EXPANDABLE METAL STENTS FOR THE TREATMENT OF CANCEROUS OBSTRUCTION OF THE GASTROINTESTINAL TRACT

TODD H. BARON, M.D.

EXPANDABLE metal stents have been approved by the Food and Drug Administration for the treatment of gastrointestinal obstruction due to cancer. Although they have not been approved for use in benign disease, there are specific clinical indications for which expandable metal stents may be beneficial. This article reviews the uses of expandable metal stents for gastrointestinal obstruction due to cancer.

GENERAL CONCEPTS

Gastrointestinal stents are placed by gastroenterologists under endoscopic guidance with the aid of fluoroscopy or by interventional radiologists using fluoroscopic guidance alone. Expandable metal stents are made of metal alloys and have varying shapes and sizes, depending on the manufacturer and the organ in which they will be placed (Fig. 1). The stents are mounted in a preloaded constrained position on a delivery catheter (Fig. 2). A guide wire is passed through the lumen of the catheter, and when the wire has been advanced beyond the obstruction, the stent is passed over it and positioned across the stricture. The constraining mechanism is released, which causes the length of the stent to decrease and its diameter to increase (Fig. 2). The radial expansile forces and the degree of shortening differ among different types of stents. Covered metal stents have a membrane to prevent reobstruction due to ingrowth of tumor through the mesh wall.

Specimens obtained from animals and from humans at autopsy or surgery show that metal stents embed themselves in the tumor and surrounding tissue with pressure necrosis and are incorporated into the wall of the organ. Completely covered stents do not become embedded, and as a result, migration of the stent is possible. Therefore, partially covered stents are used to prevent tumor ingrowth and permit anchoring of the stent (Fig. 2). One of the possible adverse effects is erosion through the gastrointestinal wall (Fig. 3). Most metal stents appear safe for patients undergoing magnetic resonance imaging (MRI); specific details of the stent and its orientation to the magnetic field should be obtained before MRI is performed.

ESOPHAGEAL STENTS

Esophageal carcinoma accounts for most cases of dysphagia due to cancer, and usually the tumor is...
unresectable. Dysphagia may also result from extrinsic compression due to lung cancer or malignant lymphadenopathy. Among many endoscopic and nonendoscopic treatment alternatives for palliation of dysphagia due to cancer, expandable metal stents are one of the main options. They are useful for patients with poor functional status who cannot tolerate radiation or chemotherapy, who have advanced metastatic disease, or in whom previous therapy has failed.6

The small diameter of expandable metal stents before deployment makes aggressive dilation of the esophagus before or after deployment unnecessary. Despite the substantially higher cost of expandable metal stents as compared with traditional rigid plastic esophageal stents, there are substantial overall cost savings resulting from the reduction in the number of days of hospitalization due to complications.7-9 One study showed that the rate of complications associated with stent insertion was lower overall for expandable metal stents than for plastic stents, but the rate of subacute complications was higher.10 In the United States, expandable metal stents have replaced plastic stents for use in the esophagus.11 Dysphagia is relieved in approximately 90 percent of patients who receive expandable metal stents.7-9

The data from comparisons of different options for the palliation of dysphagia due to cancer are limited. A retrospective study compared expandable metal stents with a variety of conventional endoscopic palliative techniques in patients with inoperable esophageal carcinoma without tracheoesophageal fistula. Patients with expandable metal stents underwent significantly fewer procedures and spent fewer days in the hospital.12 In a prospective, randomized, controlled trial of patients with esophageal carcinoma, patients with expandable metal stents had significantly more improvement in symptoms and a lower rate of reintervention than those treated by esophageal laser recanalization.13 An advantage of expandable metal stents over other endoscopic palliative methods is that they can be used to treat dysphagia due to compression caused by cancer,14,15 although the improvement in dysphagia is less than for patients with esophageal cancer.14

Esophageal expandable metal stents are also used to treat tracheoesophageal fistulas due to cancer (Fig. 4A).16,17 Tracheoesophageal fistulas develop in patients with advanced esophageal and lung cancer and lead to continuous aspiration of saliva. Tracheoesophageal fistula is the only condition in which covered expandable metal stents may increase survival as compared with other therapies. Although there have been no prospective trials comparing covered metal stents with other types for the treatment of tracheoesophageal fistulas, the covered metal stent is now accept-
ed as the primary treatment option. Closure of the fistula is successful in 70 to 100 percent of patients. For persistent fistulas, placement of an airway stent to close the fistula or surgical esophageal bypass for physiologically fit patients are additional palliative options.

