Naoki Yamanaka
Chiaki Yasui
Junichi Yamanaka
Tatsuya Ando
Nobukazu Kuroda
Shigeto Maeda
Takaaki Ito
Eizo Okamoto

Left hemihepatectomy with microsurgical reconstruction of the right-sided hepatic vasculature

A strategy for preserving hepatic function in patients with proximal bile duct cancer

N. Yamanaka (✉)
Meiwa General Hospital, 4-31,
Agenaruo-Cho, Nishinomiya,
Japan 663-8186
e-mail: nyamana@meiwa-hospital.com
Tel.: +81-798-471767
Fax: +81-798-477613

N. Yamanaka · C. Yasui · J. Yamanaka
T. Ando · N. Kuroda · S. Maeda
E. Okamoto
First Department of Surgery,
Hyogo College of Medicine 1-1,
Mukogawa-cho, Nishinomiya,
Japan 663-8501

T. Ito
Department of Dermatology,
Hyogo College of Medicine 1-1,
Mukogawa-cho, Nishinomiya,
Japan 663-8501

Abstract *Background:* Right hemi-hepatectomy (RH) for proximal bile duct canceroccasionally results in liver failure. We report the feasibility of left hemihepatectomy (LH) with vascular reconstruction (VR) of the right-sided hilar vessels to preserve hepatic reserve. *Methods:* Among 110 patients with proximal bile duct cancer (PBC) treated between January 1980 and December 1998, 11 patients underwent LH with VR of eight portal veins and nine hepatic arteries, and 14 underwent RH with VR of four portal veins and one hepatic artery. Microsurgical techniques were used in 80% (8/10) of the hepatic arterial reconstructions. *Results:* Although operation time was significantly longer in the LH group, hospital mortality, blood loss and incidence of histologically cancer positive margin at the bilioenteric anastomotic site were similar in the two groups. Peak serum liver enzyme concentration was significantly higher in the LH group with longer inflow occlusion time, whereas peak serum total bilirubin concentration was significantly higher in the RH group, which had smaller liver remnant. No liver abscess occurred in any patients who underwent microvascular reconstructions. The cumulative survival of the LH group was worse than that of the RH group, in which the proportion of vascular invasion was lower, but not significantly. *Conclusion:* LH with right-sided microvascular reconstruction is technically possible and a feasible option when RH is likely to result in postoperative liver failure.

Keywords Proximal bile duct cancer · Vascular reconstruction · Microsurgery · Left hemihepatectomy · Right hemihepatectomy

Introduction

Since the first resection for proximal bile duct cancer (PBC) was reported in 1954 [1], considerable progress in surgical and palliative modalities has been made to enhance resectability and long-term prognosis. Bismuth et al. [2] have formalized four surgical approaches: type I, local excision; type II, local excision with resection of the caudate lobe; type III, local excision with resection of the caudate lobe and partial hepatectomy; type IV, hepatectomy and liver transplantation. At present, controversy exists regarding the necessity of caudate lobectomy [3,4], the extent of resection [5, 6, 7,8], and whether preservation of the right or left lobe is preferable [7, 8, 9, 10,11]. These issues are important to resolve since relatively few patients are candidates for local excision. The vast majority of patients require a hemihepatectomy to achieve a tumor-free margin at the hepatic duct stump and/or to remove vascular lesions.

Generally, right hemihepatectomy is indicated in patients whose tumor involves the right-sided hilar vasculature. However, the risk of postoperative liver failure is high when right hemihepatectomy is performed in a cholestatic liver. The present study examined the feasibility of performing a left hemihepatectomy with right-sided vascular reconstruction as a treatment option in patients

for whom right hemi- or extended hepatectomy carries a high risk of liver failure.

Patients and methods

Between January 1980 and December 1998, 110 patients with PBC were referred to our department. Treatment selection was based on patient age, serum bilirubin concentration and cholangiogram after biliary decompression by percutaneous transhepatic biliary drainage or endoscopic nasobiliary drainage, the extent of the lesion, and the degree of vascular and nodal involvement. A palliative procedure was selected in patients with peritoneal seeding, extensive lymph node involvement beyond the hepatoduodenal ligament, parenchymal metastasis to both hepatic lobes, bilateral involvement of the hepatic ducts beyond the secondary branches, extensive bilateral vascular involvement, or persistent jaundice even after bilateral biliary decompression.

