal reobstruction, which is predominantly due to tumor overgrowth although stent migration, tumor ingrowth and fecal obstruction.

Conclusion

Currently stent insertion is well codified regarding technical, material aspects and indications. Except for emergencies, stent insertion has to be discussed during a multidisciplinary cancer conference in order to define its use in a multimodal treatment. Caution must be taken concerning oncologic outcomes of stent insertion in malignant strictures. Also, benign strictures are more and more treated with stents even if low efficacy and high morbidity rates reduce its use in such indications.

Take-home messages

- Self-expandable metallic stent (SEMS) insertion is the most common intervention for palliation of dysphagia in inoperable patients with esophageal cancer.
- Complications of esophageal stenting include stent misplacement, hemorrhage, perforation, tracheal compression, stent migration, stent fracturing, tumor ingrowth/overgrowth, fistula formation and bolus impaction.
- SEMS represent the treatment of choice of gastroduodenal malignant strictures when curative surgery is not possible.
- Oncological safety of SEMS continued to remain uncertain and thus a matter of concern.
- Colonic stenting is generally considered as a low risk procedure.
- Benign strictures are more and more treated with stents even if low efficacy and high morbidity rates reduce its use in such indications.

Clinical case

A 38-year-old man with no remarkable prior history was referred to the emergency department for acute abdominal pain. Clinical examination revealed abdominal tenderness and symptoms suggestive for colonic obstruction. The patient did not have fever.

Questions

1. What is the best imaging examination to confirm the diagnosis?
A. Abdominal plain film.
B. Abdominal ultrasonography.
C. MDCT of the abdomen and pelvis.
D. Videocolonoscopy.
E. MR colonography.

2. MDCT of the abdomen was performed first (Fig. 7). MDCT showed colon distention with marked dilatation of the cecum. Based on MDCT findings, what is the most plausible cause of colonic obstruction?
A. Acute episode of ulcerative colitis.
B. Acute episode of Crohn's disease.
C. Volvulus of the sigmoid.
D. Colonic lymphoma.
E. Colonic adenocarcinoma.

3. After discussion between the gastroenterologist and the digestive surgeon, emergency colonic stent placement was considered because of incomplete tumor stenosis and marked colon dilatation. After the procedure, abdominal distention did not resolve and the patient was still complaining of abdominal pain. Clinical examination revealed more marked abdominal distension. What is the best imaging examination to elucidate the potential cause of abdominal pain?
A. Abdominal plain film.
B. Abdominal ultrasonography.
C. MDCT of the abdomen and pelvis.
D. Videocolonoscopy.
E. MR colonography.

4. The patient underwent repeat MDCT examination (Figs. 8 and 9). On the basis of MDCT findings, what is the most plausible scenario that may explain the imaging findings?

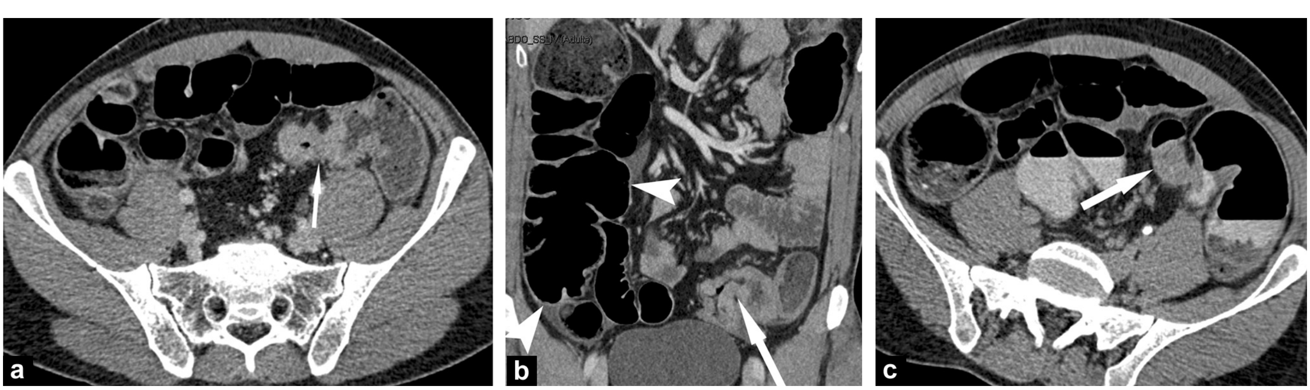

Figure 7. a: abdominopelvic MDCT image in the axial plane shows stenosis (arrow) of the sigmoid colon with marked circumferential thickening suggestive for tumor; b: abdominopelvic MDCT image in the coronal plane confirms stenosis (arrow) of the sigmoid colon with marked upstream dilatation of the right colon and cecum (arrowhead); c: abdominopelvic MDCT image in the axial plane after enema with positive contrast agent shows marked but incomplete stenosis (arrow) of the sigmoid colon with marked circumferential thickening.

Figure 8. Abdominopelvic MDCT image in the axial plane shows pneumoperitoneum (arrows).

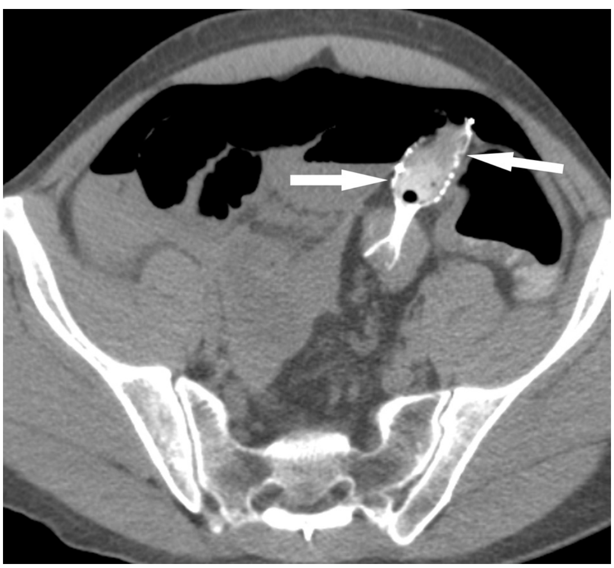

Figure 9. Abdominopelvic MDCT image in the axial plane shows perforation of the sigmoid colon with misplacement of the metallic stent (arrows) in the peritoneal cavity.

A. The patient had diastatic perforation of the cecum.
B. The patient had perforation of the colon during stent placement.
C. The patient had superimposed volvulus of the sigmoid.
D. The patient had superimposed volvulus of the cecum.
E. The patient had extraluminal stent placement.

Answers

1. C.
2. E.
3. C.
4. E. MDCT shows pneumoperitoneum (arrows on Fig. 8) and perforation of the colon with misplacement of the metallic stent (arrows on Fig. 9) in the peritoneal cavity.

End of the story

Surgery was performed immediately and consisted of proctectomy with colorectal anastomosis and temporary stoma. Histologically, the tumor was a T4 tubulated, moderately differentiated adenocarcinoma.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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