Expandable metal stents are best suited for mid-esophageal lesions. Tumors at the gastroesophageal junction are amenable to stent placement with a high rate of technical and clinical success, but stents at this location produce an open conduit for free reflux of gastric contents, with consequent severe regurgitation and aspiration. Newer stents prevent reflux and aspiration by means of a one-way flap valve on the gastric side of the stent. Placement of expandable metal stents for very proximal esophageal lesions is technically difficult because of the proximity of the stent to the upper esophageal sphincter and the lack of an uninvolved proximal margin. However, in studies of small numbers of patients with dysphagia due to esophageal obstruction caused by cancer high in the cervical esophagus, expandable metal stents were successfully placed and improved symptoms in most patients.

Placement of an esophageal expandable metal stent can lead to severe complications. Intraprocedural complications include those associated with conscious sedation, aspiration, malpositioning of the stent, and esophageal perforation. Immediate postprocedural complications may include chest pain, bleeding, and tracheal compression, with resultant airway compromise and respiratory arrest. Late complications include distal stent migration, formation of an esophageal fistula, bleeding, perforation, and stent occlusion. Although most migrated stents can be retrieved endoscopically or will simply pass through the gastrointestinal tract, small-bowel obstruction develops in some patients. Approximately 0.5 to 2 percent of patients who undergo the procedure die as a direct result of placement of an expandable metal stent (Fig. 3).

Several studies strongly suggest that the rates of delayed esophageal complications caused by expandable metal stents are higher in patients who have previously been treated with radiation, chemotherapy, or both. These complications are presumably due to stent-induced pressure necrosis within devitalized esophageal tissue. Unfortunately, patients who have recurrent or persistent dysphagia or a tracheoesophageal fistula after chemoradiation therapy often have no alternative to a stent for palliation of their symptoms. In contrast to other studies, one prospective study found that patients undergoing chemoradiation therapy after placement of an expandable metal stent had significantly longer survival than patients who received only a stent. However, shrinkage of the tumor by chemoradiation therapy could increase the risk of stent migration.

Patients with esophageal stents must modify their diet to prevent large boluses of food from becoming impacted within the stent. If a stent without an antireflux valve crosses the gastroesophageal junction, strict antireflux precautions and aggressive acid suppression are needed to prevent gastroesophageal reflux and aspiration. If the stent lumen becomes occluded by tissue ingrowth, overgrowth, or hyperplasia, a second stent may be placed through the first stent with good results. Alternatively, endoscopic laser therapy, electrocautery, or photodynamic therapy may be used to treat stent occlusion.

**BILIARY STENTS**

Treatment of obstructive jaundice due to cancer relieves pruritus, improves appetite, and reduces fat malabsorption. Surgical palliation of this condition involves the creation of an anastomosis between the bile duct and the duodenum or jejunum to bypass the obstructed biliary tree. Nonsurgical palliation is achieved by placing stents endoscopically (with the use of endoscopic retrograde cholangiopancreatography), or with radiologic guidance (by the percutaneous transhepatic approach) across the cancerous stricture to restore biliary continuity (Fig. 4B). Insertion of plastic biliary stents provides an effective alternative to open palliative surgical bypass of the biliary tree for the management of obstructive jaundice due to cancer. Unfortunately, bacterial encrustation frequently leads to occlusion of plastic stents, requiring their replacement in terminally ill patients. Plastic stents of larger diameter take longer to become occluded.

The maximal stent diameter is limited by the endoscopes that must accommodate them and the size of the tract made through the liver when they are placed percutaneously. In comparison with plastic stents, expandable metal biliary stents have a smaller diameter before placement and a larger diameter after placement. Their small diameter before placement makes percutaneous placement less traumatic and permits them to be completely placed during one procedure. Their large diameter after placement eliminates occlusion by bacterial biofilm.

Expandable metal biliary stents are much more costly than plastic stents. In two randomized, prospective trials comparing endoscopically placed, uncovered metal biliary stents and plastic stents for the palliation of jaundice in patients with previously untreated distal malignant bile-duct obstruction, the metal stents had significantly longer patency. Decreases in the rates of endoscopic procedures and rehospitalization offset the initial high cost of metal stents. Similar results were found in a large prospective, randomized trial in which stents were placed by the percutaneous transhepatic route for palliation of distal cancerous biliary obstruction. Expandable metal stents are more cost effective for patients who survive longer than four to six months, whereas a single procedure with placement of a less costly plastic stent would suffice in pa-
tients expected to have shorter survival.\textsuperscript{34,35} Another disadvantage of a metal stent in the biliary tree, as compared with a plastic stent, is that the device cannot be removed once it is implanted. Therefore, in patients with potentially resectable cancer, removable plastic stents should be used.

