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Review Article

The obstructed afferent loop: Percutaneous options

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ABSTRACT

Endoscopic drainage can be considered the treatment of choice in benign and malignant obstruction of the distal biliary tree, with percutaneous intervention reserved for cases of difficult access or complex hilar strictures. However in patients with altered anatomy due to pancreatico-duodenectomy gastrectomy, or Bilroth II reconstruction, endoscopy can be exceptionally challenging and often impossible. Surgery remains the gold standard for benign causes of obstruction of a bilio-enteric anastomosis or afferent loop, and percutaneous management remains controversial. Novel endoscopic techniques such as double balloon enteroscopy and endoscopic ultrasound guided procedures can overcome some of the anatomical challenges, but a percutaneous approach is a more established technique for cases of malignant obstruction of a bilio-enteric anastomosis or afferent loop. The altered anatomy presents unique challenges which must be fully contemplated and understood before intervention should occur, to avoid the risk of permanent external drainage.

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Keywords: Afferent loop syndrome; Bile ducts; Biliary tract neoplasms; Percutaneous stents; Self expandable metal stents

Introduction

Patients with a history of surgery for gastric, pancreatic, duodenal or biliary cancer will have altered post-surgical anatomy which can present significant challenges for endoscopic access to the afferent small bowel loop or biliary tree.

Pancreatico-duodenectomy with Roux-en Y anastomosis and Bilroth II gastrojejunostomy involve creation of an afferent or blind loop which can preclude any endoscopic access (Fig. 1, 2). Anastomotic angulation or a long afferent jejunal lead-in to a gastrojejunostomy can frequently prevent passage of a conventional endoscope. The incidence of afferent loop obstruction after surgery is reported at 0.3% to 1.0% for benign and malignant cases, rising to 13% in cases of malignant afferent loop formation for pancreatic cancer.^{1,2}

Median survival following radical pancreatico-duodenectomy for pancreatic cancer is 14 to 18 months, but with continuing advances in surgical technique and chemotherapeutic regimes, the incidence of afferent loop obstruction may be expected to increase.³

In cases of normal anatomy, percutaneous transhepatic biliary drainage (PTBD) or surgery were historically the treatments

of choice prior to the development of endoscopic retrograde cholangiopancreatography (ERCP) as a distinct technique for non-surgical decompressive biliary intervention.

ERCP is proven to be safe and effective with a technical success rate of over 90%, and is now generally accepted as the gold standard for mid to distal common duct pathologies and gall stone related disease.⁴

ERCP has recognized complications such as pancreatitis, cholangitis, duodenal perforation and stent migration, with a reported incidence of 5% to 20%.⁵

Complication profile notwithstanding, it has certain inherent limitations. It is less well suited than PTBD in cases with altered surgical anatomy or with tumors obstructing access to the duodenum or distorting the ampulla.⁶

Recent ERCP advances with double balloon enteroscopy, laparoscopy assisted ERCP and endoscopic ultrasonography guided biliary drainage show that endoscopic access is possible in some cases of surgically altered anatomy, but these procedures are less well established than PTBD, are prone to a complication rate of up to 23% and should only be performed in expert hands.^{7–14}

Even if the biliary system is reached by these novel ERCP methods, effective management can be challenging in the pres-

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Fig. 1. Representation of Bilroth II anatomy pre and post-surgery showing partial gastrectomy with gastro-jejunostomy and creation of a blind ending duodenal stump.

Fig. 2. Representation of pancreatico-duodenectomy and formation of roux loop and gastrojejunostomy (Whipples procedure) pre and post-surgery.

ence of hilar or intrahepatic/segmental strictures.⁵

PTBD is an alternative to ERCP, and involves percutaneous puncture of the liver capsule, with creation of an intrahepatic tract to access the biliary tree.

PTBD has a technical success rate of up to 98.7% and is specifically indicated in previous failed ERCP, segmental or hilar strictures, or when ERCP is unavailable.¹⁵

It is particularly suited to cases of altered surgical anatomy, as direct access to the biliary system is achieved through the liver.¹⁶

It is however not complication free, and is associated with a reported mortality rate of between 5.6% to 19.8%. However this may relate to the patients co-morbid conditions rather than the procedure.^{15–17} It should therefore be reserved for cases that are unsuitable for primary ERCP.

