



# Primary Clinical Application of Y-Shaped Jogged Stent Implantation in Patients with Malignant Hilar Biliary Obstruction

Zhongwei Zhao<sup>1,2</sup> · Jingjing Song<sup>1,2</sup> · Xiaoxi Fan<sup>1,2</sup> · Shiji Fang<sup>1,2</sup> · Minjiang Chen<sup>1,2</sup> · Weiqian Chen<sup>1,2</sup> · Fazong Wu<sup>1,2</sup> · Liyun Zheng<sup>1,2</sup> · Jianfei Tu<sup>1,2</sup> · Jiansong Ji<sup>1,2</sup>

Received: 1 August 2018 / Accepted: 21 January 2019 / Published online: 21 February 2019  
© 2019 The Society for Surgery of the Alimentary Tract

## Abstract

**Objective** To assess the feasibility, safety, and efficacy of Y-shaped jogged stent in patients with malignant hilar biliary obstruction.

**Methods** A total of 196 patients with malignant hilar biliary obstruction treated by biliary tract stent implantation from August 2010 to August 2017 were retrospectively reviewed. Seventeen consecutive patients who were treated with Y-shaped jogged stent implantation were identified as the Y-shaped jogged stent implantation group. Seventeen matched patients undergoing unilateral stent placement combined with percutaneous transhepatic cholangial drainage (PTCD) were enrolled as the control group. Baseline characteristics of patients, stent patency time, and survival time were compared.

**Results** There was no significant difference in the age, gender, tumor type and stage, biliary obstruction classification, bilirubin level at diagnosis, presence of metastasis, or chemotherapy between the Y-stent group and the control group ( $P > 0.05$ ). One week after surgery, the reduction rate of bilirubin was significantly higher in the Y-stent group (88.2% vs 53.0%,  $P < 0.05$ ). The mean stent patency time was longer in the Y-stent group ( $7.3 \pm 1.0$  months vs  $5.7 \pm 0.9$  months,  $P < 0.05$ ). The mean survival time of the Y-stent group ( $9.1 \pm 1.5$  months) was longer than the control group ( $7.2 \pm 1.1$  months,  $P > 0.05$ ). There was no severe complication occurred in both two groups.

**Conclusion** Y-shaped jogged stent implantation was a safe, feasible, and effective approach in the treatment of patients with malignant hilar biliary obstruction, with the significantly prolonged stent patency time and survival time.

**Keywords** Y-shaped jogged stent · Malignant hilar biliary obstruction · Retrospectively · Stent patency time · Survival time

## Introduction

Malignant biliary obstruction was often caused by the invasion of the malignant tumors in multiple locations such as liver, gallbladder, and pancreas.<sup>1</sup> The majority of patients with malignant biliary obstruction lost the surgery opportunity, and drainage as well as biliary stent implantation has been usually

firstly adopted for the symptomatic treatment.<sup>2,3</sup> For the patients with low-level biliary obstruction, simple straight-tube biliary stent implantation can effectively relieve biliary obstruction. In contrast, for the patients with malignant hilar biliary obstruction whose left and right hepatic duct as well as common hepatic duct were often not connected, simple straight-tube biliary stent implantation cannot effectively remove biliary obstruction, and even led to the progressive exacerbation of liver failure, especially in patients with obstructive jaundice.<sup>4</sup> Therefore, the effective removal of malignant hilar biliary obstruction as well as the improvement of life quality and survival rate remained a difficult problem to be solved in the clinical practice.

It has been shown that airway inverted Y-shaped integrated metal stent implantation was reliable in the treatment of airway complex lesions.<sup>5,6</sup> Studies also demonstrated that a self-designed Y-shaped integrated self-expandable metallic stent was successfully used to treat the stenosis of the stomach-jejunum anastomosis.<sup>4,7,8</sup> These results indicated that Y-

Zhongwei Zhao, Jingjing Song and Xiaoxi Fan contributed equally to this work.