Expandable metal biliary stents may become occluded because of tumor ingrowth or biliary epithelial hyperplasia induced by the stent. Occlusion from either cause may be treated by the insertion of a plastic stent or another metal stent through the original stent.\textsuperscript{31,35,36} Preliminary studies suggest that occlusion due to tumor ingrowth or epithelial hyperplasia may be prevented by the use of partially covered metal biliary stents.\textsuperscript{37} Overgrowth of tumor beyond the ends of the stent may result in reobstruction, necessitating placement of another stent.

Prolonged patency has been observed in expandable biliary stents used to treat low- or distal-bile-duct obstruction, but not in cases of obstruction by a tumor involving the proximal biliary system at or above the bifurcation of the right and left hepatic ducts (Klatskin's tumor). However, one small randomized trial and several uncontrolled studies suggest that expandable metal stents are more effective than plastic stents in these locations as well.\textsuperscript{38}

Complications related to expandable metal biliary stents include entrapment of the stent-delivery system in small or nondilated intrahepatic ducts, malpositioning of the stent, and trauma to the duodenal wall opposite the papilla, with resultant bleeding or perforation if an excessive amount of the distal portion of the stent protrudes into the lumen. There is no apparent increase in complications in patients who have previously received chemoradiation therapy or who receive it concomitantly.\textsuperscript{39} Although expandable metal stents are generally not removable, there are case reports of successful endoscopic removal of such biliary stents for the treatment of late complications.

GASTRODUODENAL STENTS

Successful placement of expandable metal stents for palliation of cancerous obstruction of the upper gastrointestinal tract has been reported in several series, with clinical success rates similar to those of surgical palliative bypass.\textsuperscript{40-42} Approximately 90 percent of patients with gastroduodenal stents improve clinically.\textsuperscript{40} Advanced carcinoma of the pancreatic head is the most common cancer that obstructs the gastric outlet (Fig. 4C). Gastric carcinoma or disease that metastasizes to the duodenum or jejunum may also cause obstruction.\textsuperscript{43} Patients with cancerous duodenal obstruction often also have biliary obstruction that occurs first.\textsuperscript{43} Given the difficulties in obtaining access to the biliary tree through the mesh wall of a duodenal stent placed across the papilla, an expandable metal biliary stent should be placed before the duodenal stent is placed if there is known or impending biliary obstruction. Bile flows effectively through the biliary and duodenal stents as they cross within the duodenum (Fig. 4C). To treat biliary obstruction after placement of a duodenal stent, a percutaneous transhepatic approach is usually required. Stenting of both the duodenum and the bile duct is the nonsurgical equivalent of a traditional double surgical bypass.

Endoscopic placement of gastroduodenal stents under fluoroscopic guidance is technically easier than their placement by interventional radiologists using fluoroscopic guidance alone, because the obstruction can be reached directly and because there is a mechanical advantage in passing the stent through the endoscope channel. Successful relief of obstruction in the proximal jejunum can be achieved endoscopically.\textsuperscript{43} Patients may resume oral intake almost immediately after uncomplicated placement of expandable metal stents in the upper gastrointestinal tract. They should be advised to advance from liquids to solids as tolerated and to avoid leafy vegetables, which may result in stent occlusion. Gastroduodenal stents are often placed in outpatient procedures.

Complications after placement of expandable metal stents in the upper gastrointestinal tract include perforation, bleeding, stent migration, stent malpositioning, and occlusion of the stent by tumor overgrowth or ingrowth or by food impaction. The condition of some patients with advanced cancer and gastroduodenal obstruction will not improve after successful stent placement because of gastrointestinal obstruction due to tumor at other, unidentified sites, diffuse peritoneal carcinomatosis with bowel encasement, or functional gastric-outlet obstruction due to neural involvement by tumor (e.g., of the celiac axis).\textsuperscript{44} There are no data about the safety of expandable metal stents in the stomach or small bowel in patients who have already received or are currently receiving chemoradiation therapy.

