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**Portal vein resection and reconstruction prior to hepatic dissection during  
right hepatectomy and caudate lobectomy for hepatobiliary cancer**

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Original article

### *Abstract*

**Background:** Hepatobiliary cancers invading the hilar bile duct often involve the portal bifurcation. Portal vein resection and reconstruction is usually performed after completion of the hepatectomy. This retrospective study assessed the safety and usefulness of portal vein reconstruction prior to hepatic dissection in right hepatectomy and caudate lobectomy plus biliary reconstruction, one of the common procedures for radical resection.

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**Methods:** Clinical characteristics and perioperative results were compared in patients who underwent right hepatectomy and caudate lobectomy plus biliary reconstruction with (10 patients) and without portal reconstruction (11 patients) over the last 3 years and 7 months.

**Results:** All 10 cases of portal vein reconstruction were completed successfully prior to hepatic dissection; the portal cross-clamp time ranged from 15 to 41 min (median: 22.5 min). Blood loss, blood transfusion during the operation, postoperative liver function, morbidity, and length of hospital stay were similar in the two groups. No patient suffered postoperative hepatic failure or death.

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**Conclusion:** This study demonstrates that portal vein reconstruction does not increase the morbidity or mortality of right hepatectomy and caudate lobectomy with biliary reconstruction. This approach facilitates portal vein reconstruction for no-touch resection of hepatobiliary cancers invading the hilar bile duct.

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## Introduction

The hilar bile duct lies close to the portal bifurcation. Hepatobiliary cancers, such as hilar cholangiocarcinoma, cholangiocellular liver cancer, and gallbladder carcinoma, often involve the portal bifurcation.<sup>1-3</sup> A right hepatectomy and caudate lobectomy plus biliary reconstruction is widely employed for radical resection of hepatobiliary cancers that invade the hilar bile duct because the confluence of the right and left hepatic ducts is located on the right side of the hepatic hilum.<sup>4,5</sup> As this procedure itself is one of considerable magnitude,<sup>6,7</sup> involvement of the portal vein has prevented surgeons from extending the operation to complete an en-bloc resection.<sup>8</sup> The use of hepatectomy with en-bloc portal vein resection has been advocated by several authors<sup>9-11</sup> potentially increasing the number of curative resection rates. Nevertheless, hepatectomy with en-bloc portal vein resection has yet to become accepted as standard due to the complicated and difficult technique of the portal vein reconstruction.<sup>3</sup>

This retrospective study reports an experience with portal vein reconstruction prior to hepatic dissection in right hepatectomy and caudate lobectomy. This approach seemed easier and simpler than reconstruction after hepatectomy (Nimura Y, personal communication). The safety and usefulness of this procedure were determined by comparing operative and postoperative results in patients who did and did not undergo portal reconstruction in combination with hepatectomy.

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### ***Patients and Methods***

Between September 1998 and March 2002, 53 patients with hepatobiliary cancer underwent hepatectomy with biliary reconstruction. Twenty-two patients underwent a right hepatectomy (including an extended right hepatectomy in 3 patients) and caudate lobectomy. Excluding one patient who underwent a two-stage operation, 10 patients required resection of the portal bifurcation due to malignant invasion and 11 patients did not. These 21 patients form the basis of this retrospective analysis. The primary cancers were hilar cholangiocarcinomas in 12 patients, gallbladder carcinomas in 5, and cholangiocellular liver cancers in 4 patients. Data were compared using the Mann-Whitney test or Fisher's exact test, and a *P* value <0.05 was considered significant.

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### **Operative Technique**

Portal vein reconstruction was performed prior to hepatic dissection. After lymphadenectomy around the head of the pancreas and division of the common bile duct, the hepatic artery and portal vein were skeletonized. The right hepatic artery was divided, and portal vein invasion at the level of the bifurcation confirmed. The left portal branch was isolated at the base of the umbilical portion, away from the bifurcation. Small portal branches to the caudate lobe and the Arantius canal were divided, allowing full mobilization of the left portal branch up to the base of the umbilical portion. After clamping the portal trunk and left portal branch as far from the portal bifurcation as possible, the portal vein was resected to obtain clear surgical margins. Reconstruction was performed in an end-to-end fashion, taking care to avoid torsion of the anastomosis. The

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anastomosis was created using a continuous 5-0 nonabsorbable suture using the intraluminal suturing technique for the posterior wall and the over and over method for the anterior wall. After unclamping the portal vein, the operation proceeded as follows: mobilization of the right liver and caudate lobe, division of the short hepatic veins and the right hepatic vein, hepatic dissection along the middle hepatic vein towards the right side of the umbilical portion, division of the left hepatic duct adjacent to the umbilical portion, para-aortic lymphadenectomy when indicated, and Roux-en-Y hepaticojejunostomy. At the end of the operation, portal flow was confirmed by colour Doppler ultrasonography.

