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Major hepatectomy in Bismuth types I and II hilar cholangiocarcinoma

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ABSTRACT

Background: Historically, hilar bile duct resection (HBDR) has been regarded as the choice of treatment for Bismuth types I and II hilar cholangiocarcinoma (HCCA). The present study aimed to evaluate the advantages of major liver resection (MLR) in the treatment of patients with Bismuth types I and II HCCA when compared with HBDR.

Materials and methods: Between January 2005 and September 2012, in total, 52 patients with Bismuth types I and II HCCA who underwent HBDR alone or MLR were included for retrospective analysis. The intraoperative outcomes, postoperative complications, and oncological outcomes including recurrence and overall or disease-free survival rate were compared.

Results: The MLR group had significantly higher curative resection rates compared with the HBDR group (95% *versus* 62.5%, $P = 0.021$) and lower tumor recurrence (28% *versus* 63%, $P = 0.049$), albeit with longer operating time (395.5 ± 112.7 *versus* 270.9 ± 98.8, $P < 0.001$), and higher blood transfusion requirements (70% *versus* 16%, $P < 0.001$). MLR resulted in significantly higher overall postoperative morbidity (70% *versus* 34.4%, $P = 0.012$), compared with HBDR alone. When restricted to R0 resections for all the procedures, MLR significantly increased the overall postoperative survival rate compared with the HBDR group ($P = 0.016$); the overall survival rate at 1, 3 y was 68.4% and 60.8% for MLR group and 59.6% and 21.9% for HBDR group, respectively. Also, the disease-free survival rate was significantly higher in patients who underwent MLR, as compared with those who underwent HBDR (53.2% *versus* 0% at 3 y, $P = 0.005$).

Conclusions: Our study has shown that MLR results in higher curative resections, fewer recurrences, and increased postoperative survival rate for Bismuth types I and II HCCA as compared with HBDR alone. However, there is a need for well-designed, multicenter studies to be undertaken to better inform a decision on the standard treatment for Bismuth types I and II HCCA.

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1. Introduction

Hilar cholangiocarcinoma (HCCA), also called Klatskin tumor, was first described in 1965 [1] and is defined as a tumor with involvement of the common hepatic duct at the confluence of the right and left hepatic bile duct [2]. It is a rare tumor that is generally associated with a poor prognosis, and radical surgical resection is the only curative treatment for patients with HCCA. However, radical surgical resection is challenging as the tumor often infiltrates the portal vein, hepatic artery, and liver parenchyma around the hepatic hilum [3]. Historically, hilar bile duct resection (HBDR) has been regarded as the treatment of choice for HCCA. However, this has been shown to result in recurrence after surgery due to positive surgical margins at the hepatic edge of the bile duct [4]. Subsequently, to obtain negative surgical margins and improve long-term survival, surgical treatment for HCCA was extended to include liver and vascular resections [5,6]. Patients with HCCA usually present with obstructive jaundice [7], and major liver resection (MLR) for HCCA with obstructive jaundice has been reported to result in high surgical morbidity and mortality rates [8,9]. However, preoperative biliary drainage (PBD) and portal vein embolization (PVE) have been introduced in patients with obstructive jaundice and potentially resectable tumors [6,10].

Although most surgeons accept HBDR with MLR as standard in the treatment of Bismuth types III and IV HCCA, the role of MLR in the treatment of Bismuth types I and II tumors is still controversial [4]. Some authors have reported that HBDR without MLR resulted in good outcomes when applied to selected patients with Bismuth types I and II HCCA [2,11,12]. In contrast, other studies suggest that patients with Bismuth types I and II tumors undergoing concomitant MLR had markedly better long-term survival than those undergoing HBDR alone [13,14].

However, the surgical procedure of choice is still open to debate for patients with Bismuth types I and II HCCA. The aim of this study was to evaluate the short- and long-term outcomes of HBDR alone and with concomitant MLR in the treatment of Bismuth types I and II HCCA at our center for the past 8 y.