COLORECTAL STENTS

Placement of a colorectal stent should be considered for preoperative decompression and for palliation of cancerous large-bowel obstruction.\textsuperscript{40} Up to 30 percent of patients with primary colorectal carcinoma present with large-bowel obstruction.\textsuperscript{40} The traditional method of managing complete or subtotal colonic obstruction due to cancer, particularly left-sided obstruction, involves the creation of a diverting colostomy. Patients with complete or subtotal colonic obstruction and a potentially resectable tumor cannot undergo a one-stage operative resection of the tumor and immediate reanastomosis, because stool within the uncleansed proximal colon leads to breakdown of the anastomosis. Therefore, the initial surgery includes resection of the primary tumor and colostomy, with reanastomosis at a second operation. Patients with complete colonic obstruction tend to be acutely ill, with advanced disease. Because pre-
operative placement of an expandable metal colorectal stent permits clinical stabilization with preoperative decompression and cleansing, a one-stage operation can then be performed and colostomy avoided. The stent is removed en bloc at the time of resection of the primary tumor, after serving as a bridge to surgery. If the patient is a poor candidate for surgical resection because of underlying illness or has unresectable or widely metastatic disease discovered by imaging studies, the stent can remain in place for palliation. A recent multicenter study of patients with primary colon carcinoma evaluated the effectiveness of preoperative placement of metal stents inserted radiologically. Successful stent placement, with clinical resolution of large-bowel obstruction within 96 hours, was achieved in 66 of 71 patients (93 percent). Sixty-five patients underwent elective single-stage surgery with a primary colonic anastomosis a mean of 8.6 days after stent placement. A severe complication (intestinal perforation) occurred in one patient.

In a retrospective study of the management of acute cancerous colonic obstruction, consecutive patients with colorectal carcinoma who received expandable metal stents were compared with a similar group of consecutive patients who underwent traditional surgical treatment at the same institution. When the data for patients who subsequently underwent a curative resection were analyzed, a cost savings of 28.8 percent was seen in the group receiving stents, because of decreases in the total number of days in the hospital, the number of days in the intensive care unit, and the number of surgical procedures. Despite these promising results, no completed randomized, prospective studies have compared preoperative stents with standard surgery in a group of patients with potentially resectable primary colorectal cancer and obstruction. One such study is under way in the United States. It remains to be seen whether long-term results, such as tumor-recurrence rates, are altered by the use of preoperative placement of colorectal stents.

Candidates for placement of a colorectal stent for palliation include patients with colorectal carcinoma and obstruction who have extensive local or metastatic disease or who are poor candidates for surgical resection, and patients with colonic obstruction secondary to noncolonic pelvic cancers (e.g., bladder or ovarian carcinoma) or metastatic cancer (e.g., breast carcinoma) (Fig. 4D). Successful palliation of obstruction with avoidance of colostomy can be achieved in 85 to 100 percent of patients, with some stents remaining patent and in place for more than one year. Randomized trials are needed to confirm these findings. At present, however, it is difficult to deny such patients the option of receiving a stent in order to avoid a permanent colostomy. Partially covered colorectal stents have also been used to close cancerous colovesical and colovaginal fistulas, with an acceptable risk of stent migration.

Complications of the placement of colonic stents include perforation, stent migration, bleeding, stent malpositioning, and occlusion of the stent by stool. Colonic perforation during insertion of colonic stents may be devastating, because fecal material is spilled into the abdominal cavity, resulting in peritonitis. The peritonitis may be difficult to manage surgically, because the patient may become even more acutely ill, potentially worsening the surgical outcome. Stents placed low in the rectum may produce tenesmus or fecal incontinence.

Stents may be placed endoscopically in the right colon, whereas with radiologic guidance alone, stent placement is limited to the left colon. Patients with widespread advanced cancer may not have clinical improvement after successful placement of a colonic stent because of obstruction at other sites or peritoneal carcinomatosis.

After receiving a palliative colorectal stent, patients should consume a low-residue diet and use stool softeners or laxatives to prevent stool impaction and stent occlusion. The effects of previous or concomitant chemoradiation therapy on rates of local complications are unknown.

FUTURE DIRECTIONS

Biodegradable and bioabsorbable expandable stents are being developed for the treatment of benign disease. Such stents may be useful in treating gastrointestinal strictures that are refractory to dilation, such as peptic esophageal strictures, anastomotic or radiation-induced strictures, or strictures related to Crohn’s disease. In patients with cancer, the use of expandable metal stents that emit radiation or release chemotherapeutic agents may cause tumor regression.

REFERENCES

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CURRENT CONCEPTS