In patients without tumor involvement of the portal bifurcation, isolation and division of the right portal branch was substituted for portal vein resection and reconstruction. Otherwise the procedure was the same in the two groups.

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## Results

Portal vein resection and reconstruction was completed successfully without temporary shunting of the portal flow in all 10 patients. The portal vein cross-clamp time was 15 to 41 min (median: 22.5 min). A right external iliac vein autograft was interposed between the portal trunk and left portal branch in two patients. The cross-clamp time was 36 and 39 min in these patients. In the latter patient, however, redundancy of the interposed graft after removal of the bulky mass caused a kink in the portal vein that resulted in thrombotic obstruction before the end of the operation. Portal patency was restored by thrombectomy and shortening the graft. In all 10 patients, postoperative color Doppler ultrasonography or contrast-enhanced computed tomography established anastomotic patency.

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Clinical characteristics and perioperative results of patients with and without portal reconstruction are summarized in Table 1. The type of primary cancer was different between the two groups ( $P=0.012$ ). Because gallbladder carcinoma showed more extensive local involvement than hilar cholangiocarcinoma, all 5 patients with gallbladder carcinoma had involvement of the portal bifurcation compared to 3 of 12 patients with hilar cholangiocarcinoma. Preoperative embolization of the right portal branch was performed more often in patients with portal reconstruction ( $P=0.024$ ). Only one of 10 patients with portal reconstruction did not undergo portal embolization (because of right portal vein occlusion due to tumor), 7 of 11 patients without portal reconstruction did not undergo prior portal embolization. Other predisposing factors that were

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likely to affect operative and postoperative results, such as age, presence of obstructive jaundice, the extent of hepatectomy, and concomitant resection of contiguous structures were similar in the two groups.

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Time of operation was longer in the patients with portal reconstruction ( $P=0.041$ ). Blood loss and number of packed red blood cell transfusions administered intraoperatively were similar in the two groups. Nine patients (43%) in the two groups received a blood transfusion. Postoperative levels of AST, ALT, and total bilirubin were similar, and no patient developed postoperative hepatic failure or died (Table 1). The postoperative morbidity rate and length of hospital stay were also similar. Complications occurred in 8 patients (38%) altogether: cholangitis in 3, bile leak in 2, intraperitoneal bleeding, gastric ulcer bleeding, and intraperitoneal abscess in one patient each.

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Histological examination of resected specimens revealed curative status with clear margins in all but one patient, who underwent portal vein resection. Tumor infiltration into a resected portal vein was detected in 7 patients. Lymph node metastasis and perineural invasion were found in 6 and 7 of the 10 patients with portal reconstruction, respectively, and in 2 and 9 of the 11 patients without portal reconstruction, respectively.

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Postoperative follow-up period in all 21 patients was 1 to 29 months (median: 14 months). Of the 10 patients with portal reconstruction, 3 patients (two with gallbladder carcinoma and one with cholangiocellular liver cancer) died of recurrence 7, 7 and 10 months after surgery. The remaining 7 patients have been alive for 1 to 29 months (median: 14 months). Of the 11 patients without

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portal reconstruction, one patient with cholangiocellular liver cancer died of the

disease 20 months after surgery and the other 10 patients remain alive between 2  
and 28 months (median: 14.8 months).

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## Discussion

The role of portal vein resection and reconstruction for advanced hepatobiliary cancer is controversial. Despite previous reports of high morbidity and mortality rates after portal reconstruction,<sup>1,12</sup> some recent studies have demonstrated improved results, comparable to those in patients without portal invasion who do not require a reconstruction.<sup>2,5</sup> When curative resection was achieved using portal reconstruction, resected patients survived significantly longer than unresected patients.<sup>1,2</sup> The literature is, however, conflicting. Although the overall survival of patients with portal reconstruction is poor in general.<sup>1,2,12</sup> Neuhaus et al.<sup>5</sup> have reported a 5-year survival rate of 65% for 14 patients who underwent curative hepatectomy with portal reconstruction for hilar cholangiocarcinoma.

