Gastroduodenal Stenting

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ABSTRACT

Palliative procedures for patients with malignant gastroduodenal obstruction must be readily available, have a rapid onset of action, and be well tolerated by a patient with terminal cancer. Laparoscopic gastroenterostomy and insertion of self-expanding stents are emerging as the current methods of choice.

An increasing number of dedicated enteral stents with different properties are now available. These can be placed under fluoroscopic guidance alone or with the help of an endoscope. Endoscopic placement has several advantages but requires good collaboration between the endoscopists and the radiology department. Appropriate imaging and work-up of each case at multidisciplinary meetings is required. Coexisting biliary obstruction may be dealt with endoscopically, but frequently requires percutaneous biliary stent placement prior to duodenal stenting. Reintervention is required in up to 25% of patients, usually due to stent occlusion by further tumor growth. This article suggests strategies for patient assessment, procedure planning, and stent insertion.

KEYWORDS: Gastroduodenal obstruction, pancreatic cancer, metallic stents

Objectives: Upon completion of this article, the reader will be able to (1) discuss the clinical, imaging, and technical features of using metallic stents in gastroduodenal pathology, and (2) describe the choice of stent as well as the actual procedure of stent placement.

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Malignant gastroduodenal obstruction is a dismal situation. Patients usually sit clutching a vomit bowl, reluctant to lie down for fear of massive regurgitation. Alternatively they may be tethered to their bed by continuous nasogastric drainage, or suffer attempts at palliation with venting gastrostomy. The late onset of duodenal obstruction in a patient with pancreatic cancer used to cause a sense of failure for the GI interventionalist who had successfully managed biliary obstruction, only to find the patient still needing palliative surgery in

the terminal phase of the illness. Thankfully, self-expanding metal stents have remedied this deficit. To offer such a distressed patient freedom from at least the vomit bowl, using a simple day case procedure, is as satisfying for the operator as it is for the patient.

Anecdotal evidence and some retrospective studies suggest that stenting has a lower morbidity and a quicker recovery rate than surgery,¹⁻⁴ but unfortunately the evidence base regarding gastroduodenal stenting is currently still of low grade. There is a distinct lack of

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controlled studies comparing the standard treatment of surgical gastroenterostomy with stenting or even with the newer surgical alternative of laparoscopic gastroenterostomy, which is superseding open gastroenterostomy.⁵⁻⁸

CAUSES OF GASTRODUODENAL OBSTRUCTION

Pancreatic Cancer

Pancreatic cancer is increasing in frequency and each year causes the deaths of ~40,000 Europeans and a similar number of North Americans. Disappointingly, there has been little improvement in outcome figures.⁹ Duodenal obstruction may be the presenting feature but is more likely to occur later in the disease. It is seen in ~10% of patients and most commonly involves the proximal second part of the duodenum between the D1/2 junction and the ampulla.¹⁰ It is unusual for the duodenum distal to the ampulla to become obstructed, although lesions of the body and tail of the gland may occasionally involve this site.

Gastric Cancer

The classical gastric antral tumor is diminishing in incidence while the more proximal junctional adenocarcinoma is on the increase. Tumors of the antrum, particularly those in an immediately prepyloric position, are more likely to cause gastric outlet obstruction, because of the relatively narrower diameter of this part of the stomach. Linitis plastica presents particular problems but thankfully is uncommon.

Primary Tumors of the Duodenum

Duodenal carcinoma and lymphoma as well as primary tumors of the papilla of Vater occasionally cause duodenal obstruction. While their initial treatment, as with most causes of gastroduodenal obstruction, is usually by alternative methods, stenting can have a role.

Retroperitoneal Lymphadenopathy

Lymphoma as well as metastatic disease from colorectal, ovarian, breast, prostatic, and other tumors may involve peripancreatic lymph nodes leading to duodenal obstruction. These may necrose during treatment leading to cavities and fistulae, which can communicate with more distal loops of bowel.

Peritoneal Malignancy

Although the duodenum is a retroperitoneal organ throughout most of its length, peritoneal dissemination of cancer (for example, ovarian) can involve the duodenojejunal flexure leading to obstruction.

