Multiple metallic stents placement for malignant hilar biliary obstruction: Perspective of a radiologist

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A B S T R A C T

In the palliative setting, the necessity of biliary drainage of both liver lobes for malignant hilar biliary obstruction remains controversial. However, bilateral biliary drainage is a reasonable option to prevent cholangitis of the undrained lobe and to preserve liver function during the course of chemotherapy. Bilateral biliary drainage can be accomplished by the percutaneous or endoscopic placement of multiple self-expandable metallic stents (SEMS). Although SEMS placement via bilateral (multiple) percutaneous routes is technically simple, multiple percutaneous transhepatic biliary drainage (PTBD) may lead to additional morbidity. SEMS placement via a single percutaneous route is a useful method; however, negotiation of a guidewire into the contralateral bile duct is occasionally impossible if the hilar angle between the right hepatic duct and left hepatic duct is acute. Percutaneous dual SEMS placement is generally performed using the stent-in-stent technique (T configuration or Y configuration) or the side-by-side technique. In addition, the crisscross technique has been reported as being a useful method for trisegmental drainage. The side-to-end technique is also useful for multiple SEMS placement. In the future, the combination of percutaneous intervention and endoscopic ultrasonography-guided procedures may be effective in the management of malignant hilar biliary obstruction.

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Introduction

Biliary obstruction due to hepatic hilar malignancy, including advanced Klatskin tumors, is difficult to treat because of complicated anatomical factors.¹ Because most patients with hepatic hilar malignancy are not good candidates for curative resection, palliative biliary decompression is achieved through biliary-enteric bypass surgery, endoscopic drainage, and percutaneous transhepatic biliary drainage (PTBD).² ³ Endoscopic drainage is the primary treatment for patients with biliary obstruction. However, there are some patients in whom bile duct access is not possible because of failed biliary cannulation or an inaccessible papilla. In these patients, PTBD is performed as an effective biliary drainage method.⁵

Percutaneous or endoscopic placement of a metallic stent is a well-established palliative treatment for advanced hilar malignancy.⁶–¹³ Although there have been many studies on the outcome of unilateral and bilateral stent placement in patients with advanced hilar malignancy according to the Bismuth–Corlette classification,¹⁴¹⁷ there is no definitive consensus on the best stent placement method. The decision on whether to perform unilateral or bilateral stent placement depends on the extent of the malignant biliary stricture and on the degree of biliary tract contamination.¹⁸

Unilateral drainage via a single percutaneous route carries a lower risk of complications associated with PTBD, and it is well known that the biliary drainage of > 25% of the liver volume is required for adequate palliation of obstructive cholestasis and to improve biochemical parameters.¹⁹,²⁰ Therefore, unilateral stent placement into one functional liver lobe may provide adequate palliation in most patients with malignant hilar biliary obstruction.¹⁶–²¹

In contrast, in some patients, bilateral stent placement may be the best option for palliative drainage when bilateral biliary ducts are contaminated or if chemotherapy is scheduled.¹²,²² Recently, an analysis of the factors predicting drainage effectiveness during endoscopic stent placement for malignant hilar biliary strictures was reported.¹⁸ The main factor associated with effective drainage was the volume of the liver drained (> 50%), as assessed using...
computed tomography (CT). Moreover, > 50% drainage was associated with prolonged survival in treated patients compared with patients with < 50% drainage. Therefore, to achieve a drainage volume of > 50% and its associated benefits, bilateral or multiple drainages may be warranted.

Various self-expandable metallic stents (SEMS), such as the open-cell design stent, are available for the treatment of malignant biliary obstruction. In addition, several techniques of multiple stent placement for bilateral drainage have been developed to improve the success rate and prevent complications associated with percutaneous biliary procedures.22–27

As described above, in the palliative setting, the necessity of biliary drainage of both liver lobes for malignant hilar biliary obstruction is still controversial. However, bilateral biliary drainage is a reasonable option to prevent cholangitis of the undrained lobe and to preserve liver function during the course of chemotherapy. Bilateral biliary drainage can be accomplished by the percutaneous placement of multiple SEMS.22–27

This review discusses the technique for the percutaneous placement of multiple SEMS, reintervention for stent occlusion, and possible future developments.

Percutaneous Transhepatic Biliary Drainage

Before PTBD, high-quality imaging, such as multidetector CT (MDCT) or magnetic resonance cholangiopancreatography, is essential in the workup of the patient to assess the anatomy and plan the most appropriate access route for PTBD.22–27 MDCT is also useful for evaluating complications, such as ascites and gastrointestinal obstruction, caused by tumor dissemination.