✉ Jiansong Ji  
jjstcty@sina.com

<sup>1</sup> Key Laboratory of Imaging Diagnosis and Minimally Invasive Intervention Research, Lishui Central Hospital, Lishui 323000, Zhejiang, People's Republic of China

<sup>2</sup> Department of Interventional Radiology, Zhejiang University Lishui Hospital, The Fifth Affiliated Hospital of Wenzhou Medical University, Lishui Central Hospital, No. 289 Kuocang Road, Lishui 323000, Zhejiang, People's Republic of China

shaped jogged stent could be used for the patients with malignant hilar biliary obstruction. In this study, a total of 196 patients with malignant hilar biliary obstruction treated by biliary tract stent implantation from August 2010 to August 2017 were retrospectively reviewed, evaluating the feasibility, safety, and efficacy of Y-shaped jogged stent implantation in patients with malignant hilar biliary obstruction.

## Materials and Methods

### Subjects

This retrospective study was approved by the Lishui Central Hospital, and the written informed consent was obtained from each patient. A total of 196 patients with malignant hilar biliary obstruction in the stage 4 were treated by internal stent implantation in the Lishui Central Hospital from August 2010 to August 2017 were enrolled. Seventeen consecutive patients who were treated with Y-shaped jogged stent implantation during August 2010 to August 2017 were identified as Y-shaped jogged stent implantation group. According to patients' age, gender, tumor type and stage, biliary obstruction classification, levels of bilirubin at diagnosis, and the presence of metastasis as well as treatment in the Y-shaped jogged stent implantation group, 17 matched patients undergoing unilateral stent placement combined with percutaneous transhepatic cholangial drainage (PTCD) were chosen as the control group. The patients' basic information was listed in Table 1.

The causes of malignant hilar biliary obstruction consisted of cholangiocarcinoma, liver cancer, pancreatic cancer, gallbladder cancer, and gastric cancer, with the clinical manifestation as obstructive jaundice. The examinations by computerized tomography (CT), magnetic resonance (MR), or percutaneous transhepatic cholangiography (PTC) revealed the obvious dilation of intrahepatic bile duct, and that the obstruction site was located in the hepatic portal, and the left and right hepatic duct as well as common hepatic duct were all affected (Fig. 1a, b). Besides, the classification of malignant hilar biliary obstruction was based on Bismuth-Corlette classification.

Inclusion criteria: predicted survival time > 3 months, performance status (PS) > 70, normal coagulation function. Exclusion criteria: cachexia or severe heart, liver, renal failure, and massive ascites; allergic to iodine; severe coagulation dysfunction.

### Treatments

#### Preoperative Treatment

Blood routine, coagulation function, biochemical examination, and upper abdominal CT or MR scans were performed. In addition, a 4-h preoperative fasting was conducted, followed by the treatments such as liver protection, anti-infection, and nutritional support.

#### PTCD

The extent and position of the left and right bile duct in patients were fully explored through CT or MR. Under the guidance of B ultrasound combined with digital subtraction angiography (DSA; Philips Integris Allura 12, Netherlands), the catheter drainage was performed in the left and the right intrahepatic bile duct, and the biliary stent implantation was conducted after the symptoms of obstructive jaundice were improved.