Hence, despite the advent and advances of ERCP, and a known complication profile for PTBD, PTBD remains an essential tool in the setting of biliary obstruction with altered surgical anatomy.

Etiology and Management of Afferent Loop Obstruction

Afferent loop obstruction in a patient with altered surgical anatomy can occur at any point between a bilio-enteric proximal afferent anastomosis and the distal afferent loop at the entero-enteral anastomosis. The obstruction may be partial or total, and if the obstruction is significant enough, the ultimate outcome will be intrahepatic biliary dilatation and liver dysfunction, manifested by pain and jaundice. Management of benign obstruction differs considerably to the management of malignant obstruction, and differing types and levels of obstruction require quite individualised management. A radiological diagnosis supported by clinical symptoms must be obtained prior to any intervention.

Initial management and technique

A clear understanding of the anatomy of the post-surgical afferent loop is essential, as access to the biliary system and loop can be technically achieved via three routes: a percutaneous ap-

proach through the liver with insertion of a PTBD, a per-oral approach with endoscopy and ERCP, or via a direct percutaneous approach through the abdominal wall into the afferent loop.⁷⁻¹⁴

As individual surgical practice can vary, reference to any operative notes is considered good practice before attempting intervention. Some centres may fix the Roux loop to the anterior abdominal wall to allow easy percutaneous access should obstruction develop, but this practise is not routine, and direct percutaneous roux loop access may not necessarily be the best first approach.¹⁸

A clear understanding of the exact level of the obstruction is required, as stenting of the incorrect point can condemn a patient to permanent external drainage. Transhepatic percutaneous access to an obstruction point well below a bilio-enteric anastomosis may prove impossible to traverse with a catheter due to a lack of torque through a distended loop. If an obstructed roux loop is accessed percutaneously but cannot be traversed, biliary decompression may make transhepatic salvage very difficult. Conversely, if an obstructed roux loop is drained via a transhepatic approach which does not traverse the afferent obstruction point, an attempted salvage procedure with direct percutaneous puncture of the roux loop from the abdominal wall can become difficult, again condemning the patient to permanent external drainage. In rare cases, both methods of access may be required to be ulti-

Fig. 3. Recurrent pancreatic adenocarcinoma in a patient having previously undergone Whipples procedure. (A) Fluoroscopic image shows complex stricture at bilio-enteric anastomosis (black arrow) extending into afferent (white arrow) and blind loop (arrowhead). (B) Differentiation between afferent and efferent loops is only possible when contrast is seen to pass distally (white arrow). (C) Coronal computed tomography (CT) scan demonstrates 'C' sign of obstructed afferent loop (arrowhead). (D) Axial CT shows gas in a dilated biliary tree (white arrow) due to culture proven *Candida*.

mately successful.¹⁹

It is important to identify if an obstruction point is multi-level. Lack of passage of contrast beyond a loop could indicate that the blind roux has been accessed, or indicate an obstructed afferent loop. Conventional fluoroscopy images are two-dimensional, and differentiation of an obstructed afferent loop and a blind ending surgical stump can be difficult. Fluoroscopy should ideally document passage of contrast beyond the afferent loop into normal small bowel, as stenting incorrectly into a blind loop can preclude any further stent insertion to the real point of obstruction in the afferent loop (Fig. 3A).

Pre-intervention imaging to map the afferent loop and plan the best method of access is essential. Ultrasound, barium studies, and radionuclide imaging have been used historically to achieve a primary diagnosis of afferent loop obstruction; however, these should now be best viewed as supportive or adjunctive techniques for primary diagnosis.^{20,21}

Ultrasound continues to play a key role in the initial diagnosis of biliary obstruction by confirming biliary obstruction, but has been associated with misdiagnosis of an obstructed afferent loop as either a retained native gallbladder or a pancreatic pseudocyst.²²

