International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

Different Types of Stents in Palliative Management of Malignant Biliary Obstruction

Abeer Hussein Abdelkader, Mohamed Ibrahim Radwan, Aya Mohammed Elsawy Mohammed, Mohamed Fouad Mostafa

Hepatology, Gastroenterology and Infectious diseases Department, Faculty of Medicine, Zagazig University, Egypt

***Corresponding author:** Aya Mohammed Elsawy Mohammed

Abstract:

Palliative management aims to relieve symptoms, improve quality of life, and maintain organ function in patients with advanced or incurable disease. In many malignancies, tumor infiltration or external compression may lead to obstruction of hollow organs or ducts such as the esophagus, trachea, biliary tree, ureters, colon, or vascular structures. Stents are commonly used as minimally invasive palliative tools to restore luminal patency and alleviate associated symptoms such as dysphagia, jaundice, dyspnea, or urinary obstruction. They offer rapid symptom relief, shorter hospital stay, and lower morbidity compared with surgical bypass procedures, particularly in patients with limited life expectancy. Stents vary in design, material, coating, and site of placement, and are selected based on patient condition, tumor location, and expected prognosis.

Keywords: Palliative care; Stents; Malignant obstruction; Self-expandable metal stents; Plastic stents; Esophageal stents; Biliary stents; Tracheal stents; Ureteral stents; Quality of life.

Introduction:

Palliative management focuses on improving the quality of life in patients with advanced or non-curable diseases by relieving symptoms and maintaining organ function rather than pursuing curative therapy. Malignant tumors may cause obstruction in various hollow organs such as the esophagus, biliary tract, colon, trachea, or ureters, leading to significant morbidity that impacts nutrition, breathing, and organ drainage. Minimally invasive interventions, particularly endoscopic or image-guided stenting, have become central in palliative care due to their ability to rapidly relieve symptoms with lower complication rates compared to surgical procedures **(1).**

Stents used in palliative care vary in materials, coating, diameter, and mechanical properties, allowing tailored selection according to disease location, degree of obstruction, and patient prognosis. Self-expandable metal stents (SEMS) have largely replaced conventional plastic stents in malignant obstructions due to their larger lumen, longer patency, and reduced need for re-intervention. However, choices such as covered vs. uncovered stents remain clinically relevant, as covered stents prevent tumor ingrowth but carry a higher risk of migration, whereas uncovered stents are more stable but more prone to tissue ingrowth **(2).**

Recent advances in stent technology include drug-eluting stents, biodegradable stents, and 3D-printed patient-specific stents, which aim to reduce restenosis, lower complication rates, and better accommodate anatomical variations. These innovations are particularly valuable in patients with short life expectancy in whom symptom relief and maintenance of daily function are primary goals. Consequently, stents play a vital role in the palliative management pathway by minimizing hospitalization, improving comfort, and preserving patient autonomy during advanced stages of disease **(3).**

Stent Options and Goals

The goals of stent placement for malignant biliary obstruction are palliation of symptoms and prevention of complications associated with disease progression. Whenever possible to minimize the need for repeat interventions. For example, for inoperable pancreatic adenocarcinoma, the median survival is 6 to 11 months, and for patients with metastatic disease, median survival drops to 2 to 6 months (**4**).

Given these low survival rates, stents provide lifetime patency for most of these patients, and in most cases, SEMS are favored over plastic stents to limit the need for future endoscopic interventions **(5).**

Plastic Stents

Plastic stents are used for malignant biliary obstructions, offering lower cost and easier replacement than metal stents, but with shorter patency periods. They are often replaced every 3-6 months and can be multiple plastic stents to improve patency, though metal stents generally provide longer-lasting relief. Advances include dual-layer plastic stents and antireflux designs to prolong patency **(6).**

Self-expanding Metal Stents

High technical and clinical success rates of SEMS make them well suited for palliative treatment of biliary obstruction caused by pancreatic carcinoma or cholangiocarcinoma. etc., as patency rates closely match survival rates. In a retrospective, multicenter European study of 240 patients, Canakis and Kahaleh reported 78 and 67% patency at 25 weeks stainless steel SEMS, in a patient population with 25- and 50-week survival rates of 16% **(7).**