2. Methods and methods

2.1. Patients characteristics

In total, 52 patients with Bismuth types I and II hilar HCCA underwent HBDR alone or MLR at our institution between January 2005 and December 2012. According to the Bismuth classification criteria [15], 18 patients were classified as having Bismuth type I, and 34 patients were classified as having Bismuth type II tumors. The patients were divided into two groups according to the surgical procedure undertaken as follows: patients who underwent HBDR alone (HBDR group) and patients who underwent HBDR with MLR (MLR group). Clinical data were retrospectively analyzed for HCCA in our hospital. This study was approved by the Institutional Ethics Committee of West China Hospital, Sichuan University, and written informed consent was obtained from every patient before exploratory laparotomy.

2.2. Preoperative management

Preoperative clinical work-up for patients with HCCA at our center included routine biochemical tests for liver function, serum tumor markers carbohydrate antigen 199 and carcinoembryonic antigen, abdominal ultrasonography, and contrast-enhanced computed tomography (CECT) scan. In addition, patients underwent endoscopic retrograde cholangiopancreatography, where CECT was inconclusive, requiring a tissue diagnosis, and in patients requiring biliary drainage. In cases with advanced T stage or where there was a suspicion of involvement of the peripheral ducts, the magnetic resonance imaging or magnetic resonance cholangiopancreatography was performed to inform the choice of surgery. In patients with suspected distant metastasis or extrahepatic disease, positron emission tomography was performed. In our hospital, PBD was performed if patients fulfilled one of the following criteria: duration of jaundice of >4 wk, poor nutritional status (serum albumin <3 g/dL), or signs of cholangitis. PBD procedures were performed using endoscopic biliary drainage and/or ultrasonographically guided percutaneous transhepatic biliary drainage in our center. Moreover, to minimize the risk of postoperative liver failure in candidates undergoing major hepatectomy with less than 50% of liver parenchyma remnant likely to be preserved, preoperative PVE was performed. The pathologic tumor staging (TNM) was performed according to the American Joint Committee on Cancer staging system [16].

2.3. Surgical techniques

All surgical procedures were mainly performed by three consultant surgeons, each with at least 10 y experience in performing a variety of complex hepatobiliary operations at a tertiary center. In all cases, the gallbladder was routinely removed from its liver bed and preserved in continuity with the common bile duct. Local HBDR was performed in Bismuth types I and II HCCA with T1 or T2 stage based on the preoperative imaging studies and intraoperative findings. Routine porta hepatis lymph node dissection was performed with skeletonization of the portal vein and hepatic artery, and nodal clearance up to the celiac origin and around the head of pancreas. In the patients with advanced T stage HCCA on preoperative imaging and/or intraoperative exploration, radical resection with MLR was performed. Therefore, to a certain extent, the surgeon, based on his/her intraoperative assessment, influenced the choice of operation. In cases with hepatic artery or portal vein infiltration, these structures were excised. The nomenclature for hepatic resections was based on Couinaud classification. After transection of the bile duct, the part of the liver to be resected was freed and dissected off the inferior caval vein. The related hepatic veins were dissected and ligated. Guided by the discoloration, the hepatic parenchyma was transected with the cavitron ultrasonic surgical aspirator (Valleylab, Bloomfield, CT). Whenever feasible, hemihepatic vascular occlusion of the liver to be resected was obtained by extrahepatic control of the in- and out-flow blood vessels. When hemihepatic vascular control was not possible, the Pringle maneuver was performed. After hemostasis, continuity of the biliary tract was reestablished with retrocolic Roux-en-Y hepaticojejunostomy or intrahepatic cholangiojejunostomy. Although frozen sections of the cut ends were not routinely obtained in all cases included in this retrospective study, this practice is presently being reviewed at our center. The supraduodenal remnant common bile duct was transected as close to the duodenum as possible. To obtain a negative resection margin, the margin clearance was >5 mm. Moreover, for the left liver resection, the right proximal bile duct was transected at the bifurcation site of the right anterior and right posterior bile duct. As for right liver resection, the left bile duct was transected near the origin of the umbilical portion. Most of liver resections included caudate lobectomy; however, this was not performed in patients who underwent HBDR alone. In this study, MLR was defined as resection of three or more segments of the liver with or without segment I resection. No patients were given neoadjuvant before or adjuvant chemotherapy or radiotherapy after surgery unless the patient had recurrence. R0 resection was defined as histologically negative surgical margins with a minimum tumor-free margin of 5 mm at the hepatic stump of the bile duct, the duodenal stump of the bile duct, and the excisional surface. Resections with tumor cells in any of the previously mentioned surgical margins on light microscopy were defined as R1 resections. R2 resections were defined as those with a macroscopic tumor left behind in one or more of the surgical margins.

