Abstract

Endoscopic management is presently the recommended first-line of treatment for biliary strictures. However, surgery still has an important role especially for biliary obstruction (BO) with duodenal obstruction. Even though endoscopic treatment for concurrent BO and gastric-outlet obstruction has been proposed, it is still not widespread. Duodenal obstruction is often associated with malignant BO which makes endoscopic treatment more challenging. Biliary and gastrointestinal double bypass with Roux-en-Y hepaticojejunostomy and gastrojejunostomy is the most common surgical intervention for malignant biliary and gastric-outlet obstruction. A variety of procedures of biliary bypass and gastrointestinal bypass have been reported. According to several studies, mortality rates range from 0% to 7%, while morbidity rates range from 3% to 50%. Higher morbidity was observed in symptomatic patients caused by the disease. Most common morbidity after double bypass was delayed gastric emptying. Recurrence of BO and gastric-outlet obstruction was less frequently seen after surgical bypass compared to after endoscopic treatment. Minimally invasive approach has been applied to double bypass. Studies showed that laparoscopic double bypass has a shorter hospital stay and reduced postoperative pain; however, due to its technical demand, it is still presently an uncommon procedure. Robotic bypass surgery may resolve this issue in the future. Further analyses of outcomes of both surgical and endoscopic treatments are necessary to establish better and suitable palliation options for concurrent biliary and duodenal obstruction caused by unresectable malignant tumors.

Introduction

Although endoscopic management has replaced the role of surgery in the treatment of biliary strictures in the recent years, surgical intervention is still a reliable option particularly for biliary obstruction (BO) with duodenal obstruction. Malignancy in the periampullary region, including pancreatic cancer, often leads not only BO but gastric-outlet obstruction (GOO) due to duodenal involvement. Endoscopic transpapillary stenting for BO is less invasive and thus, became the preferred choice of treatment for malignant BO. However, it is more challenging when there is a concurrent duodenal obstruction present. Although endoscopic treatment for concurrent BO and GOO has been proposed, it is technically demanding and, therefore, performed only in highly specialized centers.\textsuperscript{1-3} The most effective solution for concurrent BO and GOO due to malignancy is surgical resection of the lesion. However, periampullary malignancy, especially pancreatic head cancer, is frequently discovered as an unresectable tumor due to locally advanced or metastatic disease. A systematic review of comparative studies of R2 resection and bypass for pancreatic cancer revealed that R2 resection was associated with increased morbidity and mortality rates without improving survival.\textsuperscript{4} Therefore, biliary and gastrointestinal double bypass is usually performed as a surgical palliation for concurrent BO and GOO. While endoscopic biliary metal stent is described as a preferred method for BO alone due to unresectable pancreatic cancer in the National Comprehensive Cancer Network guidelines, open or laparoscopic gastrojejunostomy is recommended for GOO alone of patients with good performance status.\textsuperscript{5} Although there is no description of recommended treatment for concurrent BO and GOO in the guidelines, it is empirically realized that surgical bypass plays an important role in...
the clinical practice. This review describes procedures, outcomes and minimally invasive approach of biliary and gastrointestinal double bypass for concurrent BO and GOO.

**Surgical Procedures**

Double bypass for concurrent BO and GOO consists of biliary-enteric and gastro-enteric anastomosis. For biliary-enteric anastomosis, Roux-en-Y hepaticojejunostomy is commonly performed. In some cases, hepaticoduodenostomy, choledochojejunostomy, choledochoduodenostomy, cholecystojejunostomy and cholecystoduodenostomy can also be acceptable options. Based on our previous study, we also utilize hepaticocholecystojejunostomy for biliary-enteric anastomosis in selected cases (Fig. 1, 2). For gastro-enteric anastomosis, side-to-side gastrojejunostomy is the most common procedure. Some surgeons favor anastomosing the stomach to the efferent limb at the distal side of the biliary-enteric anastomosis (Fig. 1), while others anastomose the stomach to the afferent limb. The location of gastrojejunostomy is either the ventral side (antecolic) or the dorsal side (retrocolic) of the transverse colon. When gastrojejunostomy is in the antecolic position, side-to-side jejunoojejunostomy (Braun’s anastomosis) is often added. Partial stomach-partitioning is sometimes added to gastrojejunostomy (modified Devine procedure) (Fig. 3). A meta-analysis of retrospective studies showed partial stomach-partitioning significantly decreased the risk of delayed gastric emptying (DGE) after gastrojejunostomy for malignant GOO although the mechanism has not been elucidated yet.