Benign Disease

It is almost invariably unwise to place a metal stent in benign gastric outlet obstruction, most commonly caused by peptic pyloric stenosis. Naturally there is the rare case where conventional management has failed or is inappropriate, but as a rule, a stent must not be placed in benign disease without a clear management strategy in mind for the time when the stent ceases to function. Functional gastric outlet obstruction after esophagectomy and gastric pull-up procedures can present a difficult challenge. However, if stenting is the last remaining option, removable esophageal stents should be placed in the first instance.

CLINICAL FEATURES

Gastroduodenal obstruction may be the presenting feature of cancer—for example, in primary tumors of the duodenum—but it is more common to occur in the setting of known malignancy. Clinical features depend on the nature of the underlying disease, but most commonly include vomiting, anorexia, early fullness with meals or a feeling of constant fullness, gastroesophageal reflux, or regurgitation, which may be foul smelling and foul tasting. Vomited material may contain bile or blood. Anemia may be present because of bleeding or malnutrition. Jaundice occurs if the malignancy involves the bile duct and stool and urine color may change as a consequence. Most patients will have progressive weight loss. Vomiting is particularly unpleasant and many patients will virtually fast to try to avoid it, which leads to dehydration, electrolyte disturbance, and prerenal failure. Clinical examination may reveal epigastric fullness and a succussion splash.

PRELIMINARY ASSESSMENT

Clinical Assessment

In a patient with gastric outlet obstruction, anorexia and vomiting may have been present for some time and may have been of high grade. The two main metabolic consequences of this are prerenal failure because of dehydration and metabolic alkalosis. The temptation to expedite stent insertion should be resisted until metabolic abnormalities have been investigated and corrected with appropriate intravenous fluid therapy. Anemia may be present and if severe should be treated to reduce the risk of prerenal failure and sedation-related complications. Most interventional procedures require near-normal blood clotting parameters; however, stent insertion is atraumatic and rarely has to be delayed to allow correction of coagulation. However, clotting abnormalities may be a reflection of malnutrition, malabsorption, or hepatic synthetic dysfunction, and will reflect the severity of the underlying disease. Liver function tests

should be assessed, as any element of biliary obstruction will require investigation and management in its own right.

Imaging Assessment

A physician or surgeon faced with a patient with anorexia, vomiting, and weight loss is likely to refer the patient for upper gastrointestinal endoscopy. This is sensible when the diagnosis of malignancy is not yet established, such as in the patient presenting with symptoms of gastroduodenal obstruction. The diagnosis can be confirmed both visually and histologically. In the patient with known malignancy (for example, previously established pancreatic cancer), endoscopy at the onset of obstruction is probably superfluous. While endoscopy would confirm the obstruction, there are other ways of achieving the diagnosis without the need for an invasive procedure requiring sedation. In addition, endoscopy in gastric outlet obstruction is not without its problems. Sedation and intubation in the recumbent patient with a full stomach may lead to regurgitation and aspiration, potentially adding pneumonia to the patient's difficulties. For the endoscopist the examination is difficult if the stomach is full of food and fluid residue. Preliminary gastric drainage with a nasogastric tube may help, but carries significant discomfort for the patient. Nasogastric tubes measuring 12- or 14-French gauge are virtually valueless for the decompression of the stomach containing significant food residue. Even in the situation where the endoscopist has a clear view of the obstructing lesion, it is unlikely that the distal margin of the obstruction will be visualized at endoscopy. Attempts to achieve this by intubation of the obstructing lesion with or without balloon dilatation may simply make the situation worse. It is better to avoid endoscopy unless there is a specific indication for its use, such as the acquisition of biopsy material.

Given the disadvantages of endoscopy, contrast examination of the upper gastrointestinal tract may be considered. The unwary physician may ask for a barium meal to be performed, a request which may be granted by the unwary radiologist. While the diagnosis of gastric outlet obstruction may be confirmed by a barium meal, it is often not possible to see with clarity the obstructing lesion because of the volume of retained food and fluid within the stomach. For the interventionalist who has to manage the patient subsequently, barium is a nightmare. It clogs endoscopes and makes fluoroscopically guided intervention more difficult. The message is simple: in gastric outlet obstruction, avoid barium at all costs. If it is necessary to undertake an upper gastrointestinal contrast series, water-soluble material should be used. Better still is to avoid endoscopy and contrast examination completely and to make a preliminary imaging assessment using cross-sectional imaging, ideally with CT.