2.4. Definition of complications

Complication was defined as the any deviation from the normal postoperative course, which happened during the 60 d or before discharge from the hospital. It was graded according to the Clavien–Dindo classification [17]. Operative mortality was defined as death within 60 d after surgery or before discharge from the hospital. Liver failure was defined as an increased international normalized ratio with concomitant hyperbilirubinemia on or after postoperative day 5 [18]. Bile leak was defined as the drainage of ≥50 mL of bile from the surgical drain or from drainage of an intra-abdominal collection, over a period of ≥3 d [19].

2.5. Follow-up

Further to discharge, patients had follow-up every 3 mo during the first year and every 6 mo subsequently until at least 5 y after the operation. Levels of carbohydrate antigen 199 and carcinoembryonic antigen, abdominal ultrasonography or CECT scan were performed at each visit. If there was a suspicion of recurrence, further investigations in the form of enhanced magnetic resonance imaging or positron emission tomography-CT scans were performed. Once recurrence was confirmed, treatment strategies, such as adjuvant chemotherapy, radiation therapy and so forth, were proposed according to the patient's clinical status. Survival was defined as the time between the operation and patient death.

2.6. Statistical analysis

Continuous variables were expressed as a mean value with standard deviation and compared with Student *t*-test. Categorical variables were compared with the Chi-square test or Fisher exact test or R × C table analysis. Survival rates after surgery were calculated using the Kaplan–Meier method, and differences in survival rate were compared using the log-rank test. A *P* value <0.05 was regarded as statistically significant, and all *P* values were derived from two-tailed tests. Statistical analyses were performed with SPSS software (version 17.0; SPSS, Chicago, IL).

3. Results

3.1. Operative procedures

The details of the operative procedures undertaken are outlined in Table 1. Based on preoperative investigations (endoscopic and/or imaging), intraoperative findings, and postoperative pathology, the final Bismuth classification was determined. There were 18 cases with Bismuth type I and 34 cases with type II HCCA, respectively. Thirty-two patients underwent HBDR alone, whereas 20 patients underwent HBDR with concomitant MLR. In these patients, one patient with Bismuth type I underwent HBDR and hepatic artery resection with portal vein arterialization (reconstruction through duodenal artery and portal vein anastomosis). Furthermore, four patients with Bismuth type II tumors underwent portal vein resection with end-to-end anastomosis reconstruction in the MLR group (two patients with I + II + III + IV segmentectomy and two patients with I + V + VI + VII + VIII segmentectomy).

3.2. Patient characteristics and intraoperative outcomes

Patient characteristics and intraoperative outcomes for the two groups are outlined in Table 2. There were no significant differences in the baseline characteristics between the two groups. Also, there was no significant difference in the

Table 1 – Operative procedures for Bismuth types I and II HCCA.

Surgical procedure	Bismuth classification	
	Type I (N = 18)	Type II (N = 34)
HBDR alone	17	15
MLR	1	19
II + III + IV segmentectomy	0	2
I + II + III + IV segmentectomy	1	11
V + VI + VII + VIII segmentectomy	0	1
I + V + VI + VII + VIII segmentectomy	0	5
Combined vascular resection		
Portal vein resection	0	4
Hepatic artery resection	1	0

Table 2 – Patient characteristics and intraoperative outcomes.

Variable	HBDR group	MLR group	P value
N	32	20	—
Age (y)	61.8 ± 9.2	59.6 ± 10.9	0.626
Sex (M/F)	22/10	10/10	0.176
BMI (kg/m^2)	20.3 ± 2.1	22.4 ± 2.5	0.105
Obstructive jaundice on admission	28	19	0.682
Preoperative total bilirubin	273.7 ± 157.1	231.2 ± 125.7	0.325
ASA classification			
2	17	6	0.102
3	15	14	
PBD	2	3	0.577
PVE	0	1	0.385
Operation time (min)	270.9 ± 98.8	395.5 ± 112.7	<0.001
Operative blood loss (mL)	382.8 ± 208.1	915.0 ± 459.1	<0.001
Number of blood transfusions	5	14	<0.001
Blood transfusions (mL)	84.4 ± 203.4	580.0 ± 496.9	<0.001