Whilst magnetic resonance imaging (MRI) and magnetic resonance cholangiopancreatography have both been shown to be sensitive for detecting and defining afferent loop obstruction, computed tomography (CT) is regarded as the minimum requirement for defining level and cause of obstruction. The 'C-loop sign' of a distended viscus between the aorta and superior mesenteric artery is a recognised CT finding along with the 'keyboard sign' which describes how visualisation of the valvulae conniventes prevents a misdiagnosis of a gallbladder or pseudocyst (Fig. 3B).²³

CT also affords the opportunity to restage cases with a previously documented malignancy to determine whether intervention is clinically appropriate.²⁴

Management of benign and malignant obstruction can differ considerably, and conventional imaging modalities such as CT or MRI may not always provide a definitive pathological diagnosis. In cases where endoscopic access to achieve tissue diagnosis is precluded, fludeoxyglucose positron emission tomography CT has not been shown to be significantly more useful than CT or MRI for diagnosing benign or malignant obstruction, but it can prove useful to diagnose regional and distant metastases, which may make differentiation of a benign or malignant stricture somewhat academic.²⁵

A complimentary combination based imaging approach is probably associated with a more complete understanding of the nature and level of obstruction, but a CT should form the basis of any management algorithm to determine whether the obstruction is mechanico-functional, benign-fibrotic or malignant.^{26–29}

Pre-interventional imaging is also essential to determine the presence of ascites, colonic interposition, or varices formation which may complicate percutaneous access.

Once the nature and level of obstruction has been determined, intervention can be planned. As with all cases of biliary obstruction prior patient preparation is essential to ensure a safe procedure and reduce the complication profile.

A full biochemical profile, full blood count, and clotting screen are considered mandatory prior to percutaneous intervention. Coagulopathy is usually corrected within 24 hours with an intravenous administration of 5 to 10 mg vitamin K, if there is sufficient hepatocellular function.

Large volume ascites should be drained prior to biliary intervention as it can increase the risk of haemorrhage and catheter

displacement into the peritoneum.¹⁵

Sepsis is one of the main major complications of any biliary intervention.^{15,16} Administration of prophylactic antibiotics is not always required in all cases of biliary intervention but should probably be intravenously administered for at least 24 hours before and after intervention for an obstructed afferent loop as the obstructed loop also act a sump to allow significant quantities of organisms to build-up in larger volumes of infected biliary fluid than might be seen within an intact biliary tree.³⁰

It should also be noted that gas in the bile ducts may actually reflect infection with gas-forming organisms, and can be mistaken as a sign of a patent bilio-enteric anastomosis (Fig. 3C). Secure intravenous access must therefore be established prior to the procedure and appropriate fluid resuscitation instigated.

The technique of percutaneous trans-hepatic biliary access is well established. It involves ultrasound or fluoroscopic guided puncture with a 21 to 22 G Chiba needle (Cook Medical, Bloomington, IN, USA) into a suitable duct, Seldinger insertion of a 0.018-inch guidewire, over which a 6 Fr access system is inserted. This will accept a 0.035-inch guidewire, at which point a simple external drain can be inserted or the access upgraded to allow for therapeutic manoeuvres. Bright tipped 7–8 Fr vascular access sheaths are ideal for procedures where a number of different catheters, dilatation balloons, stents, or drains may have to be passed. They safeguard access to the biliary tree and allow the liver capsule and trans-hepatic track to be spared from the trauma of multiple catheter exchanges. The side arm allows contrast injection without having to remove either the catheter or the guidewire, and a radio opaque ring marker at the tip reduces error regarding the position in the duct and avoids the risk of deploying a stent within the access sheath. Biliary intervention, particularly dilatation, can be extremely painful and requires administration of conscious sedo-analgesia, or rarely general anaesthesia. Once properly prepared, careful management may proceed. Further subsequent management will depend on whether the obstruction is due to benign or malignant causes.

Causes and management of benign obstruction

Benign mechanico-functional obstruction occurs due to angulation, adhesion, or torsion of the mobile Roux loop. The standard length of a mobile afferent Roux loop is up to 45 cm. Some studies suggest that a short or tailored Roux loop can lead to a decreased incidence of functional obstruction, but this is not practised routinely.³¹ Mesocolic defects created at the time of initial surgery can allow internal herniation of the afferent loop, also resulting in obstruction.