CT allows evaluation of the proximal and distal margins of the obstructing lesion and its extraluminal extent. CT also has the benefit of demonstrating the small bowel beyond the stricture and identifying further distal obstructions. This is particularly important when gastric outlet obstruction is caused by metastatic disease (for example, metastatic ovarian cancer), where mesenteric or small bowel involvement may be multifocal (see below). In addition, CT allows detailed assessment of the biliary system, which is important for lesions in and around the pancreatic head, because abnormalities here may have significant impact on the planned course of action and on outcome.

It is wise to have a reasonably accurate understanding of the histological nature of the obstructing lesion. Where gastric outlet obstruction occurs in the setting of a known primary malignancy, biopsy is not essential. But where the clinical picture is unusual or where alternative diagnoses have to be considered, particularly lymphoma, image-guided biopsy is advisable before irreversible metal stenting is undertaken.

CHOICE OF TREATMENT

An array of options is available to the patient with gastric outlet obstruction.

Do Nothing

It is very difficult not to intervene when faced with the distressed, vomiting patient, yet it is rarely appropriate to do so. However, the occasional patient with extensive intra-abdominal malignancy and multifocal intestinal obstruction may be better spared the false hope of an interventional procedure and its risks.

Gastric Drainage

Nasogastric drainage is uncomfortable and in the presence of food residue in the stomach rarely effective. However, in a stomach filled only with fluid, nasogastric drainage may be effective although it often does not completely resolve vomiting.

Venting Gastrostomy

This may be used in situations of multifocal intestinal obstruction to avoid vomiting or long-term nasogastric drainage. It is only likely to be required as a very short-term palliative terminal maneuver and needs to be of adequate size.

Gastroenterostomy

The real debate for treatment of gastroduodenal obstruction centers around a comparison of gastroenterostomy and stenting. There is no randomized controlled

study comparing these modalities nor is there yet a prospective study comparing open gastroenterostomy with its laparoscopic counterpart. Institutional protocols and guidelines are mandated therefore by expert opinion, which is fallible and biased. Surgeons are of the view that gastroenterostomy is preferable to stenting, possibly because they have operated on patients whose stents have not functioned adequately. Radiologists will just as often point to the fact that they regularly reimage patients who have had an unsuccessful gastroenterostomy. In the absence of Grade A research-based evidence, perhaps a consideration of first principles (what is best for the patient) is best.

Most patients develop gastroduodenal obstruction in the last few months of their lives. Many will be debilitated by the presence of metastatic malignancy and may take time to recover from a surgical procedure. There will be a few days of fasting following a surgical gastroenterostomy, a time when continued immobility and intravenous infusion are required. After gastroduodenal stenting a patient can usually drink immediately, eat within 24 hours, and leave the hospital within 2 to 3 days.^{11,12} These facts are likely to mandate in favor of gastroduodenal stenting, even if stent dysfunction leads to a higher reintervention rate in stented compared with operated patients.¹³ The reduced time spent in the hospital, however, is also reflected in a significantly reduced cost of the stenting procedure when compared with surgical bypass, despite the relatively high cost of the stent itself.²

Choice of Stent

There are no comparative data to guide stent choice. However, in choosing a stent several factors can be

considered and each of these may weigh differently depending upon the position of the obstruction.¹⁴ Most stents for gastroduodenal use are bare stents made either from stainless steel or Nitinol. Some models, particularly for the pylorus, are available partially covered (Fig. 1). The disadvantage of a lack of coating is the risk of tumor or mucosal through-growth, which leads to stent malfunction in between 20% and 25% of patients. The use of covered stents has been described,¹⁵⁻¹⁷ but most operators decide against the increased risk of migration. The addition of covering to a stent may reduce reintervention although this experience has not been shown by studies of esophageal stents in esophageal malignancy. Reintervention rates for covered and uncovered esophageal stents are very similar, although the causes of reintervention are different: tumor through-growth for uncovered stents and migration for covered stents. Uncovered stents are therefore adequate for gastroduodenal use and it would indeed be a disadvantage to place a covered stent across the ampulla of Vater.