In study done by Kerdsirichairat et al. who prospectively evaluated unilateral SEMS placement for 35 patients with hilar biliary obstruction and found a 77% clinical success and a median patency of 5.4 months (**8**)**.**

Other study has achieved similar success with unilateral SEMS, Y-configured SEMS, and Y-configured covered SEMS (CSEMS) for hilar obstruction. When unilateral atrophy is present, stent placement into the most viable lobe may be preferential to bilateral Y configuration of dual SEMS, unless infection of the atrophic biliary component is suspected **(9).**

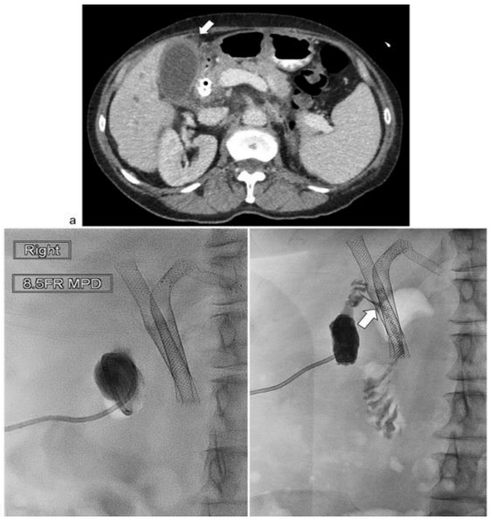

Figure 1.(a) A 66-year-old woman with Bismuth IV cholangiocarcinoma treated with bilateral bare metal stents in a Y-configuration presents with right upper quadrant pain, fever, and leukocytosis. CT with contrast demonstrates gallbladder wall thickening and surrounding fat stranding (arrow) suspicious for acute cholecystitis. (b) Cholecystostomy catheter was placed. Contrast injection shows no free passage of contrast into the cystic duct. (c) Contrast injection after 1 month shows free passage of contrast from the gallbladder to the small bowel (arrow). The catheter was eventually removed with no recurrence of cholecystitis **(9).**

Technical aspects of metal stent placement are best planned using preliminary MRCP or CT, particularly for hilar malignant obstruction (**10**)**.**

Considerations when performing metal stent placement include preserving the papilla if possible to avoid ascending cholangitis and to improve long-term patency, minimizing distention of the gallbladder to avoid post procedure cholecystitis, and avoiding the caging of branch points, if possible, to avoid associated biliary obstruction **(9).**

Prior to stent placement, balloon-assisted clearance of sludge from the biliary tree may reveal a shorter segment of malignant involvement and allow placement of a shorter stent. This maneuver can prevent unnecessary extension of the stent above the hilum (**11**).

If possible post dilatation is avoided as SEMS continue to expand after placement in most cases, and post dilatation can cause bleeding from tumor vascularity and obstruction from incursion of tumor through the interstices or around the edges of the stent **(12).**