Revision surgery is generally accepted as the gold standard treatment method in cases of benign mechanico-functional obstruction with a primary success rate of up to 90%.^{32–34}

In cases of conventional anatomy, benign-fibrotic biliary strictures are normally managed endoscopically with a combination of initial balloon dilatation and subsequent long-term stricture remodelling with the insertion of multiple plastic stents. This requires several repeat endoscopic procedures to change the stents and prevent blockage. A basic premise is that un-covered self-expanding metal stents (SEMS) should not be used in cases of benign disease due to a proven risk of poor efficacy and patency due to hyperplastic tissue ingrowth, which also prevents stent removal.^{35–37}

Covered SEMS avoid the risk of mucosal embedding and show promising results in 7 cases of benign biliary strictures. In a large prospective multinational study, removal success of cov-

ered SEMS after extended indwell and stricture resolution was achieved for approximately 75% of patients with conventional anatomy.^{38,39}

Benign-fibrotic stricturing in post-surgical cases usually occurs at a bilio-enteric anastomosis, and presents some unique anatomical challenges. As the main body of evidence for benign stricture management relates to preserved anatomy, this evidence is less relevant in a post-surgical setting with altered anatomy. Whilst stricturing at a bilio-enteric anastomosis or enteral anastomosis is more challenging to manage, it thankfully has a reported incidence of less than 1%.¹

Surgical revision is still regarded as the gold standard for management of benign-fibrotic anastomotic strictures but serial balloon dilatation via an endoscopic or percutaneous approach are both reported to be effective in some settings.⁴⁰

Repeated endoscopic balloon dilatation can be challenging, impracticable, or impossible, and percutaneous access to the stricture through a long-term percutaneous biliary drain may be the more practicable approach, and is proven to be effective however, the rate of recurrence is reported to vary from 15% to 44% (Fig. 4).⁴⁰⁻⁴⁴

A percutaneous approach will also require a long term external drainage catheter to be placed to allow future repeated balloon dilatation without the need for repeated percutaneous access and the cumulative risks involved with repeated punctures.

The role of removable covered SEMS in cases of altered bilio-enteric anatomy remains controversial due to a perception that removal may be traumatic and cause further damage to the anastomosis. Covered SEMS are however inherently more suited to stenting through benign disease as the gallbladder will usually have been resected and there is no concern about cystic duct occlusion. Novel stent designs have also been developed which may prove to be beneficial when inserted through an anastomosis, but more evidence is required. A knitted covered SEMS can be removed by inversion, as described in the oesophagus, which may allow for less traumatic removal procedures through an anastomosis.⁴⁵

Multiple small studies show that percutaneous covered SEMS removal is technically possible albeit, not yet widely reported.⁴⁶⁻⁵⁰ The largest single study of 68 patients demonstrating it to clinically effective in 87% of cases, and with primary patency rates at

1, 2, 3, 4, and 5 years of 91, 89, 76, 68, and 68%, respectively.⁵¹ Covered stents are also not without complications. A covered stent may cause branching duct occlusion if placed close to the hilum and this was observed in 38/68 patients in the above study, although it did not induce major complications. Migration of any covered stent is always a possibility, and this rule holds true in the postoperative biliary tree. In the study by Gwon et al,⁵¹ migration was observed in 11 of the 68 patients (16.2%).

Biodegradable (BD) stents (Ella-CS, Hradec Kralove, Czech Republic) constructed with woven polydioxanone would intuitively appear suited to benign strictures as they are uncovered, degrading by hydrolysis, and thus avoiding the need for removal or repeated procedures to maintain short to medium term patency. They have been successfully placed in various hollow organs throughout the human body, but are used off-label on a named patient basis in the biliary system.⁵²⁻⁵⁶

The role of BD stents in the management of benign biliary strictures in cases of altered anatomy is limited to a few individual cases performed in various institutions (Fig. 5). Although performed with some success, the exact indication and efficacy has yet to be established. The stents disintegrate via hydrolysis and resultant stent debris might be retained above an intact common bile duct sphincter, theoretically predisposing to a risk of cholangitis. Thus, a post-surgical bilio-enteric anastomosis with no sphincter might be more inherently suited to allow free passage of stent debris as it disintegrates.⁵⁷

Causes and management of malignant obstruction

Long term survival for patients with intervention for malignant biliary obstruction is less than 20% at 1 year, and the traditional aim of therapy for any biliary obstruction has been symptom palliation.¹⁵ Palliative biliary drainage aims to improve symptoms of liver dysfunction such as jaundice, pruritus, to prevent sepsis and encephalopathy, and to reduce pain.

