An Appraisal of Liver and Portal Vein Resection for Hepatocellular Carcinoma With Tumor Thrombi Extending to Portal Bifurcation

Cheng-Chung Wu, MD; Shih-Rong Hsieh, MD; Jung-Ta Chen, MD; William-Lin Ho, MD; Min-Che Lin, MD; Dah-Cherng Yeh, MD; Tse-Jia Liu, MD; Fang-Ku Peng, MD

**Background:** The role of surgical resection for hepatocellular carcinoma with tumor thrombi involving the major portal vein is controversial because of a high operative risk and poor prognosis. Previously, a resection was performed only when the tumor thrombi were limited to the first branch of the portal vein without extension to the portal bifurcation.

**Hypothesis:** Concomitant liver and portal vein resection may be beneficial in patients with hepatocellular carcinoma with tumor thrombi extending to portal bifurcation.

**Design:** Retrospective review.

**Setting:** University hospital, tertiary referral center.

**Patients:** Among 368 patients with hepatocellular carcinoma who underwent a curative resection, portal vein involvement occurred in 112 patients. Fifteen of the 112 patients underwent a concomitant liver and portal vein resection owing to extension of tumor thrombi to the portal bifurcation (group 1). The remaining 97 patients did not need portal vein resection (group 2).

**Intervention:** Surgical indications, procedures, and results of pathological examination of resected specimens were assessed in patients in group 1. The clinicopathological characteristics, operative morbidity and mortality, and operative results were compared between the 2 groups.

**Main Outcome Measures:** Disease-free and actuarial survival rates.

**Results:** Intramural tumor infiltration was found at the site of thrombi adhesion to the portal vein cuff in 11 of 15 patients in group 1. Owing to patient selection bias, patients in group 1 were significantly younger and had better liver function and greater resected liver weight. The operative time, postoperative hospitalization, operative blood loss, amount of blood transfusion, and operative morbidity and mortality did not differ significantly between the 2 groups. The 5-year disease-free survival rates of groups 1 and 2 were 21.6% and 20.4% \( (P = .19) \), respectively, while the actuarial survival rates were 26.4% and 28.5% \( (P = .33) \), respectively.

**Conclusion:** Liver resection with partial resection of the portal vein is justified in selected patients with hepatocellular carcinoma with tumor thrombi extending to portal bifurcation.

Arch Surg. 2000;135:1273-1279

**Although surgical resection remains the only curative therapy for hepatocellular carcinoma (HCC), the resection rate is generally low with a high rate of recurrence.**1-4 Hepatocellular carcinoma usually spreads intrahepatically through the portal vein branches.3,5 Many investigators have described the vascular involvement of HCC as an adverse prognostic factor after hepatic resection.1,4,6-8 When tumor thrombi extend to the major portal vein (defined as the first branch or main trunk of the portal vein), the TNM staging system7 defines such a tumor as T4, stage IV, with an extremely poor prognosis.1,2,3,8,10-13 Previously, surgical resection was advocated only in patients whose tumor thrombi were limited to the first branch of the portal vein without extension to the portal bifurcation.1,2,4 When tumor thrombi extend to the portal bifurcation or main trunk, liver resection with direct removal of tumor thrombi in the portal vein has been proposed to relieve portal hypertension and to improve survival.10,13 However, this procedure remains controversial because of high operative risks and poor outcome.1,2,4

*See Invited Critique at end of article*

Recently, major hepatectomy (defined as right or left lobectomy of the liver with or without extension to the contralateral lobe) with main portal vein resection has been advocated for hilar biliary cancers.19 If HCC and its tumor thrombi extend to the portal bifurcation, the main tumor and part

From the Department of Pathology, School of Medicine, National Yang-Ming University, Taipei (Drs Chen and Ho); and the Department of Surgery, School of Medicine, National Yang-Ming University, Taipei and Taichung Veterans General Hospital, Taichung (Drs Wu, Hsieh, Lin, Yeh, Liu, and Peng), Taiwan.
PATIENTS AND METHODS

PATIENTS

Between January 1990 and December 1998, a total of 368 patients with HCC underwent a curative liver resection (defined as a resection that results in no grossly remaining tumor). Among them, 15 patients underwent concomitant liver resection and partial resection of the main portal vein because of apparent tumor thrombi extension to the portal bifurcation. The backgrounds and operative results of these 15 patients (group 1) were reviewed.