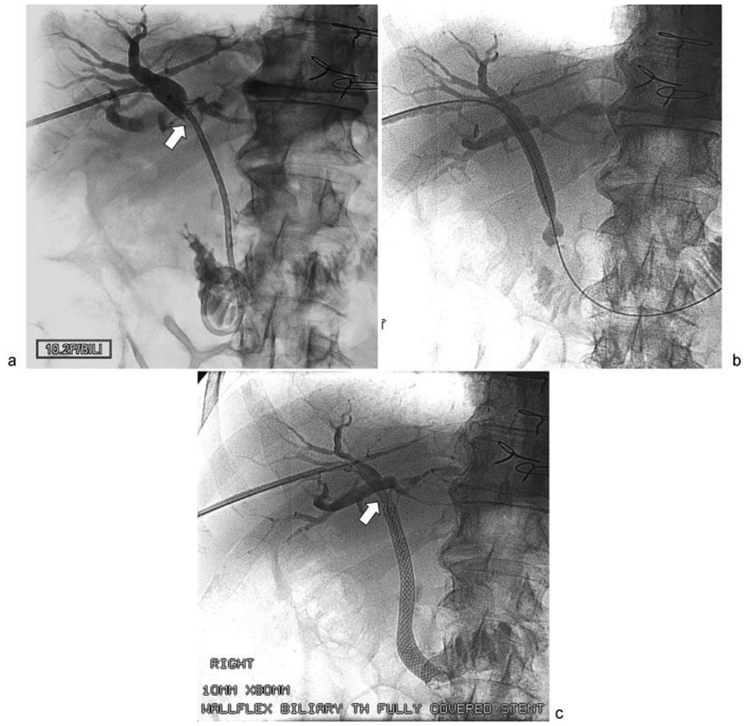

Figure 2.(a) An 81-year-old man with locally invasive gastric cancer presents for metal stent placement after interval percutaneous drainage for cholangitis. Sludge in the biliary hilum gives the false appearance of malignant involvement (arrow). (b) Prior to stent placement, low-pressure balloon clearance and dilatation of the biliary tree were performed. (c) Involvement of the hilum was excluded by balloon clearance (arrow) and a covered metal stent was placed. Involvement of the sphincter of Oddi made trans papillary stent placement necessary in this case **(9).**

Types of Stents:

Endoscopic stents appear to offer a less invasive option, but the many designs and stent types available have made selecting the ideal stent for individual patients complicated (**13**).

There are several combinations of materials, with or without anti-reflux valves, uncovered SEMS (uSEMS), partially covered SEMS (pcSEMS) or cSEMS, and different kinds of mesh. All of them have different possible complications and conflicting information in the literature (**14**).

1. **Plastic Stents**

Used for short-term palliation or in patients with limited life expectancy. Prone to occlusion (median patency ~3–4 months) due to bile sludge or tumor ingrowth. Require frequent replacement, increasing procedural burden (**15**).

For malignant biliary obstruction, published data support SEMS over plastic stents for their higher clinical success rates, higher long-term patency rates, and lower cost because of the reduction of secondary procedures, even in the case of hilar cholangiocarcinoma as demonstrated by a short, prospective randomized trial of plastic versus metal stents **(7).**

2. **Uncovered Self-Expandable Metallic Stents (UCSEMS)**

High radial force ensures durable luminal patency. Susceptible to tumor ingrowth (occlusion rate ~20–30%), necessitating reintervention (**16**).

3. **Partially Covered Self-Expandable Metallic Stents (PCSEMS)**
Designed to minimize tumor ingrowth while reducing migration risk compared to fully covered stents. Limited evidence suggests intermediate patency rates between UCSEMS and fully covered stents (**16**).

4. **Fully Covered Self-Expandable Metallic Stents (FCSEMS)**
Prevent tumor ingrowth but carry a higher risk of migration (up to 20%), limiting long-term use (**16**).

5. **Multihole Fully Covered Self-Expandable Metallic Stents (MHFCSEMS)**
A novel design features multiple side holes to reduce bile duct side branch obstruction and improve stent stability. Combines the benefits of FCSEMS (prevents ingrowth) with reduced migration risk due to the multihole architecture (**17**).

Multihole Fully Covered Metallic Stents (MHFCSEMS) Versus UCSEMS/PCSEMS

The multihole design enhances anchoring within the bile duct, lowering migration rates compared to traditional FCSEMS. In comparative studies, MHFCSEMS demonstrated lower migration rates (5–10%) versus UCSEMS (2–5%) and PCSEMS (8–15%)(**16**).

The 2.5-mm holes in the stent membrane prevent the occlusion of bile duct tributaries, reducing cholangitis risk (**17**).

Unlike UCSEMS, MHFCSEMS can be removed endoscopically if needed (e.g., for tumor response to therapy), offering flexibility in management (**17**).