There is probably little to choose between Nitinol and stainless steel stents. More important are the physical characteristics of the stent itself. Stents with closed wire loops at their ends are preferable to stents with sharp protruding wire ends (Fig. 2). Tightly woven stents with a high radial force or stents that are cut with laser from a solid tube have a tendency to conform to a straight position. This is undesirable when stenting around the loop of the duodenum. A more open softer weave allows the stent to maintain a curved shape after deployment, thereby allowing the axis of the stent to remain parallel to the axis of the bowel loop in which it is placed. This is clearly a benefit for stent function.

Figure 1 Duodenal stents. (A) 22-mm stainless steel Enteral Wallstent (Boston Scientific; St. Albans, UK). (B) 22-mm Nitinol EnterElla duodenal stent (Radiologic UK, Sheffield, UK/EllaCS, Hradec, Czech Republic) with retrieval purse string for repositioning (arrow). (C) 18-mm Nitinol uncovered and partially covered enteral Hanaro stent (Diagmed, Thirsk, UK/M.I.Tech., Seoul, Korea). (D) 18-mm Nitinol Niti-S pyloric stent (Pyramed, Esher, UK/TaeWoong Medical, Seoul, Korea). (E) 18-mm partially covered Nitinol Niti-S duodenal stent (Pyramed, Esher, UK/TaeWoong Medical, Seoul, Korea).

Figure 2 Cut wire stent (left) and continuous wire stent (right). The sharp ends of the stainless wires may protrude into the bowel wall or twist around each other. Note the retrieval string on the Nitinol stent (arrow).

Equally important is the delivery system. If stents are placed endoscopically, then the delivery systems must be of 11-F size or smaller. For nonendoscopic placement, delivery system diameter is less important, but the delivery system must be long enough to allow the stent to pass through the obstruction, even allowing for loop formation in the stomach.

TECHNIQUES

Sedation and Monitoring

Manipulation of an endoscope or a catheter through the oropharynx and the subsequent passage of a stent delivery system is usually an unpleasant experience for the patient. Most if not all patients value the opportunity of a period of oblivion while upper GI procedures are performed.¹⁸ In some departments where anesthetic support is readily available, the patient or the radiologist may elect to use general anesthesia. This affords excellent control of the situation and if the patient is intubated, it provides complete safety from the risk of regurgitation and aspiration. However, in most departments intravenous sedation will be the method of choice. In the United Kingdom new guidelines on the use of sedation by nonanesthetists recently became available from both the Royal College of Radiologists and the British Society of Gastroenterology.^{19,20} These guidelines set the parameters of preprocedural assessment, intraprocedural monitoring, drug usage and dosage, and postprocedural recovery. Techniques of intravenous sedation are normally extremely safe as long as guidelines are followed, but additional safety can be achieved by the use of the bispectral index monitoring technique, which

allows the objective quantitative assessment of the depth of sedation using the continuous assessment of frontal lobe EEG activity.^{21,22} In clinical practice it appears that the addition of a short-acting opioid such as fentanyl to an intravenous benzodiazepine such as midazolam improves the quality of sedation. The combination of opiates and benzodiazepines, even with careful monitoring, is not without risk in terms of over-sedation, hypoxia, and hypotension,²³ but the extra safety offered by bispectral index monitoring is helpful in minimizing this risk.²⁴ Pharyngeal anesthesia with 4% xylocaine spray prior to the administration of sedation also helps to improve the quality of the experience for the patient.

Stent Placement

EQUIPMENT

For accurate stent placement, fluoroscopy is invaluable to determine the precise position and extent of the stricture. A catheter passed beyond the lesion allows the injection of contrast medium so that in addition to assessing position and extent, any further obstruction distally can be excluded. Precise positioning of the stent before and during deployment can be monitored fluoroscopically in real time and steps taken to modify stent positioning if necessary. The more important question is whether to use an endoscope. In general, the more distal the lesion the greater the benefit of using a scope. It overcomes the tortuous access through a distended stomach, improves control over the guide wire and the delivery system, and prevents coiling of wire and catheter in the stomach (Fig. 3). It is clearly possible to place stents in the stomach and duodenum without a scope, particularly with the help of a long stiffening sheath through which the stent is passed. However—in contrast to esophageal stenting—the procedure is almost invariably easier and quicker using a scope. Large-channel (4.2-mm) therapeutic end-viewing endoscopes are effective but a side-viewing duodenoscope is even better. The forceps elevator of the duodenoscope gives extra control because of its ability to grip the stent, thus allowing forward or backward traction to be applied during placement.