Treatments included extrahepatic bile duct resection alone in nine, combined bile duct resection and hemihepatectomy in 37, external drainage in 37, plastic or metallic stenting in 24, and surgical bypass in three. Of the 37 patients with combined bile duct resection and hemihepatectomy, 14 patients underwent (extended) right hemihepatectomy (RH group), and 11 underwent (extended) left hemihepatectomy with right-sided vascular reconstruction (LH group). The remaining 12 patients had hepatectomy for the central region. The operative procedure was selected according to the site of involved bile duct and safety of hepatic resection range. We have been using a multiple regression equation to determine which hepatic lobe, right or left, can safely be resected without postoperative liver failure [12,13]. The equation is $Y=-84.6+0.933$ volume ratio of the lobe to be resected $+1.11$ indocyanine green retention rate at 15 min after intravenous injection of the dye (0.5 mg/kg) + 0.999 patient's age. The volume ratio was measured using computed tomography. If the Y-value for right hemihepatectomy exceeded 50 points, the operative procedure was changed to left hemihepatectomy even if the right-sided vasculature was involved.

Preoperative data and surgical procedure

Age, gender, and preoperative liver function after biliary decompression were similar in the two groups (Table1). The volume ratio of the resected liver [12,13] was 65±9.8% for the RH group, and 25±12% for the LH group. Caudate lobectomy was combined in 93% of the RH group and in 100% of the LH group. The left portal vein was reconstructed in three patients, and both the left portal vein and the left hepatic artery were reconstructed in one patient in the RH group. In the LH group, the right portal vein alone was reconstructed in two, the right hepatic artery alone in three, and both vessels in six. One patient who had both vessels reconstructed, had only the posterior branch of the right hepatic artery reconstructed because back bleeding from the right anterior branch obviated the need to perform reconstruction of the posterior branch. Microsurgical techniques were used in 80% (8/10) of hepatic arterial reconstructions, using the hepatic artery proper or the gastroduodenal artery. The left or right portal vein was reconstructed by end-to-end anastomosis ($n=9$) or using an interposition autograft from the umbilical vein ($n=2$) [14] or the left renal vein ($n=1$). Sixty-four percent of patients in the LH group required multiple bilioenteric anastomoses by Roux-en-Y jejunal loop, compared to 21% in the RH group ($P<0.01$).

Statistical analysis

Intraoperative data and the postoperative course of the two groups were compared. Statistical comparisons were performed by Stu-

Table 1 Preoperative data and surgical procedure. Numbers in parentheses indicate autografts for reconstuction. *RH* right hemihepatectomy, *LH* left hemihepatectomy, *Bil* serum total bilirubin, *PV* portal vein, *Alb,* serum albumin, *HA* hepatic artery, *PT* prothrombin time, *NS* not significant

	RH group	LH group	
Patients (*n*)	14	11	NS
Age (years)	55±10	60±11	NS
Sex (M/F)	9/5	6/5	NS
Preoperative data after decompression			
Bil (mg/kl)	2.9±1.7	1.4±0.8	P<0.01
Alb (g/dl)	3.9±0.3	3.7±0.5	NS
PT (%)	94±23	89±19	NS
Volume ratio of resected lobe (%)	65±9.8	25±12	*P*<0.01
Combined caudate lobectomy	93% (13/14)	100% (11/11)	NS
Vascular reconstruction	29% (4/14)	100% (11/11)	*P*<0.05
PV alone	3 (1)	2	
HA alone	0	3	
PV+HA	1	6 (2)	
No. of bilio-enteric anastomoses			
1	11 (79%)	4 (36%)	NS
2	2	5	
3	1	2	

dent's unpaired *t*-test or the chi-square test, with statistical significance defined as $P<0.05$. Survival was calculated by the Kaplan-Meier method and compared by the log-rank test.

Results

Intraoperative and pathological findings

Operation time in the LH group was significantly longer than that in the RH group because the number of bilioenteric anastomoses was larger and all patients in the LH group required vascular reconstruction (Table 2). Amount of blood loss in the two groups was similar. Portal clamping time used for the portal reconstruction was somewhat longer in the LH group, which included two patients who required an interposition autograft. The hepatic duct stump was histologically positive for cancer in 14% of patients in the RH group and in 9% in the LH group. Regional and/or distant lymph node metastases were found in approximately half the patients in both groups, and the incidence of perineural invasion was at least 80% in both groups. There was no significant difference in the pTNM stage [15] and histological type of the tumor, although three of 14 in the RH group were at stage I.