**Outcomes**

Table 1 shows outcomes of biliary and gastrointestinal double bypass from the literature. Among the 14 studies, two were prospective randomized controlled trials (RCTs) comparing double bypass and biliary bypass alone, eight studies were retrospective comparative studies and the remaining were case series.
Perioperative outcomes

Operative time was available in seven studies.\textsuperscript{6,9,14,16,18–20} Double bypass was significantly longer than exploration laparotomy or single bypass, but shorter than pancreaticoduodenectomy.\textsuperscript{14,16,18–20} Mortality rates ranged from 0% to 7%, and morbidity rates ranged from 3% to 50%.\textsuperscript{6,9,10,14–22} The morbidity rates were relatively high probably because the preoperative condition of a symptomatic patient is usually suboptimal due to medical problems caused by the disease (i.e., jaundice secondary to BO, undernourishment secondary to GOO). Furthermore, our analysis showed that prophylactic double bypass performed for unresectable pancreatic and periampullary cancer patients without symptoms of BO and GOO was associated with lower morbidity rate (3%).\textsuperscript{6,9,10,22} In addition, Hamada et al\textsuperscript{2} reported that dysfunction of the duodenal stent was observed in 21% of the patients. Meta-analysis of studies comparing stent and surgery for malignant GOO also revealed that reintervention was less required in gastrojejunostomy compared to stent placement.\textsuperscript{26} RCTs revealed that prophylactic gastrojejunostomy for unresectable periampullary cancer patients without GOO reduced reintervention for GOO compared to biliary bypass alone.\textsuperscript{14,15} Median survival time after double bypass ranges from 6 to 14.6 months.

Minimally Invasive Approach of Biliary and Gastrointestinal Double Bypass

Since Semm performed the first laparoscopic appendectomy in 1980, laparoscopic surgery has widely spread in the field of digestive surgery including palliative surgery.\textsuperscript{27} Laparoscopic biliary bypass for malignant BO was first reported in 1992.\textsuperscript{28} In the same year, a report on laparoscopic gastroenterostomy for malignant GOO was also published.\textsuperscript{29} Minimally invasive biliary and gastrointestinal double bypass was first reported by Rhodes et al\textsuperscript{10} in 1995, wherein they performed laparoscopic cholecystojejunostomy and gastroenterostomy. In addition, Röthlin et al\textsuperscript{11} described the first laparoscopic double bypass with hepatoicojejunostomy. In this study, they compared laparoscopic bypass cases with matched open bypass cases; results showed that laparoscopic bypass significantly decrease duration of hospital stay and reduce morphine use. Despite of the benefits of laparoscopic surgery in terms of postoperative pain, which may translates to enhanced patient recovery, laparoscopic double bypass is still an uncommon procedure. First, laparoscopic hepatoicojejunostomy is technically difficult\textsuperscript{12}; it requires suturing in the hepatic portal area, wherein manipulation of instruments is limited. Second, failure in suturing causes complications such as bile leak or biliary stenosis which

Long–term outcomes

Five studies revealed that incidence of recurrence of BO ranges from 0% to 5%.\textsuperscript{6,9,10,22} On the other hand, recurrence rate of endoscopic treatment for malignant BO with duodenal obstruction was 34%.\textsuperscript{3} Meta-analyses of studies comparing endoscopy and surgery for malignant BO revealed that recurrence of BO was significantly less in biliary bypass compared to biliary stent.\textsuperscript{24,25} With regards to GOO recurrence, studies showed that incidence rate ranges from 0% to 4.8%.\textsuperscript{6,7,9,10,14,15,22} In addition, Hamada et al\textsuperscript{2} reported that dysfunction of the duodenal stent was observed in 21% of the patients. Meta-analysis of studies comparing stent and surgery for malignant GOO also revealed that reintervention was less required in gastrojejunostomy compared to stent placement.\textsuperscript{26} RCTs revealed that prophylactic gastrojejunostomy for unresectable periampullary cancer patients without GOO reduced reintervention for GOO compared to biliary bypass alone.\textsuperscript{14,15} Median survival time after double bypass ranges from 6 to 14.6 months.