GUIDE WIRES

Most delivery systems are between 210 and 260 cm long, necessitating the use of endoscopic guide wires. A 400-cm-long guide wire is an advantage as it allows more wire to be placed distal to the lesion without limiting the length of wire available proximally for exchange. If an endoscope is used, a long guide wire is essential. A stiffer guide wire is helpful in preventing loop formation and improving the tracking of stent delivery system through the lesion. The plastic coated Nitinol wires used in endoscopic retrograde cholangiopancreatography (ERCP) for biliary stent placement are ideal for this.

Figure 3 Endoscopic stent placement. (A) The duodenoscope acts as an over-tube to straighten out the access route to the stricture in the third part of the duodenum. (B) Deployed 14-cm Hanaro stent (arrows) (DiagMed/M.I.Tech). Stent expansion will continue over several days.

STOMACH

Obstructive lesions in the proximal part of the stomach can be managed using the same technique as for esophageal stent placement. With the patient lying in the left lateral position or, preferably, prone, a torque-controlled catheter (e.g., 7-F Headhunter, Cordis/Johnson & Johnson, South Ascot, UK) together with a hydrophilic guide wire (e.g., 0.035-inch Radiofocus, Terumo, Knowsley, UK) are negotiated through the pharynx into the upper esophagus and into the stomach. After removal of the wire, water-soluble contrast material (e.g., iohexol 350) is injected to delineate the proximal margin of the obstruction. After flushing the catheter with saline the hydrophilic wire is reintroduced and negotiated through the lesion together with the catheter. Contrast material is again injected to delineate the distal margin of the lesion. With the hydrophilic wire replaced, the catheter/guide wire combination is negotiated through the pylorus down to at least the second part of the duodenum, and where possible, into the third part to prevent proximal displacement of the guide wire by possible loop formation during stent insertion. A stiff 0.035-inch guide wire (e.g., 260-cm Amplatz or 400-cm Nitinol) is passed through the catheter to lie with its tip as distal as possible. The catheter is removed and the delivery system is placed over the wire (Fig. 4). Except for very proximal gastric lesions, the use of stents designed for esophageal use should be avoided. Esophageal stent introducer systems are almost invariably too stiff to be negotiated through tight distal gastric lesions. They fail to track around corners and start to loop above the stricture and displace the guide wire. If a proximal loop forms, the esophageal stent introducer system is usually also too short to allow the stent to be negotiated through the gastric lesion. It is better to use an endo-

scopic-length narrow-bore delivery system carrying an uncovered enteral stent, of which there are now a number available.

Having prepared the stent by flushing its guide wire channel and sheath channel with saline, the stent is placed over the guide wire and passed through the lesion. Precise positioning of the stent can be difficult, particularly if a stent is used that shortens during deployment (e.g., Wallstent Enteral, Boston Scientific; St. Albans, UK). Generally it is best to position the distal tip of the stent too far distal at the start of deployment. As the stent expands during deployment, the distal margin of the lesion will be evident by its inhibition of expansion of the stent. The stent can then either be pulled back into the lesion to provide a better position, or, depending on the system, the stent can be partially resheathed and withdrawn. During withdrawal of the stent it is important that both the central catheter of the deployment system and the outer sheath are gripped tightly together and withdrawn together. Traction on the covering sheath alone will only deploy the stent without modifying its position. Once the stent is fully deployed, a check on the adequacy of its position and on its drainage is advisable before the procedure ends. This may be obvious, as contrast material previously placed within the stomach may pass readily through the stent or contrast material may be seen to reflux through the stent, confirming its patency. Alternatively the introducer system of the stent can be exchanged over a guide wire for the previously used torquable catheter. Contrast material is injected during steady withdrawal of the catheter through the stent. If any doubt exists that the proximal margin of the stent does not lie above the proximal margin of the tumor, for example, because there is incomplete expansion of the proximal margin of the