The resected specimens of all patients with HCC who underwent liver resection were carefully examined by senior pathologists (J.-T.C. and W.-L.H.) to determine the pathological characteristics, such as resection margin, tumor multicentricity, tumor capsule formation, presence of satellite nodules, and presence of intrahepatic vascular involvement. In the same period, we retrospectively selected 97 patients whose tumors had invaded the intrahepatic portal branches as confirmed on pathological examination, but did not involve the portal bifurcation (group 2). This group included 4 patients whose tumor thrombi were limited to the left portal vein and 2 patients whose tumor thrombi were limited to the right portal vein with some distance to the portal bifurcation. The tumor thrombi were included in the resected specimen by conventional major hepatectomy. Surgical procedures for patients in group 2 did not include portal vein resection.

PREOPERATIVE ASSESSMENTS

Preoperatively, all HCC patients underwent conventional liver function tests (including Child-Pugh classification), as well as the indocyanine green (ICG) clearance test, serum hepatitis B surface antigen, serum hepatitis C antibody, and α-fetoprotein examinations. Imaging studies included abdominal ultrasonography, computed tomography, and angiography. When the patient's general condition fulfilled the American Society of Anesthesiologists physical status score class I or II, and when there was no resectable extrahepatic metastasis, the resectability of HCC and extent of liver resection were based on the tumor location and extension (from imaging studies), serum bilirubin level, and ICG 15-minute retention rate (ICG R15, normal value ≤10%), as presented in Table 1.

When preoperative angiography showed that tumor thrombi extended to the portal bifurcation and totally obstructed the ipsilateral portal vein branch or budded into the main portal vein lumen (Figure 1), major hepatectomy with partial resection of the main portal vein was considered if the portal blood flow in the main portal vein and contralateral side of the portal vein was intact. According to the aforementioned patient selection criteria, ICG R15 less than or equal to 10% was required for right hepatectomy, and ICG R15 less than or equal to 15% was required for left hepatectomy. Patients with tumor thrombi occupying the main portal vein with the “thread and streaks sign” in the main portal vein or “total occlusion” of main portal blood flow were not considered for this operation. For patients with severe esophageal varices, endoscopic sclerosing therapy or varical ligation should be performed before liver resection.

The surgical indications and extent of liver resection for patients in group 2 generally followed convention and have been previously reported.

SURGICAL TECHNIQUES

Before liver resection, intraoperative ultrasonography was performed on patients in group 1 to confirm the location and extension of HCC and tumor thrombi and to define the resection line on the liver surface. After cholecystectomy, the hepatoduodenal ligament was dissected as for conventional major hepatectomy. The main bile duct, hepatic artery, and main portal vein were individually taped. The portal vein to the conserved lobe was also dissected and taped. The vascular tape for the main portal vein was applied as distally as possible. The bile duct and hepatic artery to the resected lobe were divided and ligated. Dissection of the hepatoduodenal ligament should be gentle, and care should be taken to avoid squeezing or fragmentizing the tumor thrombi, using intraoperative ultrasonography to monitor the course of this procedure. After intravenous administration of 200 mg of hydrocortisone sodium succinate, the main and contralateral portal veins were simultaneously occluded and the lumen of the main portal vein was opened to identify the actual extent of tumor thrombi (Figure 2). Pieces of gauze were placed around the venotomy site to avoid possible dissipation of cancer cells into the free peritoneal cavity. Part of the main portal vein wall was resected with a safe margin about 1 to 2 mm from the most extensive part of tumor thrombi (Figure 3). In 12 patients, the main portal defect was directly closed as in Figure 2. In 2 patients who underwent an extended right hepatectomy, a segment of the main portal vein was resected with direct anastomosis of the distal part of the main portal vein to the left portal vein. In another patient who underwent left hepatectomy, the portal vein defect was covered with a patch graft obtained from the right gonadal vein. The portal blood flow was restored after completion of portal vein reconstruction. The opened portal vein of the portal vein containing the thrombi may be resected en bloc with similar techniques. Although some surgeons have also mentioned this procedure for HCC, the details and outcomes have not been specifically addressed.