Postoperative data

Operative mortality in the two groups was comparable (7.1% vs. 9.1%) (Table 3). One patient in the RH group who underwent right trisegmentectomy (right trisectionectomy) [16] without vascular reconstruction died of

Table 2 Intraoperative data and pathologic findings. *RH* right hemihepatectomy, *LH* left hemihepatectomy, *NS* not significant

	RH group	LH group	
Operative time (min)	477±130	708±193	*P*<0.01
Blood loss (ml)	2590±1170	2250±1030	NS
Weight of specimens (g)	791±167	265±105	*P*<0.01
Portal clamping time (min)	32±25	44±33	NS
Stump of the remnant hepatic duct (positive)	14% (2/14)	9% (1/11)	NS
Node (positive)	50% (7/14)	55% (6/11)	NS
Perineural invasion (positive)	86% (12/14)	100% (11/11)	NS
pTNM stage			NS
I	21% (3/14)	–	
II	–	18% (2/11)	
III	21% (3/4)	9% (1/1)	
IV	58% (8/14)	73% (8/11)	
Histology			
Tubular	86% (12/14)	91% (10/11)	NS
Good	3	2	
Moderate	9	7	
Poor	0	1	
Papillary			
Good	2	0	
Adenosquamous	0	1	

Table 3 Postoperative data. *RH* right hemihepatectomy, *LH* left hemihepatectomy, *NS* not significant, *AST* aspartate aminotransferase, *ALT* alanine aminotransferase

	RH group	LH group	
Hospital mortality	7.1% (1/14)	9.1% (1/11)	NS
Peak value[a]			
AST (U/l)	255±180	850±756	*P*<0.05
ALT (U/l)	152±128	519±414	*P*<0.05
Bilirubin (mg/dl)	6.3±3.4	2.4±1.0	*P*<0.01
Morbidity[a]			
Bile leakage	23% (3/13)	30% (3/10)	NS
Hyperbilirubinemia (>=5 mg/dl)	69% (9/13)	10% (1/10)	*P*<0.01
Liver abscess	7.7% (1/13)	10% (1/10)	NS
Portal hypertension	0% (0/13)	10% (1/10)	NS
Recurrence site			
Hilum	75% (9/12)	38% (3/8)	*P*<0.05
Peritoneum	58% (7/12)	75% (6/8)	NS
Liver	–	25% (2/8)	NS
Lung	8.3% (1/12)	–	NS

[a] For patients who survived

progressive liver failure. One patient in the LH group who had vascular reconstructions of both the right hepatic artery and the right portal vein died 2 months postoperatively. This patient suffered two episodes of late-onset bleeding from a mesenteric vessel in the jejunal loop,
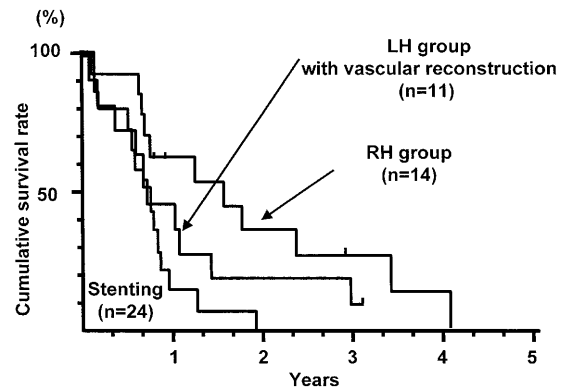
Fig. 1 Prognosis in right (*RH*) and left hemihepatectomy (*LH*)

probably due to bile leakage and local sepsis. This caused progressive liver failure even though patency of the vascular anastomosis was confirmed by Doppler ultrasound.

The peak serum concentrations of liver enzymes were significantly higher in the LH group. Hepatic ischemic time was longer in this group because two patients underwent both the right portal vein and the right hepatic artery reconstruction, which took 65 and 100 min, respectively, until portal flow circulation was reestablished. However, the peak serum total bilirubin concentration was significantly lower, and the incidence of hyperbilirubinemia more than 5 mg/dl was lower in the LH group. The incidence of bile leakage and liver abscess was similar in the two groups. Two patients developed liver abscess, and in neither case was the hepatic arterial reconstruction performed using microsurgical technique. Liver abscess did not occur in any patient who underwent microsurgical reconstructions. One patient with double reconstructions developed portal hypertension and ascites after hospital discharge. In this patient, the right portal vein was reconstructed using a 4-cm autograft of the umbilical vein, and graft obstruction was confirmed by the Doppler ultrasound. Esophageal varices were treated successfully by endoscopic variceal ligation, and ascites subsided spontaneously. However, this patient died of peritoneal recurrence 1 year after surgery.