Significant amounts of ascites separating the liver from the abdominal wall should be drained prior to biliary intervention as this increases the risk of hemorrhage and catheter displacement into the peritoneum.29

Coagulopathy (international normalized ratio ≥ 1.5 and platelet count ≤ 50,000/mm³) is a relative contraindication to percutaneous transhepatic cholangiography and biliary drainage.29 Every effort should be made to correct or improve coagulopathy before the procedure.30

The technique of PTBD is well established.22–30 The PTBD procedure is performed under conscious sedation using intravenous premedication, such as pentazocine hydrochloride, and local anesthesia, such as lidocaine hydrochloride. Under the guidance of ultrasonography (US) or fluoroscopy, the peripheral intrahepatic bile duct is punctured with an 18-gauge needle in a one-step technique or a 21-gauge needle in a two-step technique, and a 7 to 10 Fr drainage catheter is inserted alongside a safety wire, which is inserted into the CBD, and another guidewire is inserted via the catheter to select the contralateral bile duct.30

After PTBD, high-quality imaging, such as multidetector CT (MDCT) or magnetic resonance cholangiopancreatography, is performed to assess the success of the procedure and to preserve liver function during the course of chemotherapy. Bilateral biliary drainage can be accomplished by the percutaneous placement of multiple SEMS.22–27

In such cases, an additional contralateral route is needed.

Access Route

**Bilateral (multiple) percutaneous routes**

Bilateral (multiple) percutaneous routes allow for easy handling and negotiation of a guidewire into the common bile duct (CBD) through the stricture caused by the tumor. SEMS placement via bilateral access is also technically simple. However, multiple PTBD procedures may lead to additional morbidity and discomfort from multiple drainage tubes.22–27

**Single percutaneous route**

SEMS placement via a single percutaneous route using the stent-in-stent technique has been reported as being a useful method in several articles along with reports on the development of various open-cell design stents.22,24,26,27 There are several anatomical variants of the right posterior duct (RPD) jointing the right hepatic duct (RHD) or the left hepatic duct (LHD). In addition, the angle between the RPD and the jointing duct is often acute.10 Hence, in a patient with hilar tumor extending beyond the segmental ducts, the left-sided percutaneous route may be better in multiple SEMS placements for trisegmental drainage via a single percutaneous route. When inserting a guidewire into the contralateral bile duct through the hilar stricture, a “safety-wire” technique using an 8 to 10 Fr sheath is useful.29 The seeking biliary catheter is inserted alongside a safety wire, which is inserted into the CBD, and another guidewire is inserted via the catheter to select the contralateral bile duct.

However, negotiation of a guidewire into the contralateral bile duct is occasionally impossible if the hilar angle between the RHD and LHD is acute.22,26 In such cases, an additional contralateral route is needed.

**Additional route**

In patients with surgical biliary reconstruction, malignant biliary obstruction may be difficult to treat, especially by an endoscopic route, because of complicated anatomical changes after operative reconstruction.29 Furthermore, afferent limb obstruction sometimes occurs with biliary obstruction. Although PTBD is an effective treatment for these conditions, it may introduce the risk of retrograde biliary infection. An additional percutaneous jejunostomy route may be useful for biliary obstruction complicated with afferent limb obstruction (Fig. 1).33 However, percutaneous jejunostomy carries a risk of intraperitoneal digestive fluid leakage from the afferent limb.34

**Metallic Stent Placement Technique**

Percutaneous multiple SEMS placement has been reported as being a procedure with a high success rate (93%–100%). It is generally performed using the stent-in-stent technique (T configuration or Y configuration) or the side-by-side technique.8,12,13,22,25–28 In addition, the crisscross technique has been reported as being a useful method for trisegmental drainage.10 The side-to-end technique is also useful for multiple SEMS placement.

The favorable features of SEMS for hilar biliary obstruction are high flexibility and minimal foreshortening during deployment. In addition, from the viewpoint of patency duration and the frequency of reintervention, SEMS with low axial force and open-cell design are favorable for hilar biliary obstruction.29

In general, an uncovered metallic stent is used when there is a concern over the risk of blocking a hilar branch bile duct. However, a clinical study on partially covered metallic stent placement for hilar biliary obstruction has been reported.25,26 According to this report, regardless of the number of blocked branching ducts, the serum bilirubin level significantly decreased after stent placement. Therefore, partially covered metallic stents, which can prevent tumor ingrowth, may be effective.