ASA = American Society of Anesthesiologists; BMI = body mass index.

number of patients undergoing PBD and PVE procedures. When compared with the MLR group, the HBDR procedure had a significantly shorter operation time (270.9 ± 98.8 *versus* 395.5 ± 112.7, $P < 0.001$), fewer patients who needed blood transfusion (70% *versus* 16%, $P < 0.001$), lower operative blood loss (382.8 ± 208.1 *versus* 915.0 ± 459.1, $P < 0.001$), and volume of blood transfused (84.4 ± 203.4 *versus* 580.0 ± 496.9, $P < 0.001$).

Table 3 – Pathologic features of resected hilar cholangiocarcinoma.

Variable	HBDR group (N = 32)	MLR group (N = 20)	P value
Bismuth classification			0.001
Type I	17	1	
Type II	15	19	
Tumor size (cm)	2.3 ± 1.0	3.0 ± 1.0	0.064
Macroscopic type			
Papillary	3	1	0.501
Nodular	3	4	
Infiltrative	26	15	
Histologic type			
Well-differentiated	2	2	0.259
Moderately differentiated	21	16	
Poorly differentiated	9	2	
Lymphatic permeation	8	5	1.000
Perineural invasion	16	10	1.000
TNM classification			
T stage			
Tis	0	0	0.223
T1	3	3	
T2a	10	6	
T2b	8	2	
T3	10	5	
T4	1	4	
N stage			
N0	27	17	1.000
N1	5	3	
Histologic curability			0.021
R0	20	19	
R1	12	1	
Proximal positive margin	11	1	0.035
Distal positive margin	7	0	0.035
Total number of dissected LN	13.9 ± 2.5	15.7 ± 2.5	0.194
Total number of metastatic LN	0.7 ± 1.2	1.5 ± 1.8	0.358

LN = lymph node.
Proximal resection margin is that the intramural margin of the transected end of the hepatic duct, distal resection margin is that the intramural choledochal margin of the transected end of the duodenum.

Table 4 – Postoperative outcomes after surgical resection for hilar cholangiocarcinoma.

Postoperative outcomes	Grade(s)	HBDR group (N = 32)	MLR group (N = 20)	P value
Morbidity, *n* (%)		11 (34.4)	14 (70)	0.012
Liver failure	II–IVa	0	4	0.018
Bile leakage	IIIa–IVb	1	3	0.304
Anastomotic leakage	IIIa	0	1	0.385
Abdominal bleeding	IIIa–IIIb	1	1	1.000
Abdominal abscess	II–IIIb	0	2	0.143
Abdominal fluid collection	I–IIIa	2	1	1.000
Cholangitis	II	3	1	0.967
Gastrointestinal bleeding	II–IIIa	2	1	1.000
Septic shock	IVa	1	0	1.000
Wound infection	IIIa–IIIb	1	0	1.000
Pleural effusion	II–IIIa	0	2	0.143
Lung infection	II	1	1	1.000
Cerebral infarction	IVa	0	1	0.385
Mortality	V	1	1	1.000
Length of hospital stay	—	18.7 ± 8.4	22.2 ± 18.0	0.269

3.3. *Pathology findings*

Pathology data and tumor stage are presented in Table 3. The Bismuth classification, tumor size, macroscopic type, histologic type, lymphatic permeation, perineural invasion, and TNM classification were not significantly different between the two groups. Furthermore, the total number of lymph nodes dissected and the number of metastatic lymph nodes positive were not significantly different between the two groups. The curative resection rate in the MLR group, however, was significantly higher than that of the HBDR group ($P = 0.021$). R0 resection rates were 62.5% in the HBDR group and 95% in the MLR group. Proximal positive margins were found in 11 patients in the HBDR group and 1 patient in the MLR group ($P = 0.035$). Distal positive margins were found in seven patients in the HBDR group, with none in the MLR group ($P = 0.035$).

3.4. *Surgical morbidity, mortality, and length of hospital stay*

Postoperative complications occurred in 25 of 52 patients (Table 4) with 11 patients (34.4%) in the HBDR group and 14 patients (70%) in the MLR group, respectively. The MLR group had significantly higher number of overall complications ($P = 0.012$) and liver failure ($P = 0.018$) compared with those in the HBDR group. There were no significant differences in other postoperative outcomes, mortality, and length of hospital stay between the HBDR and MLR groups (all $P > 0.05$).