With advances in chemotherapy, a further main aim of biliary intervention is now to optimise liver function to allow delivery of systemic chemotherapy, and even small gains in liver reserve may allow this.

Malignant obstruction can occur due to anastomotic tumour recurrence, loco regional metastatic infiltration of the afferent

Fig. 4. Trans-hepatic dilatation of a benign anastomotic stricture. (A) Anastomotic stricture (arrow) with 10 Fr internal-external drain passing through the strictured segment. (B) Balloon dilatation to 9 mm, demonstrating compression of the balloon at the tightest point of the stricture (arrow).

Fig. 5. Biodegradable (BD) stent delivery. (A) Delivery system containing the radiolucent stent is inserted across the anastomotic stricture. The radio-opaque markers woven into stent (black arrows) identify the upper and lower end of the stent. (B) Balloon dilation is performed. (C) Contrast injection through the access sheath (white arrow) confirms stent expansion and correct placement with radio-opaque markers (black arrows) denoting the upper and lower end of the stent. (D) Stent prior to delivery within a 13 Fr sheath.

Fig. 6. (A) Complex bilio-enteric stricture requiring three percutaneous transhepatic access routes to achieve global biliary drainage. White arrows show two right sided percutaneous transhepatic biliary drainage (PTBD) routes. Black arrow shows left PTBD route. (B) Placement of three 10 × 8 mm uncovered stents (white arrows). The tracts have been closed using injectable collagen paste (black arrows).

loop, or from disseminated peritoneal tumour spread. Obstruction can be intramural, extrinsic or often both, and may be mechanical or functional, but often both, as the afferent loop may have been denervated at surgery with poor peristalsis. Benign strictures and radiation changes may co-exist and contribute to malignant causes of obstruction in any case of peritoneal disease and obstructed bowel.^{58,59}

Focal disease confined to the gastro-jejunal anastomosis or very distal portion of the afferent loop could and perhaps should be managed surgically. Surgical revision is accepted as the gold standard for management of benign afferent loop obstruction, but in general, surgery usually has a limited role in the management of malignant obstruction. Surgical bypass is the preferred decompression option in those with focal single point gastro-jejunal dis-

ease, a good performance status, slow disease progression and a life expectancy of more than 60 days. However, even with careful patient selection, 30-day mortality can approach 40%. Co-existing ascites, disseminated intra-peritoneal disease, post treatment adhesions, and poor nutritional or performance status all contribute to complication rates of up to 90% in cases of attempted surgical palliation.^{60,61} In cases of advanced intra-abdominal malignancy, bowel involvement can be multi-focal in up to 76% of cases and is usually multifactorial, thus successfully managing the obstructed afferent loop may simply move any obstruction point further downstream. Given that the survival rates associated with biliary intervention are described as 48% at 90 days, 32% at 180 days and < 20% at one year, careful multi-disciplinary discussion must occur prior to any intervention.¹⁵

Focal malignant obstruction at the bilio-enteric anastomosis is best managed with a percutaneous trans-hepatic approach. If the afferent loop is obstructed due to tumour obstruction further downstream, percutaneous access becomes more challenging, but may still provide the best chance of success if an endoscope cannot be passed. In both of these roles the ultimate aim is to traverse any stricture and place a SEMS to restore biliary drainage.

Balloon dilatation has no real role in the management of malignant afferent loop obstruction other than as an adjunct to definitive stenting, and permanent external drainage should only be performed if all stenting options have been exhausted.

Obstruction at the bilio-enteric anastomosis can be challenging if infiltrative tumour spread obstructs more than one hilar duct, requiring multiple hilar stents and more than one trans-hepatic route (Fig. 6). In such cases, targeted ultrasound access of specific intrahepatic ducts is required, and blind fluoroscopic access is not advised.