**Side-by-side technique**

The side-by-side technique is the placement of two parallel
metallic stents to drain the bile ducts of both liver lobes (Fig. 2). Although this placement technique is simple, bilateral percutaneous routes are needed. In addition, this parallel placement may oversretch the CBD and prevent full expansion of metallic stents at the hepatic confluence.\textsuperscript{22,24}

**Stent-in-stent technique**

In the stent-in-stent technique, a second stent is placed through the mesh of the first stent to enter the CBD.\textsuperscript{22,26,27,37} By using this technique, the entire length of the stricture can continuously expand within a single stent caliber.\textsuperscript{22} Moreover, the overlapping of two stents can effectively prevent the displacement of stents.\textsuperscript{8,24} However, passing the second stent through the mesh of the first stent can be technically difficult if the first stent has a tightly woven closed-cell design.\textsuperscript{22}

Two-stent placement in a T configuration via a single route is suitable for an obtuse hilar angle between the RHD and LHD.\textsuperscript{22,26} Stent placement in a T configuration is performed either via the right or left access. The transverse stent is placed first to connect the right and left lobar ducts, and a guidewire is inserted from an access route into the CBD through the mesh of the first stent. The second stent, connecting the transverse stent to the CBD, is then placed (Fig. 3).\textsuperscript{26}

For an acute hilar angle, two-stent placement in a Y configuration via bilateral routes is technically easy.\textsuperscript{22,26} In Y-configured stent placement, the first stent is placed connecting one lobar duct and the CBD. Then, a guidewire is inserted from the contralateral route into the CBD through the mesh of the first stent. The second stent, connecting another lobe to the CBD, is then placed (Fig. 4).\textsuperscript{26}

For a lesion that separates the right anterior duct from the RPD, two-stent placement in a crisscross configuration is a useful
Fig. 3. Hilar invasion of gall bladder cancer. (A) The cholangiogram shows hilar biliary obstruction. (B) The first stent (8-mm diameter, 40-mm length, Zilver stent; COOK Medical) was placed from the left hepatic duct into the right hepatic duct, and the second stent (8-mm diameter, 80-mm length, Zilver stent) was placed from the left hepatic duct into the common bile duct through the mesh of the first stent.

Fig. 4. Hilar dissemination of gastric cancer. (A) The cholangiogram via bilateral routes shows hilar biliary obstruction. (B, C) The first stent (8-mm diameter, 60-mm length, Zilver stent; COOK Medical) was placed from the left hepatic duct into the common hepatic duct, and the second stent (8-mm diameter, 40-mm length, Zilver stent) was placed from the right hepatic duct into the common hepatic duct through the mesh of the first stent.

Fig. 5. Hilar cholangiocarcinoma. (A) The cholangiogram shows hilar biliary obstruction with separation between each segment duct (right anterior duct [RAD], right posterior duct [RPD], and left hepatic duct [LHD]). Residual fractured catheter inserted in a previous hospital (arrow). (B) A guidewire was inserted from the LHD into the RPD using the pull-through technique and another guidewire was inserted from the RAD into the common bile duct (CBD). (C, D) The first stent (8-mm diameter, 80-mm length, Zilver stent; COOK Medical) was placed from the LHD into the RPD, and the second stent (8-mm diameter, 80-mm length, Zilver stent) was placed from the RAD into the CBD through the mesh of the first stent.
Crisscross-configured stent placement is performed with two stents inserted via two unilateral or bilateral accesses. The first stent is placed connecting a right segment duct and the LHD. The second stent is then placed from another right segment duct crossing the first stent to the CBD (Fig. 5).

**Side-to-end technique**

In the side-to-end technique, a second stent is placed overlapping with the proximal edge of the first stent. By using this technique, there is no need to pass a second metallic stent delivery system through the mesh of the first stent. However, if stent placement via a single route is performed using this technique, parallel insertion of a two-stent delivery system is needed (Fig. 6). Therefore, dilation of the access route is required.

Although the entire length of the stricture can expand within a single stent caliber, the risk of separation between the first stent and second stent should be considered (Fig. 7). Hence, the favorable feature of SEMS in this technique is minimal foreshortening during deployment.