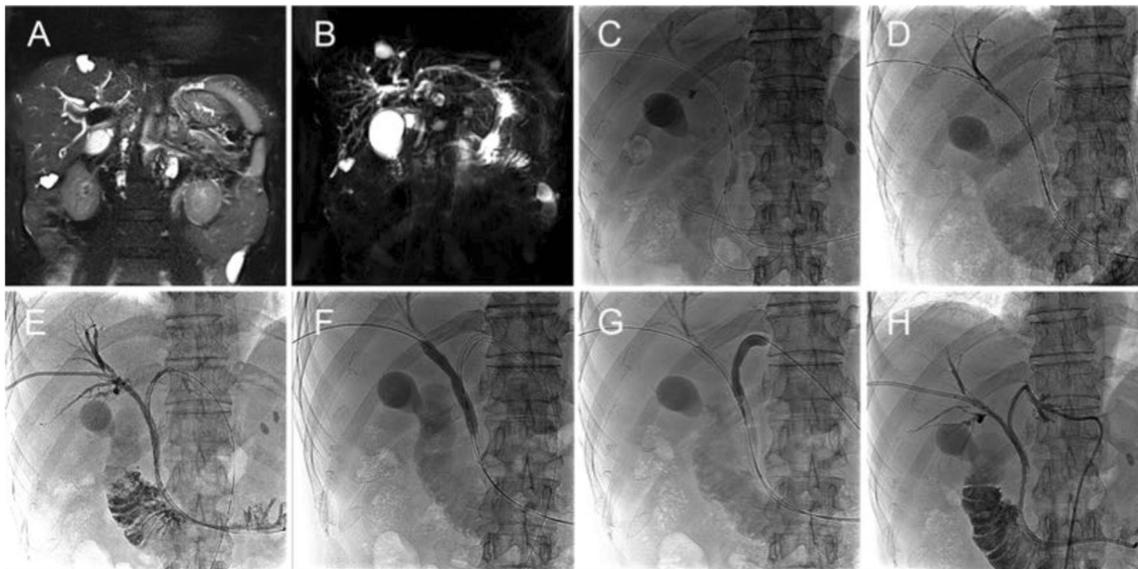
#### Unilateral Biliary Stent Placement Combined with PTCD

After clarifying the position, narrow degree and range of biliary obstruction, and the unobstructed rate of left and right hepatic duct using PTC (Cook Group, US), the side of bile duct with bigger expansion range was chosen as the stent implantation path. The guide wire (0.035 in.; Terumo Corporation, Japan) was introduced by drainage tube (8.5 F; Cook Group, US) into the intestinal cavity through the bile duct. The corresponding type of biliary metal stent (diameter 6–10 mm, length 4–10 cm; JNJ, US) was inserted along the guide wire. Then, one side of the biliary obstruction was removed; meanwhile, the drainage tube on the other side of bile duct was maintained for full drainage.

**Table 1** Baseline demographics and clinical characteristics of patients

| Group    | Case (n) | Age (years) | Gender |       | Cancer site |       |          |             |         | Bismuth-Corlette classification |       |       | Bilirubin ( $\mu\text{M}$ ) | Metastasis | Chemotherapy |
|----------|----------|-------------|--------|-------|-------------|-------|----------|-------------|---------|---------------------------------|-------|-------|-----------------------------|------------|--------------|
|          |          |             | M      | F     | Bile duct   | Liver | Pancreas | Gallbladder | Stomach | II                              | IIIa  | IIIb  |                             |            |              |
| A        | 17       | 57 $\pm$ 12 | 14     | 3     | 5           | 4     | 3        | 3           | 2       | 5                               | 7     | 5     | 93.1 $\pm$ 32.4             | 6          | 5            |
| B        | 17       | 58 $\pm$ 11 | 12     | 5     | 5           | 4     | 3        | 3           | 2       | 5                               | 7     | 5     | 99.2 $\pm$ 38.6             | 8          | 4            |
| <i>P</i> |          | > .05       | > .05  | > .05 | > .05       | > .05 | > .05    | > .05       | > .05   | > .05                           | > .05 | > .05 | > .05                       | > .05      | > .05        |
| <i>t</i> |          | 1.00        |        |       |             |       |          |             |         |                                 |       |       | 0.98                        |            |              |