We adopted an aggressive policy regarding liver resection for HCC in 1989. Liver resection with simultaneous partial resection of the main portal vein is performed on patients who have HCC with tumor thrombi extending to portal bifurcation. To elucidate the role of this procedure for patients in such an advanced stage of cancer, we retrospectively reviewed the operative results of these patients with HCC and compared them with other patients with resected HCC whose tumors involved the intrahepatic portal vein but did not extend to portal bifurcation, eliminating the need for portal vein resection.

RESULTS

The background characteristics of the patients with HCC in both groups are presented in Table 2. Because of case...
on the resected side was temporarily covered with a plastic bag to avoid further spillage of tumor thrombi into the free peritoneal cavity.

Using the intermittent hepatic inflow blood occlusion technique, the liver parenchyma was transected along the previously defined resection line. The caudate lobe of the liver (Couinaud segment I) was also resected in patients who required a left hepatectomy. For patients who required a right hepatectomy, the caudate process and paracaval portion of caudate lobe (Couinaud segment IX) were also resected. Of the patients in group 1, 10 patients underwent left hepatectomy, and 5 patients underwent right hepatectomy. Concomitant resection of the diaphragm was performed in 4 patients.

The surgical procedures for patients in group 2 included various types of liver resection guided by Couinaud liver segmentation, including some major hepatectomies without resection of the portal vein. Such liver resections were also performed under intermittent hepatic inflow blood occlusion to minimize operative blood loss.

The operative morbidity and mortality were defined as complications or deaths occurring within 30 days after operation or during the same hospitalization.

POSTOPERATIVE FOLLOW-UP

After pathological examination, the TNM staging system was applied to each patient. Patients with hepatocellular carcinoma who survived the operation were followed up at our outpatient clinic every 3 to 4 months. Serum α-fetoprotein was measured and abdominal ultrasonography and/or a computed tomography scan was performed to detect tumor recurrence. Recurrent tumors confined to the liver were treated by re-resection or transcatheater arterial chemoembolization. Extrahepatic recurrences that were unresectable were treated by systemic chemotherapy using fluorouracil, epirubicin hydrochloride, and cisplatin.

STATISTICAL ANALYSIS

The clinicopathological characteristics, as well as short-term and long-term operative results, were compared between the 2 groups. The continuous variables were presented as mean±SEM and compared with the Mann-Whitney U test. The frequencies were compared with the Fisher exact test. The survival rates were calculated by the Kaplan-Meier method and compared using the generalized Wilcoxon rank sum test. \( P<.05 \) was defined as statistically significant.

## Table 1. Patient Selection Criteria for HCC Resection*

<table>
<thead>
<tr>
<th>Criteria</th>
<th>No Hepatectomy</th>
<th>Hepatectomy (Absence of the Above Criteria)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preservable nontumorous liver</td>
<td>40% (ICG R15 &lt;50%) and preservable nontumorous liver ≤7.5 segments</td>
<td>30% (ICG R15 &lt;40%) and preservable nontumorous liver ≤7 segments</td>
</tr>
<tr>
<td>Presence of tumor thrombi over both sides of portal vein</td>
<td>20% (ICG R15 &lt;30%) and preservable nontumorous liver ≤6 segments</td>
<td>10% (ICG R15 &lt;20%) and preservable nontumorous liver ≤5 segments</td>
</tr>
<tr>
<td>Uncontrollable ascites</td>
<td></td>
<td>ICG R15 ≤10% and preservable nontumorous liver ≤2 segments</td>
</tr>
<tr>
<td>Total serum bilirubin ≥68 µmol/L (≥4 mg/dL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICG R15 ≥50%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*HCC indicates hepatocellular carcinoma; ICG R15, indocyanine green 15-minute retention rate. Segments follow Couinaud’s definition of segmentation.