To date, two meta-analyses demonstrated no benefits to survival or morbidity in cSEMS compared to uSEMS. There is still no SEMS that has presented a far superior result compared to the others **(7).**

Usually uSEMS are associated with obstruction due to ingrowth while cSEMS have higher migration rates and association with cholecystitis if placed across the cystic duct in patients not cholecystomized **(18).**

A retrospective study from 2011 evaluated uSEMS versus cSEMS and found that the adverse event rate is about 27% for both, tumor ingrowth with recurrent obstruction is more common in the uSEMS group (76% versus 9%,), and stent migration is more common in cSEMS group (36% versus 2%,) (**19).**

A more recent pcSEMS was developed, trying to gather the best of both worlds. Apparently, it has better results with less stent migration than cSEMS but more than uSEMS (pcSEMS 5.9% versus uSEMS 0%,) and less tumor ingrowth than uSEMS (pcSEMS 5.9% versus uSEMS 19.2%,) (**20).**

The major causes of dysfunction of the large bore cSEMS are attributed to the reflux of duodenal content into the prosthesis and to stent migration. Although studies with innovative mechanisms to surpass the migration problem failed to show any difference, the antireflux mechanism has shown to lead to longer patency (**21).**

In the study by Morita et al., the overall reflux of barium was 7.7% in the Anti-Reflux Valve Metal Stent (ARVMS) group versus 100% in the cSEMS group and the cumulative median duration of stent patency was 407 days for ARVMS versus 220 days for cSEMS **(22).**

To overcome the main problem of obstruction due to tumor ingrowth when using the uSEMS, the use of novel SEMS that are combined with radioactive seeds (I125) or brachytherapy is still being studied and has shown promising results regarding patency time and survival (mean survival of 8 months versus 3 months in the study by Zhu et al.). The use of drug-eluting stents, namely, with paclitaxel, had not shown expressive benefits (**23).**

The use of bilateral versus unilateral SEMS in the proximal MBO is an issue not yet resolved. Despite the better cumulative patency demonstrated in the studies, the complication and survival rates do not seem to improve in bilateral drainage, although the physiologic mechanism that would lead to a better outcome seems plausible (**24).**

Altogether it is not yet possible to state the optimal choice for palliative SEMS in MBO. Hence, each case has to be assessed individually and evaluated regarding the pros and cons. Novel products and techniques are promising but lacking in RCTs in favor of certain specific SEMS **(25).**

Complications of Metal Stents

Complications of SEMS include:

1-Cholangitis

Cholangitis is typically well tolerated and treated with antibiotics and repeat intervention to clear stent obstruction, if necessary. Fogel et al in a review of 134 patients comparing ERCP- and PTBD-guided metal stent placement found lower rates of procedure-related cholangitis with PTBD (**26).**

2-Migration

Measures to mitigate the risk of cholangitis include avoidance of overdistention of the biliary system with contrast material, supra-papillary rather than transpapillary SEMS placement if possible, avoidance of branch point obstruction by SEMS if possible, and treatment of cholangitis to resolution with temporary drainage and antibiotics prior to metal stent placement**(9).**

3-**Cholecystitis**

Cholecystitis occurs in approximately 5% of cases of SEMS placement across the cystic duct ostium and is managed well by percutaneous cholecystostomy. Cholecystostomy catheters after SEMS placement may be removable after resolution of cholecystitis if patency of the cystic duct and biliary tree is demonstrated (**27).**

Figure 3*:* (a) A 49-year-old woman who underwent a Whipple procedure for pancreatic cancer presents with recurrent biliary obstruction. A short common bile duct is anastomosed to a Roux-en-Y. Hepatic arterial coils are related to prior iatrogenic haemobilia. Obstruction extends to the hilum, and a nondeployed 4-cm-long covered stent is preliminarily placed with the proximal end above the obstruction (arrow). (b) After deployment, the proximal end has migrated distally (arrow), and most of the stent protrudes into the Roux limb. (c) Abdominal radiograph obtained the next day shows stent migration distally into the small bowel (arrow). (d) A 4-cm-long

bare metal stent was placed with the proximal end flared and appropriately placed within the biliary hilum (arrow) **(9).**

References:

1. Kumar, N., Gupta, R., & Sharma, V. (2022). Palliative stenting in malignant gastrointestinal and biliary obstruction: Current perspectives. Journal of Palliative Medicine, 25(4), 567–575. https://doi.org/10.1089/jpm.2021.0354
2. Li, Y., Chen, D., Wang, Z., & Liu, H. (2023). Self-expandable metal stents in malignant obstruction: Selection, outcomes, and complications. Endoscopic Oncology Review, 18(2), 145–158. https://doi.org/10.1016/eor.2023.02.007
3. Sato, T., & Yamamoto, M. (2024). Advances in biodegradable and drug-eluting stents for cancer palliation. Cancer Treatment Reviews, 126, 102–115. https://doi.org/10.1016/j.ctrv.2023.102115
4. Cappello, A., Landi, R., Gerges, C., Cennamo, V., Costamagna, G., & Tringali, A. (2023). Trans-papillary bilio-pancreatic stenting: When how and which stent. *Frontiers in Gastroenterology*, *1*.
5. Lam, R., & Muniraj, T. (2021). Fully covered metal biliary stents: A review of the literature. *World Journal of Gastroenterology*, *27*(38), 6357.
6. Raijman, I. (2003). Biliary and pancreatic stents. Gastrointestinal Endoscopy Clinics of North America, 13(4), 561–592. https://doi.org/10.1016/S1052-5157(03)00077-9
7. Canakis, A., & Kahaleh, M. (2022). Endoscopic palliation of malignant biliary obstruction. *World Journal of Gastrointestinal Endoscopy*, *14*(10), 581.
8. Kerdsirichairat, T., Arain, M. A., Attam, R., Glessing, B., Bakman, Y., Amateau, S. K., & Freeman, M. L. (2017). Endoscopic Drainage of >50% of Liver in Malignant Hilar Biliary Obstruction Using Metallic or Fenestrated Plastic Stents. *Clinical and Translational Gastroenterology*, *8*(8), e115.
9. Lorenz, J. M. (2016). Biliary Interventions: Management of Malignant Biliary Obstruction. *Seminars in Interventional Radiology*, *33*(4), 259.
10. Takahashi, K., Ohyama, H., Takiguchi, Y., Kan, M., Ouchi, M., Nagashima, H., Ohno, I., & Kato, N. (2023). Endoscopic Transpapillary Stenting for Malignant Hilar Biliary Stricture: Side-by-Side Placement versus Partial Stent-in-Stent Placement. *Journal of Personalized Medicine 2023, Vol. 13, Page 831*, *13*(5), 831.
11. Jung, J. H., Park, S. W., Hyun, B., Lee, J., Koh, D. H., & Chung, D. (2021). Identification of risk factors for obstructive cholecystitis following placement of biliary stent in unresectable malignant biliary obstruction: a 5-year retrospective analysis in single center. *Surgical Endoscopy*, *35*(6), 2679–2689.
12. Xu, M. M., & Sethi, A. (2015). Diagnosing Biliary Malignancy. *Gastrointestinal Endoscopy Clinics of North America*, *25*(4), 677–690.
13. Moutzoukis, M., Argyriou, K., Kapsoritakis, A., & Christodoulou, D. (2023). Endoscopic luminal stenting: Current applications and future perspectives. *World Journal of Gastrointestinal Endoscopy*, *15*(4), 195.
14. Mangiavillano, B., Pagano, N., Arena, M., Miraglia, S., Consolo, P., Iabichino, G., Virgilio, C., & Luigiano, C. (2015). Role of stenting in gastrointestinal benign and malignant diseases. *World Journal of Gastrointestinal Endoscopy*, *7*(5), 460.
15. Lee, T. H., Moon, J. H., & Park, S. H. (2020). Biliary stenting for hilar malignant biliary obstruction. *Digestive Endoscopy*, *32*(2), 275–286.
16. Kulpatcharapong, S., Piyachaturawat, P., Ridtitid, W., Kongkam, P., & Rerknimitr, R. (2019). Sa1450 EFFICACY OF MULTI-HOLE STENT COMPARE TO FULLY COVERED AND UNCOVERED SELF-EXPANDABLE METAL STENTS FOR THE TREATMENT OF MALIGNANT DISTAL BILIARY OBSTRUCTION. *Gastrointestinal Endoscopy*, *89*(6), AB236.
17. Park, J.-S., Jeong, S., Kobayashi, M., & Lee, D. (2019). Safety, efficacy, and removability of a fully covered multi-hole metal stent in a swine model of hilar biliary stricture: a feasibility study. *Endoscopy International Open*, *07*(04), E498–E503.
18. Kim, G. H., Ryoo, S. K., Park, J. K., Park, J. K., Lee, K. H., Lee, K. T., & Lee, J. K. (2019). Risk Factors for Pancreatitis and Cholecystitis after Endoscopic Biliary Stenting in Patients with Malignant Extrahepatic Bile Duct Obstruction. *Clinical Endoscopy*, *52*(6), 598.
19. Kawakubo, K., Isayama, H., Nakai, Y., Togawa, O., Sasahira, N., Kogure, H., Sasaki, T., Matsubara, S., Yamamoto, N., Hirano, K., Tsujino, T., Toda, N., Tada, M., Omata, M., & Koike, K. (2011). Efficacy and safety of covered self-expandable metal stents for management of distal malignant biliary obstruction due to lymph