**Complications**

There are some complications associated with percutaneous biliary procedures. These include sepsis, hemobilia, and infections, such as peritonitis, cholecystitis, pancreatitis, and pleuritis. However, most complications are related to the initial PTBD and are usually self-limiting. The use of prophylactic periprocedural antibiotics can help to reduce the incidence of procedure-associated infections. Although a temporary drainage catheter is placed after stent placement, bile leakage around the clamped...
catheter usually indicates stent occlusion and should be investigated by cholangiography.\textsuperscript{33} Crushing of the first stent during insertion of the second stent has been reported as a complication of the stent-in-stent technique.\textsuperscript{36}

\section*{Reintervention}

Stent occlusion is caused by tumor ingrowth, biliary sludge, and mucosal hyperplasia by chronic inflammation.\textsuperscript{37} Although current approaches include a second SEMS placement, PTBD, and mechanical cleaning, the appropriate management for stent occlusion has not been well established.\textsuperscript{40} Unfortunately, mechanical cleaning has been proven to be ineffective because it provides suboptimal patency time.\textsuperscript{41}

The outcome of second interventions, including plastic stent (PS), SEMS, and PTBD, for occluded SEMS in patients with malignant biliary obstruction, has been investigated.\textsuperscript{40} According to that report, in general, a second SEMS insertion in occluded SEMS provided a significantly longer patency time compared with PS or PTBD. However, in hilar obstruction, there was no statistical difference in patency and survival time. Hence, the benefit of a second SEMS placement in poor-prognosis patients with hilar biliary obstruction remains controversial.

\section*{Future Developments}

In recent years, endoscopic ultrasonography (EUS)-guided procedures have been developed.\textsuperscript{5,42} However, EUS-guided choledocoduodenostomy is not indicated for hilar biliary obstruction. In addition, EUS-guided hepaticogastrostomy may be not suitable for hilar biliary obstruction because inserting a guidewire from the LHD into the RHD through the hilar stricture is technically difficult.\textsuperscript{5}

The combination of percutaneous stent placement connecting both lobar ducts and EUS-guided hepaticogastrostomy can be effective in the management of malignant hilar biliary obstruction (Fig. 8). Furthermore, in the EUS-guided procedure, a second intervention for stent occlusion requires substantial technique, such as additional stent placement or stent exchange. If a second intervention via the endoscopic route is unsuccessful, percutaneous procedures are useful (Fig. 9). These EUS-guided procedures should be performed in institutions with back-up procedure systems, such as PTBD or surgery, for unsuccessful EUS-guided procedures.

Recently, endoscopic photodynamic therapy and radiofrequency ablation in combination with biliary stenting for pancreatic cancers have been used to improve stent patency.\textsuperscript{43,44} In addition, the feasibility studies of percutaneous intraductal device, though few in number, have been reported.\textsuperscript{5,46} Mizandari

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\caption{Hilar invasion of gall bladder cancer after endoscopic ultrasonography-guided hepaticogastrostomy. (A) The cholangiogram via the right anterior duct (RAD) shows hilar biliary obstruction. (B, C) A guidewire was inserted from the RAD into the stent of hepaticogastrostomy route. The stent (8-mm diameter, 30-mm length, Zilver stent; COOK Medical) was placed from the RAD into the left hepatic duct.}
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\begin{figure}[h]
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\includegraphics[width=\textwidth]{Fig9}
\caption{Stent occlusion after endoscopic ultrasonography-guided hepaticogastrostomy for pancreatic cancer. (A) The endoscopic cholangiogram shows stent occlusion caused by mucosal hyperplasia. However, the stent delivery system could not pass the stricture via the endoscopic route. (B, C) A guidewire was inserted from the right anterior duct into the stent of hepaticogastrostomy route via the percutaneous biliary drainage route and the additional stent (8-mm diameter, 40-mm length, Zilver stent; COOK Medical) was placed at the stricture point in stent-in-stent.}
\end{figure}
indicated that percutaneous intraductal radiofrequency ablation combined with biliary stenting was feasible and safe for malignant biliary obstruction including cholangiocarcinoma. Drug eluting stents have a local cytotoxic effect in malignant disease and may delay the time to reocclusion. 29 To date, there are a few published studies on the use of drug-eluting stents for malignant biliary obstruction. 47 Although these developing treatments may be promising, there are no sufficient data of patients with malignant hilar biliary obstruction. Hence, further investigation such as randomized, prospective studies is necessary.

Conclusion

Percutaneous multiple SEMS placement is a feasible palliative treatment in patients with hepatic bile duct malignancy. However, adequate levels of experience and technique are required. In addition, accurate anatomical assessment and planning of the most appropriate access route for PTBD and subsequent SEMS placement are essential.

Conflicts of Interest

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

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