Group A, Y-shaped jogged stent implantation group; group B, control group



**Fig. 1** A 64-year-old female diagnosed with cholangiocarcinoma combined with hepatic portal lymph node metastasis (Bismuth-Corlette II). Magnetic resonance cholangiopancreatography revealed the hilar biliary obstruction, with the intrahepatic bile duct being widely expanded, and the hepatic duct confluence, common hepatic duct, and common bile duct being widely irregular and narrow (a). The bilateral PTCD was firstly conducted (b). The exchange guide wire was inserted into the bilaterally dilated biliary tract (c). The first stent was implanted into the right bile

duct (d). In the left bile duct, the guide wire passed through the stent mesh in the right bile duct and entered the stent and the common bile duct into the intestinal cavity (e). After crossing the right biliary stent along the guide wire, the second stent was implanted and the balloon was expanded (f and g). Two biliary metal stents were chimed into a Y-shaped scaffold, completely removing the hilar biliary obstruction, with the contrast agent passing smoothly (h)

### Biliary Y-Shaped Jogged Stent Implantation

After clarifying the position and length of biliary obstruction using PTC, the corresponding type of biliary metal stent was selected and implanted on one side. On the other side, the guide wire firstly was inserted into the stent through the metal stent mesh. Then, the guide wire went through the stent and entered the intestine through the common bile duct. After the balloon (diameter 4–8 mm, length 2–8 cm; JNJ, US) was delivered along the guide wire to predilate the stent mesh, another biliary metal stent was inserted along the guide wire, which can be released through the predilated stent mesh on the contralateral side. If the stent expansion was limited, the balloon can be expanded. These two biliary metal stents were chimed into a Y-shaped scaffold, restoring the anatomic form of the hilar biliary tract, and effectively removing malignant tumor-induced obstruction of the left and right hepatic duct as well as common hepatic duct (Fig. 1).

### Statistical Analysis

The statistical analysis was performed using SPSS15.0 software. The measured data in accordance with normal distribution were shown as mean  $\pm$  SD, and *t* test was applied in the comparison of two groups. The enumeration data were shown as *n* (< 40), tested by the Fisher test. The unobstructed time of stent and survival time was analyzed by the Kaplan-Meier estimate. Due to the same weight of time points of the biliary

obstruction and death, the log-rank test was used for the comparison of the long-term effects between groups. The *P* value less than 0.05 was taken as statistically significant.

## Results

### Comparison of the Patients' Basic Information Between the Two Groups

To determine whether the basic information affects the patients, we first presented the comparison of the basic information between the two groups. As shown in Table 1, there was no significant difference in the age, gender, tumor type and stage, biliary obstruction classification, bilirubin level at diagnosis, and the presence of metastasis as well as chemotherapy between the Y-shaped jogged stent implantation group and the control group ( $P > 0.05$ ).

### Comparison of the Outcomes Between the Two Groups

Next, the outcomes between the two groups were compared. The results revealed that there was no significant difference in the preoperative narrow length of biliary tract between the Y-shaped jogged stent implantation group ( $38.3 \pm 10.6$  mm) and the control group ( $40.4 \pm 9.5$  mm,  $P > 0.05$ ). The preoperative diameter of biliary tract at stenosis in the Y-shaped jogged

stent implantation group ( $1.0 \pm 0.7$  mm) was similar as the control group ( $1.0 \pm 0.9$  mm,  $P > 0.05$ ). After surgery, there was still no significant difference in the diameter of biliary tract at stenosis between the Y-shaped jogged stent implantation group ( $4.2 \pm 1.2$  mm) and the control group ( $3.4 \pm 1.4$  mm,  $P > 0.05$ ). One week after surgery, there was no significant difference in the reduction rate of alanine aminotransferase (ALT) between the Y-shaped jogged stent implantation group (68.5%) and the control group (57.4%,  $P > 0.05$ ). However, we found that the reduction rate of bilirubin was significantly higher in the Y-shaped jogged stent implantation group (88.2%) compared with the control group (53.0%,  $P < 0.05$ ).

Besides, a total of 10 cases of postoperative symptoms of biliary tract infection, such as intolerance of cold and fever, were found in the two groups, with no significant difference ( $P > 0.05$ ). The infection was completely controlled after anti-infective and symptomatic treatment. There was no case with serious complications, such as biliary hemorrhage, perforation, fistula, pancreatitis, or death, in both two groups (Table 2).