3.5. *Postoperative survival*

When patients with R1 resection were excluded, the survival rate for R0 resection only was compared. The median follow-up was 16 mo (3–82 mo) in all groups. The median survival was 13.0 mo (10–16 mo) in the HBDR group and 45.0 mo (13.5–77 months) in the MLR group. The overall cumulative survival rates of the HBDR and MLR groups were 59.6%, 68.4% at 1 y, and 21.9%, 60.8% at 3 y, respectively (Fig. 1). The overall cumulative survival rates for the MLR group were markedly higher than those in the HBDR group ($P = 0.016$). In addition, the disease-free survival rates in the HBDR and MLR groups were 49.1% and 68.4% at 1 y, and 0% and 53.2% at 3 y, respectively. The disease-free survival rate was higher in the

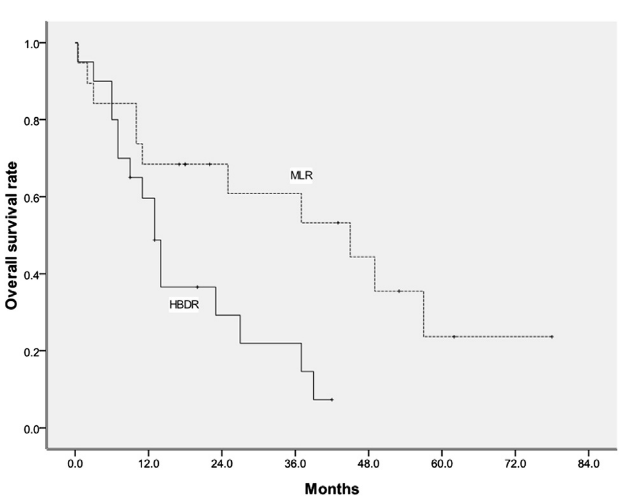

Fig. 1 – Overall survival curves for patients in the HBDR and MLR groups with R0 resection ($P = 0.016$).

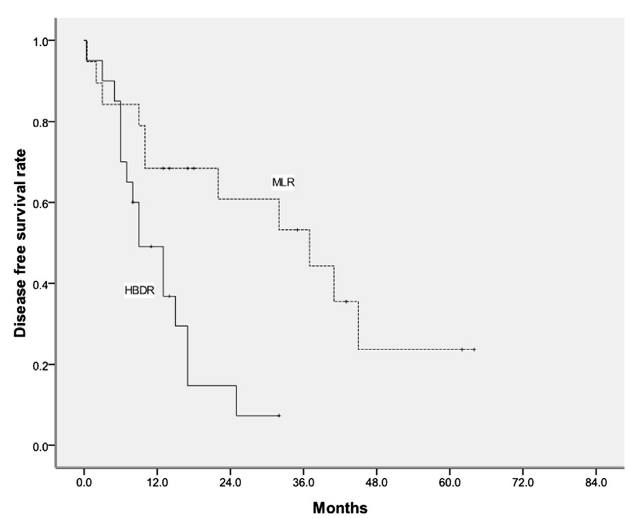

Fig. 2 – Disease-free survival curves for patients in the HBDR and MLR groups with R0 resection ($P = 0.005$).

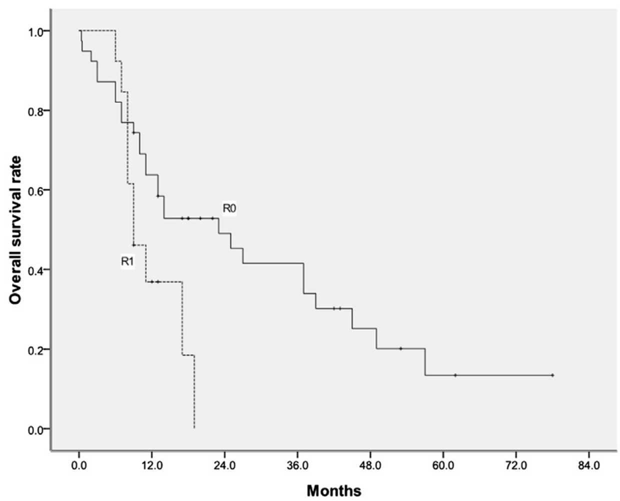

Fig. 3 – Overall survival curves for R0 and R1 resection groups (P = 0.037).