Previous reports on radical resection of hepatobiliary cancer involving the portal bifurcation have recommended that the portal vein be resected after the hepatic dissection is completed, and portal reconstruction be performed after removal of the specimen.<sup>9,10</sup> This situation creates several problems that do not exist in a standard right hepatectomy, where the right portal branch is isolated and divided prior to hepatic dissection. The remaining portal system is a hindrance to continuing dissection, especially when it is time to divide the left hepatic duct adjacent to the umbilical portion. It is impossible to block the portal inflow into the right liver, which might increase blood loss during hepatic dissection and finally, the possibility exists of unexpected obstruction of portal flow into the future-remnant left liver during mobilization of the right liver. This might lead

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to ischemic liver damage. These problems are avoided by performing portal vein resection and reconstruction prior to hepatic dissection. Some surgeons may hypothesize that surgical maneuvers after portal vein reconstruction might produce tension on the portal anastomosis leading to its disruption, but in practice this did not occur.

削除: and postoperative hepatic failure if the arterial blood supply is decreased secondary to arterial spasm resulting from surgical manipulation.

Several factors require attention to create a successful anastomosis. The left portal branch should be fully mobilized up to the base of the umbilical portion by division of the caudate branches and the Arantius canal. The main portal trunk should be fully mobilized back to the confluence of the splenic and mesenteric veins together with lymphadenectomy around the head of the pancreas. This degree of mobilization makes direct end-to-end anastomosis easy. In the present study, only two patients required graft interposition. When this is needed, redundancy should be avoided because kinking may occur<sup>9,10,13</sup>. Colour

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Doppler ultrasonography provides valuable information about portal flow and adequacy of the anastomosis.<sup>14</sup> Torsion of the anastomosis must be avoided.

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This is achieved by maintaining precise anterior-posterior orientation when placing vascular clamps. An intraluminal suturing technique for the posterior wall with an over and over method for the anterior wall makes rotation of the anastomosis unlikely, since the stump of the left portal branch is fixed. When tension on the proper hepatic artery hinders creation of the anastomosis, division of the gastroduodenal artery allows the hepatic artery to be mobilised to the left.

No patient in this study required temporary portal bypass during portal

clamping.<sup>15,16</sup> Only 20 to 25 minutes was needed for portal clamping; with an

additional 10 – 15 minutes in patients who required d graft interposition. Temporary bypass might be useful under special circumstances in which the portal cross-clamp is expected to exceed 60 min.<sup>17</sup>

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This study has shown that perioperative results in patients with portal reconstruction were similar to those in the patients without reconstruction.

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Although this lengthens the operating time, this is a reflection of more extensive

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local tumour and a greater need for pre-operative portal embolization as well as

portal vein invasion. The safety, ease, and simplicity of this procedure suggests

削除: predominance of gallbladder carcinoma, high frequency of preoperative portal embolization, and long operative time in the patients with portal reconstruction were related with more extensive tumor involvement as well as portal vein invasion.

that routine portal vein resection in patients with hepatobiliary cancers who are undergoing curative resection may be appropriate.<sup>5</sup>

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Table 1. Comparison of clinical characteristics and perioperative results between patients who did and did not undergo portal reconstruction in combination with right hepatectomy and caudate lobectomy

	Patients with resection of the portal bifurcation (n=10)	Patients without portal reconstruction (n=11)	<i>P</i>
Age	66.0 [48–76]	63.0 [49–79]	NS
Gender (male/female)	4/6	8/3	NS
Primary cancer			0.012 <sup>b</sup>
Hilar cholangiocarcinoma	3	9	
Gallbladder carcinoma	5	0	
Cholangiocellular liver cancer	2	2	
Preoperative embolization of right portal branch	9	4	0.024
Operative time (min.)	652.5 [505–792]	549.0 [460–705]	0.041
Blood loss during operation (mL)	1282.5 [893–1660]	1220.0 [620–2490]	NS
Blood transfusion during operation (unit <sup>a</sup> )	2.0 [0–6]	0.0 [0–6]	NS
AST (IU/L): postoperative day 1	375.5 [152–785]	393.0 [112–1204]	NS
ALT (IU/L): postoperative day 1	340.0 [107–972]	428.0 [108–1224]	NS
Bilirubin (mg/dL): maximum level during postoperative course	4.6 [1.6–11.1]	3.7 [1.3–8.2]	NS
Postoperative hospital stay (days)	40.0 [31–148]	47.0 [23–108]	NS

Data are expressed as median [range] or number of patients.

<sup>a</sup>: equivalent to whole blood, 200 mL

<sup>b</sup>: gallbladder carcinoma *versus* hilar cholangiocarcinoma and cholangiocellular liver cancer

NS: not significant