## Discussion

As estimated, the surgical excision rate of malignant hilar biliary obstruction was less than 20%.<sup>9,10</sup> The metal stent implantation was recommended for the patients with malignant hilar biliary obstruction of the estimated lifetime more than 3 months, according to the guidelines from the Asia-Pacific Consensus and European Society of Gastrointestinal Endoscopy (ESGE).<sup>11,12</sup> Bilateral PTCd catheter drainage can lead to a significant increase in the drainage area and a better drainage. However, the drainage tube was probably subjected to blockage, infection, shedding, and biliary loss, resulting in the homeostasis imbalance and other complications. Moreover, the long-term carrying of the drainage tube also reduced the life quality of the patients.<sup>13,14</sup> Therefore, in this study, according to the hilar biliary anatomical features, we designed the Y-shaped jogged stent for the treatment of patients with malignant hilar biliary obstruction. We found that the reduction rate of bilirubin was significantly higher in the Y-stent group compared with the control group 1 week

after surgery. The mean stent patency time was longer in the Y-stent group than the control group. Moreover, the mean survival time of the Y-stent group was significantly longer. These results demonstrated that the Y-shaped jogged stent implantation revealed better clinical effects with longer stent patency and survival time. The Y-shaped jogged stent restored the anatomic structure of hilar biliary tract, and completely removed the biliary obstruction with the bile passing smoothly, leading to the increased curative effect of Y-shaped jogged stent implantation (Fig. 1).

As reported, the patency rate of bilateral drainage stent was better than that of the unilateral drainage stent; meanwhile, the other stent can maintain patency when one drainage stent was accompanied by tumor growth inside and on both ends.<sup>15–17</sup> At present, there were still a lot of controversies about the application of unilateral stent implantation or bilateral stent implantation in the patients with malignant hilar biliary obstruction.<sup>18,19</sup> A retrospective study of 480 patients revealed that the patency rate of bilateral endoscopic stent implantation was superior to that of unilateral endoscopic stent implantation in Bismuth-Corlette II patients.<sup>20</sup> Another study also confirmed that the bilateral endoscopic metal stent was more effective compared with the unilateral endoscopic metal stent for malignant hilar biliary obstruction.<sup>19</sup> However, in these studies, two stents were implanted side by side into the biliary tract under the endoscope. Such operation was difficult, because it requires the simultaneous release of both stents, and the distal end of the second stent cannot exceed the distal end of the first stent when releasing, lowering the success rate less than 90%. Moreover, the bile duct was prone to overspread in the stent overlapping region, damaging the biliary wall and thus leading to the occlusion of the portal vein and cystic duct, and eventually causing the cholecystitis.<sup>21–23</sup> In our study, the Y-shaped jogged stent was more in line with the anatomical structure of the biliary tract, without the need for simultaneous release of both stents, causing less extended common bile duct and postoperative complications. Indeed, no severe complications with stent implantation were found in our study.

Consistent with our work, Hwang et al demonstrated that Y-shaped endoscopic bilateral stenting using a Y-stent appears

**Table 2** Outcome for patients in the two groups

| Group    | Preoperative narrow length of biliary tract (mm) | Preoperative diameter of biliary tract at stenosis (mm) | Postoperative diameter of biliary tract at stenosis (mm) | Postoperative reduction rate of bilirubin (%) | Postoperative reduction rate of alanine aminotransferase (%) | Postoperative complications (n) |
|----------|--|---|--|---|--|---------------------------------|
| A        | $38.3 \pm 10.6$                                  | $1.0 \pm 0.7$   | $4.2 \pm 1.2$  | 88.2  | 68.5   | 4                               |
| B        | $40.4 \pm 9.5$                                   | $1.0 \pm 0.9$   | $3.4 \pm 1.4$  | 53.0  | 57.4   | 6                               |
| <i>P</i> | > .05  | > .05   | > .05  | .024  | > .05  | > .05                           |
| <i>t</i> | 1.9  | 2.0   | 4.0  |   |  |                                 |