MLR group ($P = 0.005$) compared with that in the HBDR group (Fig. 2). The overall cumulative survival rate in the R0 group was significantly higher than that in the R1 group ($P = 0.037$), with 63.7% and 36.9% at 1 y, and 41.5% and 0% at 3 y, respectively (Fig. 3).

3.6. *Tumor recurrence*

During follow-up, tumor recurrence occurred in 17 of 37 patients (all R0 resections), with 12 patients in the HBDR group and 5 patients in MLR group; this excluded 13 patients with R1 resections and 2 patients who died in hospital (Table 5). The total recurrence rate was lower in the MLR group ($P = 0.049$) as compared with that in the HBDR group. Compared with the HBDR group, the MLR group ($P = 0.045$) had a lower incidence of local recurrence. The recurrence rate at the site of bilioenteric anastomosis was significantly higher in the HBDR group

Table 5 – Comparison of recurrence in the HBDR and MLR groups.

Recurrent site	HBDR group (N = 19)	MLR group (N = 18)	P value
Total, *n* (%)	12 (63.2)	5 (27.8)	0.049
Local recurrence	11	4	0.045
Liver resection margin	0	1	0.486
Local lymph nodes	2	0	0.486
Bilioenteric anastomosis	5	0	0.046
Distal bile duct	3	2	1.000
Peritonitis carcinomatosa	1	1	1.000
Distant metastases	2	1	1.000
Lung	1	0	1.000
Bone	0	0	—
Liver	1	1	1.000

than that in the MLR group ($P = 0.046$). Distant metastases occurred in three patients with no difference in between the two groups. In the HBDR group, there was one patient with lung metastases and one with liver metastases, whereas there was one patient with liver metastases in the MLR group. Among the patients with recurrence, one patient in the HBDR group had local recurrence accompanied by distant lung metastases. Among those undergoing R1 resections, recurrence was observed in six patients in the HBDR group (liver resection margin, $n = 3$, bilioenteric anastomosis, $n = 2$, and distal bile duct and liver metastases, $n = 1$) and in one patient in the MLR group (liver resection margin, $n = 1$) (data not shown).

4. Discussion

Currently, the only effective treatment for HCCA is surgical resection [20]. However, the choice of procedure for patients with Bismuth types I and II HCCA is still open to debate. In our study, patients with Bismuth-Corlette types I and II HCCA who underwent MLR had a longer operation time, higher operative blood loss and blood transfusions. Also, the postoperative complications, particularly liver failure, were significantly higher in the MLR group as compared with those in the HBDR group. However, the MLR group had higher rates of R0 resections, lower recurrence rates, and longer survival rates.

Historically, HBDR was the treatment of choice for HCCA. However, as HCCA has a tendency to spread intraluminally along the bile ducts into the liver and extends into surrounding tissue, with perineural invasion and hepatic parenchymal invasion, this affects the rates of curative resections and survival of patients undergoing HBDR alone [14]. The adequacy of margin clearance for HCCA has been recommended to be >5 mm [16]. Various studies have reported low R0 resection and survival rates with HBDR [4,21]. Some studies have suggested that selected patients, such as those with papillary T1 or T2 tumors (Bismuth type I or II HCCA), may be good candidates for HBDR alone [12,22]. Otani *et al.* [22] reported R0 resections in all patients with papillary tumors undergoing HBDR alone, with an excellent 5-y survival rate (100%), whereas in patients with nodular and flat tumors, R0 resection was achieved less frequently (50%) with a poor 5-y survival (0%). To achieve radical resection and improved long-term survival, HBDR with concomitant liver resection, combined with portal vein or hepatic artery resection and reconstruction, is being increasingly used to treat patients with HCCA [5,6,23,24]. Various studies have reported higher rates of R0 resections with improved survival in patients undergoing HBDR with concomitant liver resection as compared with those undergoing HBDR alone [11,13]. However, many of these studies did not focus on patients with Bismuth types I and II HCCA.