Figure 4 Radiological stent placement. (A) Functional gastric outlet obstruction after cardioesophagectomy and gastric pull-up. The proximal duodenum is compressed just above the diaphragm (arrow). (B) Insertion of a removable plastic Polyflex esophageal stent (Rüsch, Esslingen, Germany). (C) The position of the radiolucent stent is indicated by three marker bands (arrows). The patient is well 2 years later, having required four stent changes thus far.

tumor, it is best not to withdraw the catheter completely for fear of inability to reintubate the stent. In this circumstance the guide wire should be replaced and a second stent placed slightly more proximally.

DISTAL GASTRIC AND DUODENAL LESIONS

For these lesions the technique is essentially as already described, except that an endoscope is of supreme assistance. As before, with the patient in the left lateral position or prone, the scope is passed to the proximal margin of the tumor. Using a standard ERCP catheter, contrast is injected proximal to the lesion. A hydrophilic guide wire allows access through the lesion following which catheter access and contrast injection allow delineation of its distal margin. The stent is placed

through the lesion under endoscopic and fluoroscopic control over a 400-cm guide wire and deployed as described. Advancement or withdrawal of the endoscope may be necessary to obtain optimum stent position. For example, once the distal margin of the stent is adequately positioned and stent deployment begins, it is frequently obvious that the proximal margin of the stent still lies within the operating channel of the endoscope. In this situation it is best to anchor the distal margin of the stent by deployment and then withdraw the endoscope, advancing the stent introducer system at the same time. In this way the stent can then be deployed with its proximal margin outside the endoscope but without risking inadvertent proximal displacement of the stent by endoscope withdrawal. Once the stent has been positioned, contrast

injection distally will confirm an adequate position and endoscopic inspection of its proximal margin will confirm adequate drainage. A second stent can be placed without the guide wire having been withdrawn.

DISTAL DUODENAL OBSTRUCTION

Provided the lesion in the distal duodenum can be crossed using a catheter guide wire combination, stent placement is easier than with a proximal duodenal lesion. This is because the endoscope can be passed deep into the second part of the duodenum, which anchors its position more firmly during stent deployment. Occasionally it is difficult to pass a catheter guide wire combination through a lesion at the distal margin of the duodenum, because it is rarely possible to pass the endoscope distal to the junction of the second and third parts. However, with the use of a hydrophilic guide wire together with a relatively stiff catheter (for example, a polyethylene 7-F biliary dilatation catheter rather than a standard ERCP catheter), it is usually possible to cannulate such lesions and pass a long guide wire deep into the proximal part of the jejunum. Stent deployment is then as described above.

BILIARY OBSTRUCTION

If a duodenal stent is to be placed across the papilla of Vater, thereby precluding future endoscopic access to the papilla, it is worthwhile considering the role of preliminary biliary stenting. If a patient with pancreatic cancer has a pre-existing plastic endoscopic stent in position, it may be helpful to change this for a large-diameter metal stent prior to duodenal stent placement. This can usually be accomplished endoscopically, perhaps with balloon dilatation of the obstructing duodenal

lesion to allow endoscopic access. Once the biliary stent has been changed, a duodenal stent can be placed at the same examination.

For the patient who presents with jaundice together with duodenal obstruction, it is best to place a biliary stent prior to duodenal stent placement.^{25,26} Even in the presence of duodenal obstruction this can often be accomplished endoscopically and a metal stent should be placed before the deployment of the duodenal stent (Fig. 5). If the endoscopic attempt at biliary stenting fails, then percutaneous transhepatic biliary stenting should be undertaken prior to placement of the duodenal stent. It is best to resist immediate placement of a duodenal stent after failed endoscopic biliary stenting prior to transhepatic biliary stenting.