Group A, Y-shaped jogged stent implantation group; group B, control group

to be a feasible and effective method for palliation of unresectable malignant hilar biliary obstruction.<sup>24</sup> All of the patients enrolled in their study were diagnosed with cholangiocarcinoma or gallbladder cancer, and it was an uncontrolled study.<sup>24</sup> In the present study, we enrolled the patients with different cancer sites, including bile duct, liver, pancreas, gallbladder, and stomach. The matching patients undergoing unilateral stent placement combined with PTCO were assigned to the control group, and the result indicated that patients with Y-shaped jogged stent implantation appeared better therapeutic effects than the control, indicating the advantage of Y-shaped jogged stent in treating hilar biliary obstruction. We believed that Y-stent could let the bile flow more freely and prevent the accumulation of bilirubin, thus helping the recovery of liver function, and finally improve the survival rate of Y-stent implanted patients. However, due to the small sample size, less related literature reports, and lack of a prospective randomized control of this study, more evidence was required for the more accurate evaluation of curative effect and safety of Y-shaped jogged stent implantation.

In conclusion, our findings demonstrated that Y-shaped jogged stent implantation was a safe, feasible, and effective approach in the treatment of patients with malignant hilar biliary obstruction, with the significantly prolonged stent patency time and survival time.

**Authors' Contributions** Zhongwei Zhao: Substantial contributions to the conception or design of the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Jingjing Song: Substantial contributions to the conception or design of the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Xiaoxi Fan: Substantial contributions to the conception or design of the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Shiji Fang: The acquisition, analysis, or interpretation of data for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Minjiang Chen: The acquisition, analysis, or interpretation of data for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Weiqian Chen: The acquisition, analysis, or interpretation of data for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Fazong Wu: The acquisition, analysis, or interpretation of data for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related

to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Liyun Zheng: The acquisition, analysis, or interpretation of data for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Jianfei Tu: The acquisition, analysis, or interpretation of data for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Jiansong Ji: Drafting the work or revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

**Funding** This work was supported by the Zhejiang Province Natural Science Funding of China (no. LQ17H180001), Zhejiang Province Medical and Health Technology Projects (no. 2017KY724, 2017KY728) and Zhejiang Province Lishui City High-level Talents Development Project (no. 2016RC29, 2017RC08 and 2017RC09), Zhejiang Province Ministry of Construction Project (no. WKJZJ-1629) and Zhejiang Province Lishui City Science and Technology Bureau Social Welfare Project (no. 2016GYX36).

## Compliance with Ethical Standards

**Disclaimer** The process and results of this study were not affected by relevant equipments, materials, or pharmaceutical companies.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

## References

1. Boulay, B.R. and M. Parepally, *Managing malignant biliary obstruction in pancreas cancer: choosing the appropriate strategy*. World J Gastroenterol, 2014. **20**(28): p. 9345–53.
2. Boulay, B.R. and A. Birg, *Malignant biliary obstruction: From palliation to treatment*. World J Gastrointest Oncol, 2016. **8**(6): p. 498–508.
3. Pu, L.Z., et al., *Malignant Biliary Obstruction: Evidence for Best Practice*. Gastroenterol Res Pract, 2016. **2016**: p. 3296801.
4. Mangiavillano, B., et al., *Biliary and pancreatic stenting: Devices and insertion techniques in therapeutic endoscopic retrograde cholangiopancreatography and endoscopic ultrasonography*. World J Gastrointest Endosc, 2016. **8**(3): p. 143–56.
5. Menon, S., *Hilar stenting for malignant biliary obstruction*. Gastrointest Endosc, 2016. **83**(2): p. 478–9.
6. Fu, Y.F., et al., *Subcarinal ventilation-assisted Y-shaped stent insertion under local anesthesia for patients with complex tracheobronchial stenosis: initial clinical experience*. Diagn Interv Radiol, 2014. **20**(4): p. 330–4.
7. Li, T.F., et al., *Application of Y-shaped, coated self-expandable metallic stents for anastomotic stenosis after gastrojejunostomy (Billroth II)*. Acta Radiol, 2017. **58**(1): p. 41–45.
8. Shin, M. and J.W. Joh, *Advances in endoscopic management of biliary complications after living donor liver transplantation: Comprehensive review of the literature*. World J Gastroenterol, 2016. **22**(27): p. 6173–91.