In our study, the MLR group had an R0 resection rate of 95%, as compared with 62.5% in the HBDR group (three patients had papillary HCCA). In this retrospective study, intraoperative frozen sections were not routinely used to assess the remnant ductal. Again, the operating surgeon took a decision to send frozen sections if he/she had any concerns that there was distal involvement. This is because sometimes it is difficult to assess margin positivity accurately because of inflammatory stromal infiltration innate histologic characteristic of HCCA [25]. However, this practice is presently being reviewed at our center. In this study, the overall cumulative survival rate in the MLR group was significantly higher than that in the HBDR group ($P = 0.016$). Also, the disease-free survival rate in the MLR group was significantly higher than that in the HBDR group ($P = 0.005$). Patients with R0 resections had a survival benefit compared with those with R1 resections in our series ($P = 0.037$). These results suggest that HBDR with MLR is effective in achieving tumor-free resection, which translates into a survival benefit for patients.

Aggressive surgical resection to obtain histologically curative resection may result in a better prognosis in HCCA. However, the postoperative morbidity and mortality rates after MLR for HCCA have been reported to be high [5,9,24,26]. Also, the overall survival rate might have been influenced by serious postoperative complications, such as fatal liver failure, especially in patients with severe jaundice [9]. In an attempt to reduce postoperative morbidity and mortality, strategies such as PBD and PVE have been adopted in jaundiced patients undergoing MLR [6,10,16]. Furthermore, parenchyma-preserving liver resection has been reported by some centers to provide the benefits of radical resection and at the same time reduce postoperative complications [8,27,28]. In our study, postoperative complications occurred in 25 of 52 patients (48.1%). The complication rates in the HBDR and MLR groups were 34.4% and 70%, respectively; the MLR group had more complications than the HBDR group ($P = 0.012$). Liver failure occurred only in the MLR group (four patients, 20%). The morbidity in our study was higher than previous reports [6,16]. The higher morbidity in our study may be attributed to the higher preoperative total bilirubin, with the mean preoperative total bilirubin in our study being higher (>13 mg/dL) when compared with previous studies, although without significant difference between the two groups. Also, most patients in our study did not undergo PBD and only one patient underwent PVE. A large number of studies have recommended PBD in patients with a high bilirubin to reduce surgical complications [29–31]. Therefore, to reduce postoperative complications, PBD and PVE might be important for patients with severe jaundice and insufficient remnant liver volume.

We accept the limitations of our study. On the one hand, it is a retrospective study and may be associated with a selection bias, whereas on the other hand, the total number of cases included is low. However, HCCA being a rare disease, it is difficult to conduct large randomized studies at a single center, investigating the two different surgical procedures in the management of Bismuth types I and II HCCA. This makes it imperative to conduct large prospective multicenter studies in HCCA. Also, although we performed HBDR for stage T1 or T2 in Bismuth I and II HCCA, and MLR in more advanced T stages, based on preoperative investigations and intraoperative findings, it is possible that understaging or overstaging could have affected the outcomes as reflected in the TNM stage on histology.

5. Conclusions

In conclusion, our study has shown that HBDR with MLR is associated with improved rates of radical resection, decreased recurrence, and longer survival as compared with HBDR alone, albeit with a longer operative time, higher intraoperative blood loss, higher blood transfusion volume and postoperative complications, which should be considered in patients with Bismuth types I and II HCCA. The postoperative complications may be reduced in MLR with the use of PBD and PVE, where appropriate. Therefore, HBDR with concomitant MLR may be considered an effective treatment for Bismuth types I and II HCCA, particularly in cases where preoperative investigations and/or intraoperative findings are suggestive of an advance T stage. However, there is a need for well-designed, multicenter studies to be undertaken to better inform a decision on the standard treatment for Bismuth types I and II HCCA.

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Authors' contributions: J.X. and Q.M.N. contributed equally to this work. X.L., G.M., and W.H. designed this study. J.X., Q.M.N., and W.H. analyzed the data and wrote the article. W.H. and A.W. collected the data. J.X. and N.K. completed the statistical analysis. All authors read and approved the final article.

Disclosure

The authors reported no proprietary or commercial interest in any product mentioned or concept discussed in this article. The authors confirm that there is no conflict of interest in relation to this study.

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