Prognosis

Cumulative survival of the LH group was worse than that of the RH group which required vascular reconstruction less frequently, although there was no statistical difference (Fig. 1). The mode of recurrence was determined in 12 patients in the RH group and eight patients in the LH group and included local recurrence at the hilum or anastomotic site, peritoneal recurrence, intrahepatic recurrence and distant metastasis (lung) (Table 4). In both groups, local and peritoneal recurrences were more com-

mon than the other modes of recurrence. Although local recurrences were rather frequent in the RH group, in which a histologically positive margin of the resected intrahepatic duct was seen more often, peritoneal and hepatic recurrences were more frequent in the LH than in the RH group.

Discussion

Some authors recommend extrahepatic bile duct resection alone [5,17] or combined with limited hepatectomy because the mortality rates of these procedures are much lower and the survival curves are similar to those who undergo extensive resection. Although the type of resection should be based primarily on the extent of the lesion [18], a more radical approach, combined with extensive hepatic resection [3, 8,19], has been recommended for the majority of patients so as to yield a tumor-free margin at the hepatic duct stump; this strategy offers the best hope for long-term survival [6, 7, 8, 20,21]. In this context, right hemihepatectomy, including resection of the caudate lobe, has been recommended as the most satisfactory type of liver resection [7, 11, 22,23] unless the lesion is extended far into the left hepatic duct. This recommendation is based on the fact that the left hepatic duct is anatomically longer, which makes it easier to secure a tumor-free margin at the hepatic duct stump [11,23]. The problem is that high mortality is associated with extensive hemihepatectomy [3, 11, 13,23]. A clinical review by Boerma [7] confirmed that operative mortality for local resections with or without limited hepatectomy was half that of major hepatic resections (8% vs. 15%), and that right hemihepatectomy was associated with a higher mortality than left hemihepatectomy (25% vs. 7%). In fact, in our series the peak serum bilirubin concentration was significantly higher, and one patient died of liver failure in the RH group. Despite the higher frequency of complications, mean and long-term survivals are similar for the right and left approach [7].

Preoperative portal embolization of the right lobe has been advocated to promote hypertrophy of the left lobe prior to right hemihepatectomy [22,24]. This intervention induces the translocation of approximately 10% of the hepatic volume from the right lobe to the left lobe within 2–3 weeks [25]. This stepwise approach may reduce mortality due to hepatic insufficiency after right hemihepatectomy. The down side is that portal embolization requires a waiting time of 2–3 weeks to allow the contralateral lobe of the liver to regenerate adequately and does not always produce a satisfactory atrophy–hypertrophy process because portal recanalization of the occluded segments can occur.

Under these conditions, left hemihepatectomy with right-sided vascular reconstruction can be an alternative to right hemihepatectomy when the risk of liver failure is high, unless the lesion extends far toward the right hepatic duct (type IIIa) [2]. The introduction of microsurgical techniques has improved the quality of the arterial anastomosis, and earlier problems of liver necrosis secondary to arterial occlusion no longer complicate this procedure. The right hepatic artery usually can be reconstructed using the hepatic artery proper or, when that is not possible, the gastroduodenal artery may be used.

Stepwise resection for double reconstruction of the portal vein and right hepatic artery is performed as follows. First, the left hemiliver is removed en bloc with the caudate lobe and involved portal vein, leaving the involved right hepatic artery behind. The right portal vein is reconstructed by an end-to-end anastomosis or by interposing an autologous vein graft from the left renal vein [26] or the umbilical vein [14]. Secondly, the involved right hepatic artery is resected and reconstructed. This stepwise approach to vascular resection, where inflow from one side remains intact, avoids complete ischemia in the liver remnant. Another strategy is to perform simultaneous en bloc resection of the hepatic artery and portal vein with the hemiliver. This option would be better than stepwise vascular resection and would minimize intraoperative seeding of the tumor cell. The seeding may cause peritoneal recurrence later. In one patient, the ischemia-induced right hemiliver was cooled topically by seeding ice slush [27,28] to minimize the ischemic insult due to interruption of inflow for 90 min before portal circulation was reestablished.

There was no difference at 1-year survival between the LH group and stenting group, and the number in each group was too small to statistically compare their survival. However, it is a fact that long survival can only be expected if the resection has been aggressive. Left hemihepatectomy combined with right-sided vascular reconstruction can be put in a surgical tool box for patients whose cancer involves the right-sided hilar vasculature and in whom a right approach carries a high risk of liver failure, although it remains to be seen whether survival for locally advanced PBC is increased by right hemihepatectomy combined with preoperative right portal embolization.

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