node metastases. *Surgical Endoscopy*, *25*(9), 3094–3100.

20. Waidmann, O., Trojan, J., Friedrich-Rust, M., Sarrazin, C., Bechstein, W. O., Ulrich, F., Zeuzem, S., & Albert, J. G. (2013). SEMS vs cSEMS in duodenal and small bowel obstruction: High risk of migration in the covered stent group. *World Journal of Gastroenterology : WJG*, *19*(37), 6199.
21. Wu, C. H., Lee, M. H., Tsou, Y. K., Lin, C. H., Sung, K. F., Pan, K. T., & Liu, N. J. (2021). Risk Factors of Duodenobiliary Reflux-Related Dysfunction of Covered Biliary Metal Stents after Treatment of Duodenal Stricture in Patients with Malignant Biliary and Duodenal Obstruction. *Current Oncology*, *28*(5), 3738.
22. Morita, S., Arai, Y., Sugawara, S., Sone, M., Sakamoto, Y., Okusaka, T., Yoshinaga, S., Saito, Y., & Terai, S. (2018). Antireflux Metal Stent for Initial Treatment of Malignant Distal Biliary Obstruction. *Gastroenterology Research and Practice*, *2018*.
23. Li, Z., Jiao, D., Han, X., & Liu, Z. (2021). A Comparative Study of Self-Expandable Metallic Stent Combined with Double 125I Seeds Strands or Single 125I Seeds Strand in the Treatment of Advanced Perihilar Cholangiocarcinoma with Malignant Obstructive Jaundice. *OncoTargets and Therapy*, *14*, 4077.
24. Kongkam, P., Tasneem, A. A., & Rerknimitr, R. (2019). Combination of endoscopic retrograde cholangiopancreatography and endoscopic ultrasonography-guided biliary drainage in malignant hilar biliary obstruction. *Digestive Endoscopy*, *31*(S1), 50–54.
25. Pu, L. Z. C. T., Singh, R., Loong, C. K., & De Moura, E. G. H. (2016). Malignant Biliary Obstruction: Evidence for Best Practice. *Gastroenterology Research and Practice*, *2016*.
26. Fogel, E. L., Shahda, S., Sandrasegaran, K., Dewitt, J., Easler, J. J., Agarwal, D. M., Eagleson, M., Zyromski, N. J., House, M. G., Ellsworth, S., El Hajj, I., O'Neil, B. H., Nakeeb, A., & Sherman, S. (2017). A Multidisciplinary Approach to Pancreas Cancer in 2016: A Review. *American Journal of Gastroenterology*, *112*(4), 537–554.
27. Gosain, S., Bonatti, H., Smith, L., Rehan, M. E., Brock, A., Mahajan, A., Phillips, M., Ho, H. C., Ellen, K., Shami, V. M., & Kahaleh, M. (2010). Gallbladder stent placement for prevention of cholecystitis in patients receiving covered metal stent for malignant obstructive jaundice: A feasibility study. *Digestive Diseases and Sciences*, *55*(8), 2406–2411.