The most difficult situation is one in which it is necessary to deploy a duodenal stent across the papilla of Vater in a patient who has no clinical, biochemical, or radiological evidence of biliary obstruction. Pre-emptive biliary stenting may be difficult particularly if it has to be undertaken transhepatically in a nondilated duct system. A biliary metal stent has a finite life span and stenting prior to the onset of biliary obstruction may aggravate rather than alleviate problems. Endoscopic access through a duodenal stent to the papilla of Vater for the placement of a metal stent if biliary obstruction should develop in the future is a tour de force that is extremely difficult for the endoscopist. Transhepatic placement when biliary obstruction occurs is relatively simple, although it may be necessary to place the biliary stent through the interstices of the duodenal stent. This is not usually technically difficult, but it may be that expansion of the biliary stent is limited by its placement through the duodenal stent, which may increase the risk

Figure 5 Endoscopic biliary stent placement. (A) Coaxial placement of a second biliary stent. The first stent had occluded as the patient developed duodenal obstruction. The narrowed air contour of the duodenum is just appreciable (arrows). (B) After deployment of the biliary stent, a 9-cm Enteral Wallstent was placed in the duodenum.

Figure 6 Percutaneous biliary stent placement. (A) Subsequent to duodenal stenting, the patient developed obstructive jaundice. A percutaneous catheter and guide wire are passed into the duodenum. (B) A biliary Wallstent is placed, with immediate good drainage into the duodenum.

of biliary stent occlusion. Perhaps in this situation the best option is to place a duodenal stent and to leave the biliary system unstented. If biliary obstruction subsequently develops, a transhepatic approach will be necessary (Fig. 6). Once access to the duodenum has been achieved transhepatically, then it is best to try to place the biliary stent alongside rather than through the duodenal stent. This can be achieved using a short torquable biliary catheter (e.g., biliary manipulation catheter) and a J-tipped guide wire. As the guide wire passes alongside the duodenal stent, the transhepatic catheter should be advanced until the distal end of the duodenal stent has been passed. This ensures that at no point has the guide wire passed through the duodenal stent. The transhepatic catheter can then be removed and a transhepatic metal biliary stent placed. The biliary stent will then expand to its full diameter and biliary drainage will be as good as could possibly be achieved. Future access for repeat transhepatic biliary or endoscopic duodenal stenting then remains possible.

SPECIAL CIRCUMSTANCES

Linitis Plastica

Occasionally patients with vomiting due to extensive gastric involvement in linitis plastica are referred for stenting. While this may be technically possible it is frequently disappointing from the point of view of alleviation of the patient's symptoms. However several simple measures may maximize success. In linitis plastica it is often possible to pass an endoscope through the tubular stomach into the duodenum beyond, indicating that vomiting is as a result of a functional deficiency of the stomach rather than mechanical obstruction.

Placement of a stent, which turns a rigid tubular stomach into a rigid tubular stomach with a slightly larger diameter, may therefore not be successful. When stenting linitis plastica it is best to stent the whole stomach. The distal margin of the first stent should probably lie in the proximal part of the second part of the duodenum, thereby avoiding any component of mechanical obstruction afforded by the pylorus. It is usually then necessary to insert a second stent overlapping the first so that the proximal margin of the second stent lies in normal stomach as proximally as possible. If there is no normal stomach and the whole stomach is involved with tumor, then the proximal margins of the stents should be left in the distal esophagus.

Gastroenterostomy

It is perfectly possible to stent patients who have recurrent tumor at the site of a previously placed gastroenterostomy whether this has been in combination with a partial gastrectomy or not. The principles of stenting are as with distal gastric or duodenal stenting, but it is absolutely crucial to ensure that the stent is placed in the efferent loop of the gastroenterostomy. Even when there is only an efferent loop and a Roux loop is inserted more distally, it is wise to be absolutely certain that the stent is placed into the efferent loop properly. Many surgeons anastomose the efferent loop side-to-side to the stomach so that there may be a short, blind segment of jejunum, of which the radiologist should be very wary during guide wire placement.

Multiple Obstructions

Occasionally it is obvious from preliminary imaging or during contrast injection immediately prior to stent

placement that more than one obstructive lesion is present. If the second lesion is relatively proximal then it may be possible to place two stents, one through each obstruction (Fig. 7).²⁷ Unfortunately, it is often the case that the more distal lesion cannot be accessed and a decision has to be made as to whether or not it is worth placing a stent across the proximal lesion. In general, apart from cost, there is no disadvantage to placing the planned stent. It may be that alleviation of the proximal obstructing lesion will give some respite to the patient from his or her symptoms even in the presence of a more distal obstructing lesion. Perhaps the most important point is that where multiple obstructing lesions are known to be present from preliminary assessment, careful discussion should be had with the patient beforehand about the probable outcome of intervention.