Either enteral or biliary stents can be placed at a bilio-enteric anastomosis depending on the tightness of the stricture and the length of any residual biliary tree. Obstruction within the afferent loop proper should be managed in the same way as any small bowel stricture and a formal enteral stent should be placed in preference to a biliary stent. Placement of an enteral stent through a trans-hepatic tract requires a larger delivery system than a biliary stent, and the creation of a larger tract is likely to increase the risk of haemorrhage or peritoneal bile leak.

Unlike benign obstruction, the choice of uncovered or covered SEMS has traditionally been less important in cases of malignant obstruction. Uncovered stents will be prone to tumour ingrowth, and covered SEMS will be prone to migration.¹⁵ This has histori-

cally been less of an issue in cases of advanced malignancy where survival is limited, but with improving chemo-therapeutic options, any intervention should assume that stent complications and re-intervention may ultimately be required (Fig. 7). Uncovered stents may allow more options at the liver hilum by permitting future re-access through stent interstices, and are less prone to migration. Should tumour ingrowth then occur, a covered stent may then be placed. In an obstructed aperistaltic afferent loop which only carries bile, migration of a covered enteral SEMS might be expected to occur less often than in a peristaltic small bowel loop carrying food boluses, but more research is required. New stent designs are available which have the covering component of the stent within two layers of nitinol, thus allowing the outer layer of nitinol mesh to partially adhere but without ingrowth (ComVi [TaeWoong Medical, Seoul, Korea] and EGIS [S&G Biotech, Seoul, Korea]). This may lead to a decreased re-intervention rate, but it is best to assume that any case may need re-intervention if the patient survives long enough.

Discussion

Surgery remains the gold standard for benign causes of obstruction of a bilio-enteric anastomosis or afferent loop. Percutaneous and endoscopic management for benign causes of afferent loop obstruction remain technically achievable but controversial with respect to long term resolution.

Endoscopic drainage can be considered the treatment of choice in benign and malignant obstruction of the surgically intact distal biliary tree, with percutaneous intervention reserved for cases of difficult access or complex hilar strictures.⁶⁻¹⁴ However in

Fig. 7. Stent complications. (A) Computed tomography (CT) 9 months post uncovered enteral stent placed through afferent loop stricture with tumour ingrowth (short arrow) and distal fracture (long arrow). (B) Salvage with co-axial trans-hepatic placement of a covered enteral stent (arrow). (C) Placement of a covered enteral stent into an afferent loop stricture (arrows). (D) CT of same patient showing stent migration and impaction to the gastrojejunostomy causing biliary and gastric distension (arrow).

patients with altered anatomy due to pancreaticoduodenectomy or Billroth II reconstruction, endoscopy can be exceptionally challenging and often impossible. Novel endoscopic techniques such as double balloon enteroscopy and endoscopic ultrasound guided procedures can overcome some of the anatomical challenges, or can be used in conjunction with a rendezvous technique alongside percutaneous access.^{7–14} The percutaneous approach is the more established technique for cases of malignant obstruction of a bilio-enteric anastomosis or afferent loop, but presents unique challenges which must be fully contemplated and understood before intervention should occur.

A definitive understanding of the cause and surgical anatomy of any afferent loop obstruction is essential prior to undertaking percutaneous intervention. Incorrect choice of access route or inadequate understanding of the anatomy can condemn a patient to permanent external drainage. Even when the cause and anatomy of afferent loop obstruction are understood, consideration must be given to the expected survival of the patient and the risk versus benefit of intervention. Sepsis must be assumed to be a risk in any afferent loop intervention. An understanding of stent choice and stent complication profile is essential as a bilio-enteric anastomotic stricture and an afferent loop enteral stricture behave differently to conventional biliary and enteral strictures.

As advances in surgical technique and chemotherapy may lead to increased patient survival, the incidence of benign and malignant afferent loop obstruction may increase. There is no dedicated protocol for management, and each patient requires an individualised management algorithm which should consist of multimodality imaging and multidisciplinary clinical team discussion.¹⁵

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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