Table 1 Outcomes of Biliary and Gastrointestinal Double Bypass

| Author (year) | No. of patients | Procedure | Operative time (min) | Mortality (%) | Morbidity (%) | Hospital stay (day) | Recurrence of BO (%) | Recurrence of GOO (%) | Prognosis (mo) |
|---------------|----------------|-----------|----------------------|---------------|---------------|---------------------|----------------------|----------------------|--------------|
| Lillemoe et al\textsuperscript{11} (1999) | 44 | HJ + GJ | 254 (mean) | 0 | 32 | 8.5 (mean) | NA | 0 | 8.2 (mean) |
| Van Heek et al\textsuperscript{12} (2003) | 36 | HJ + GJ | NA | 3 | 31 | 11 (median) | NA | 2.8 | 7.2 (MST) |
| Lesurtel et al\textsuperscript{7} (2006) | 83 | HD or HJ + GJ | 203 (mean) | 4.8 | 27 | 16 (median) | 1.2 | 4.8 | 9.2 (MST) |
| Schniewind et al\textsuperscript{19} (2006) | 129 | HJ + GJ | 246 (mean) | 2.6 | 42 | 15 (mean) | NA | NA | 6 (MST) |
| Fusai et al\textsuperscript{17} (2008) | 39 | BE + GJ | NA | 3.1 | 31.1 | 11 (median) | NA | 9 (MST) |
| Mann et al\textsuperscript{18} (2009) | 102 | HJ + GJ | NA | 5.9 | 26.7 | 12 (median) | 2 | 2 | 9.5 (MST) |
| Bockhorn et al\textsuperscript{15} (2009) | 40 | HJ + GJ | 140 (median) | 5 | 18 | 17 (median) | NA | NA | 7.5 (MST) |
| Walter et al\textsuperscript{10} (2011) | 154 | HJ + GJ | 261 (mean) | 3.9 | 38 | 17 (mean) | NA | NA | 6 (MST) |
| Lyons et al\textsuperscript{12} (2012) | 60 | HJ, CJ, HD, CD or CCJ + GJ | NA | 3 | 15 | NA | 5 | 2 | NA |
| Ausania et al\textsuperscript{11} (2012) | 50 | HJ + GJ | NA | 4 | 50 | 12.6 (median) | NA | NA | 14.6 (MST) |
| Ueda et al\textsuperscript{14} (2014) | 69 | HCJ or HJ + GJ | NA | 0 | 15 | NA | 0 | 0 | NA |
| Tol et al\textsuperscript{17} (2015) | 203 | HJ + GJ | NA | 2 | 18 | 9 (median) | NA | NA | 9 (MST) |
| Insulander et al\textsuperscript{18} (2016) | 74 | HJ + GJ | 169 (median) | 7 | 35* | 9 (median) | NA | NA | 7.2 (MST) |
| Miyasaka et al\textsuperscript{17} (2017) | 32 | HCJ, HJ or CCJ + GJ | 272 (median) | 0 | 3 | 18 (median) | 0 | 0 | 11 (MST) |

HJ, hepaticojejunostomy; GJ, gastrojejunostomy; HD, hepaticoduodenostomy; BE, bilo-enterostomy; CJ, choledochojejunostomy; CD, choledochoduodenostomy; CCJ, cholecystojejunostomy; HCJ, hepatocholecystojejuno-stomy; NA, not available; BO, biliary obstruction; GOO, gastric-outlet obstruction; MST, median survival time.

*Clavien Dindo grade IIIa.
delay introduction of systemic chemotherapy. Hence, cholecysto-
jejunostomy is a more favored procedure for laparoscopic biliary bypass since cholecysto-jejunal anastomosis is technically easier.15 However, it is not useful for cases with occluded cystic duct.

Development of robotic surgery has made intracorporeal suturing easier. Lai and Tang14 reported 9 cases of robot-assisted laparoscopic bypass, of which 5 cases had hepaticojejunostomy and 4 cases had double bypass, with favorable perioperative outcomes. Robotic surgery may remedy the limitations of laparoscopic bypass and may possibly enhance recovery of patients who need double bypass for concurrent BO and GOO.

Conclusion

Although endoscopic palliation has become mainstream treat-
ment for BO, surgical bypass still plays an important role in the management of concurrent BO and GOO for selected patients. Recent development of new chemotherapeutic regimens have improved the prognosis of patients with unresectable periampullary cancer. It demands long-lasting palliation of BO and GOO. In terms of surgery, double bypass should be considered as an option for patients with good performance status. Furthermore, prophylactic bypass for asymptomatic patients with unresectable tumors have better outcomes. In terms of approach, minimally invasive surgery reduces postoperative pain and length of hospital stay but surgeons need continuous training to prevent complication. Robotic bypass surgery may resolve limitation issues of laparoscopy in the future.

Tailoring the ideal palliative treatment in patients can reduce unnecessary procedures and morbidity that may delay the induction and reduce the efficacy of chemotherapy. In addition, further analyses of outcomes of both surgical and endoscopic treatment, including RCTs, are necessary to establish better and suitable palliation options for concurrent biliary and duodenal obstruction due to unresectable malignant tumors.

Conflicts of Interest

No potential conflict of interest relevant to this article was re-
ported.

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