Altered Anatomy

Occasionally gastroduodenal stenting may be required where normal antegrade access to the stricture is impossible, as, for example, after surgery. Transhepatic and transthoracic placement of the stents has been described,²⁸⁻³⁰ but this should be reserved for centers with the relevant experience.

Aftercare

Pain and other complications after gastroduodenal stenting are not common and usually patients can start drinking clear fluids as soon as they have recovered from sedation. Provided there is no ill effect from this, free fluids and a light soft liquid diet can be given. If the patient has been vomiting significantly for some time before stent placement, it can be difficult to regain the confidence that eating can take place without the risk of vomiting. A steady progressive increase in intake and more solid texture of food should be encouraged, with constant reassurance by the patient's caregivers. Normally, patients can be discharged 24 to 48 hours following stent placement, provided they have immediate access to assistance should problems occur. In the absence of an obvious clinical complication there is no advantage to undertaking a routine contrast meal examination following stent placement.

COMPLICATIONS

Some discomfort due to gaseous distension of small bowel following endoscopic insufflation is common in the hours following stent placement. This passes. Intestinal bleeding and perforation rarely occur but may do so, particularly where the stent is too short to cover the bends

Figure 7 Multiple lesions from metastatic ovarian carcinoma treated with two Enteral Wallstents.

Figure 8 A difficult stent. (A) Gastric outlet obstruction from pancreatic carcinoma. Injection through the catheter (arrow) demonstrates a stricture of the first part of the duodenum. Note the distended stomach (arrowheads). (B) Placement of delivery system around the curve of the duodenum. (C) Deployed stent is too short: the proximal end does not extend beyond the stricture. The wire ends of the distal end have become entangled and prevent expansion. (D) Reintubation. Looping the wire tip prevents exiting through the interstices of the first stent. (E) Apparent good result, but failed expansion of the distal end due to twisted wires (arrows).

of the duodenal 'C,' where the end of the stent is forcibly embedded in the duodenal wall, or where the stent ends have unfinished, sharp edges.^{31,32} Pancreatitis following stenting across the papilla has been described.²⁷ Stent migration is unusual, particularly when the stent has been placed in the duodenum or beyond. However, if a stent

has been used that shortens during deployment, occasionally one end of the stricture becomes unstented during stent expansion, and reintervention will then be necessary because of persistent symptoms. Stents made from individual strands of cut wire may fail to expand if the wire ends have become entangled (Fig. 8). Balloon

dilatation is often unsuccessful due to elastic recoil and the passage of a scope may be required to open the stent. Modern stents made from a continuous loop of wire avoid this problem.

OUTCOME AND REINTERVENTION

Following gastroduodenal stenting, about 75% of patients will remain symptom free on a modified (soft) diet. However, up to 25% of patients will need reintervention either because of stent shortening as described above or because of tumor extension. When symptoms recur, repeat gastroduodenal stenting can be undertaken exactly as previously described and could be expected to be successful. Unfortunately, in a small minority of patients, perhaps 5%, symptoms persist despite perfectly adequate technical success. Although the stent is open and at reassessment it is possible to pass an endoscope through the stent into the unobstructed bowel distally, occasionally a patient has persistent vomiting. This situation is also seen after surgical gastroenterostomy where there is no mechanical obstruction to the gastroenterostomy itself or to the efferent loop, but symptoms persist. The explanation for this is not obvious although it is probable that the problem is functional because of abnormal or absent peristalsis.

CONCLUSION

The provision of a gastroduodenal stenting service is a challenge to the interventional gastrointestinal radiologist. It requires total provision of care from referral to discharge or death. Clinical and radiological preprocedural assessments are important integral parts of the service, as are the provision of safe sedation monitoring and recovery facilities. For the radiologist who does not have endoscopic skills, close collaboration with a gastroenterologist or surgeon for the provision of this service is mandatory, but the rewards to be gained by relieving the patient of the distress of vomiting are considerable.

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