9. Singhal, D., T.M. van Gulik, and D.J. Gourma, *Palliative management of hilar cholangiocarcinoma*. *Surg Oncol*, 2005. **14**(2): p. 59–74.
10. Lorenz, J.M., *Management of Malignant Biliary Obstruction*. *Semin Intervent Radiol*, 2016. **33**(4): p. 259–267.
11. Rerknimitr, R., et al., *Asia-Pacific consensus recommendations for endoscopic and interventional management of hilar cholangiocarcinoma*. *J Gastroenterol Hepatol*, 2013. **28**(4): p. 593–607.
12. Dumonceau, J.M., et al., *Biliary stenting: indications, choice of stents and results: European Society of Gastrointestinal Endoscopy (ESGE) clinical guideline*. *Endoscopy*, 2012. **44**(3): p. 277–98.
13. Venkatanarasimha, N., et al., *Diagnosis and Management of Complications from Percutaneous Biliary Tract Interventions-Erratum*. *Radiographics*, 2017. **37**(3): p. 1004.
14. Luo, D.C., et al., *Clinical value and indication for the dissection of lymph nodes posterior to the right recurrent laryngeal nerve in papillary thyroid carcinoma*. *Oncotarget*, 2017. **8**(45): p. 79897–79905.
15. Chandrashekhara, S.H., et al., *Current Status of Percutaneous Transhepatic Biliary Drainage in Palliation of Malignant Obstructive Jaundice: A Review*. *Indian J Palliat Care*, 2016. **22**(4): p. 378–387.
16. Gamanagatti, S., et al., *Unilobar Versus Bilobar Biliary Drainage: Effect on Quality of Life and Bilirubin Level Reduction*. *Indian J Palliat Care*, 2016. **22**(1): p. 50–62.
17. Kato, H., et al., *Current status of endoscopic biliary drainage for unresectable malignant hilar biliary strictures*. *World J Gastrointest Endosc*, 2015. **7**(11): p. 1032–8.
18. De Palma, G.D., et al., *Unilateral versus bilateral endoscopic hepatic duct drainage in patients with malignant hilar biliary obstruction: results of a prospective, randomized, and controlled study*. *Gastrointest Endosc*, 2001. **53**(6): p. 547–53.
19. Naitoh, I., et al., *Unilateral versus bilateral endoscopic metal stenting for malignant hilar biliary obstruction*. *J Gastroenterol Hepatol*, 2009. **24**(4): p. 552–7.
20. Liberato, M.J. and J.M. Canena, *Endoscopic stenting for hilar cholangiocarcinoma: efficacy of unilateral and bilateral placement of plastic and metal stents in a retrospective review of 480 patients*. *BMC Gastroenterol*, 2012. **12**: p. 103.
21. Naitoh, I., et al., *Side-by-side versus stent-in-stent deployment in bilateral endoscopic metal stenting for malignant hilar biliary obstruction*. *Dig Dis Sci*, 2012. **57**(12): p. 3279–85.
22. Nam, H.S. and D.H. Kang, *Current Status of Biliary Metal Stents*. *Clin Endosc*, 2016. **49**(2): p. 124–30.
23. Jang, S., et al., *Association of covered metallic stents with cholecystitis and stent migration in malignant biliary stricture*. *Gastrointest Endosc*, 2018. **87**(4): p. 1061–1070.
24. Hwang, J.C., et al., *Y-shaped endoscopic bilateral metal stent placement for malignant hilar biliary obstruction: prospective long-term study*. *Scandinavian Journal of Gastroenterology*, 2011. **46**(3): p. 326–332.