**Figure 1. Portal venogram showing tumor thrombi. A, Total occlusion of left portal vein. B, Total occlusion of left portal vein and budding into the right portal vein lumen (arrowheads). The flow in right portal vein branches is intact.**

(selection bias, the patients in group 1 were significantly younger and had significantly lower ICG R15 values, lower bilirubin levels, and shorter prothrombin times.)

INTROOPERATIVE RESULTS

The hepatic inflow occlusion mean±SEM duration for portal vein resection and reconstruction was 19.1±3.5 minutes (range, 12.2–28.2 minutes). There were no significant differences in mean±SEM total liver ischemic time (group 1, 60.2±5.5 minutes; group 2, 59.2±5.8 minutes; \( P=.89 \)), or total mean±SEM operative time (group 1, 6.17±1.36 hours; group 2, 5.71±1.99 hours; \( P=.23 \)) between the 2 groups. Because of worse liver function in patients in group 2, the mean±SEM resected liver weight was significantly smaller than in patients in group 1 (755.5±26.1 g vs 480.4±22.6 g, respectively; \( P=.02 \)). The mean±SEM operative blood loss (1705.8±36.2 mL in group 1 vs 1390.2±46.7 mL in group 2, \( P=.51 \)) and the mean±SEM amount of blood transfusion (group 1,
874.8±12.8 mL; group 2; 766.4±13.6 mL; P = .66) did not differ between the groups.

**EARLY POSTOPERATIVE RESULTS**

Postoperative complications are presented in **Table 3**. No patients in group 1 died after their operations. However, 3 patients in group 2 died due to postoperative hepatic failure, intra-abdominal abscess with sepsis after colonic leakage, and pneumonia after hypnotics overdose, respectively. The postoperative morbidity and mortality did not differ between the groups. The mean±SEM postoperative hospital stay also did not significantly differ between the groups (group 1, 18.5±3.2 days; group 2, 13.8±4.5 days; P = .49).

**PATHOLOGICAL CHARACTERISTICS**

The pathological characteristics of the resected specimens of both groups are presented in **Table 4**. Generally, there were no significant differences regarding any feature between the 2 groups. However, because tumor stages in all patients in group 1 were defined as TNM stage IV, the tumor stages of patients in group 2 were significantly better. The histological features of the free border of tumor thrombi that adhered to the portal vein wall were carefully examined. In 11 patients in group 1, after serial examination of the resected portal vein cuff, the cancer cells were found to not only adhere to the intima of the portal vein cuff, but also to infiltrate the portal vein wall at the level of the most distal site of tumor thrombi adhesion (**Figure 4**). No cancer involvement could be found in the cut margin of the main portal vein cuff.

**LONG-TERM RESULTS**

As of September 1999, 4 patients in group 1 were alive and disease-free, with 1 of the 4 patients surviving the longest at 94 months. Liver cancer recurred in 1 patient 58 months after left hepatectomy and 78 months after the operation the patient was still living. The cancer recurrence was con-
trolled under periodic transcatheter arterial chemoembolization. Of 11 patients in group 1 who had cancer recurrence, 7 also had extrahepatic recurrence (lung, 7; skin and bone, 1 each). At present, 31 patients in group 2 are still alive and disease-free (including 1 who underwent a re-resection for liver recurrence), 9 patients are alive with cancer recurrence, 53 patients are dead due to cancer recurrence, and 1 patient is dead due to liver failure without cancer recurrence. Extrahepatic recurrence was observed in 13 patients in group 2. Patients in group 1 had a significantly higher incidence of extrahepatic recurrence (7 of 11 in group 1 vs 13 of 63 in group 2; \( P = .007 \)).

The 5-year disease-free survival rates of groups 1 and 2 were 21.1% and 20.4%, respectively, while the 5-year actuarial survival rates of groups 1 and 2 were 26.4% and 28.5%, respectively. The differences between groups were not statistically significant (Figure 5).

**Table 2. Background Characteristics of Patients With HCC and Portal Venous Involvement**

<table>
<thead>
<tr>
<th>Pathological Characteristics</th>
<th>Group 1 (n = 15)</th>
<th>Group 2 (n = 97)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>46.9 ± 3.6</td>
<td>55.7 ± 3.9</td>
<td>.01</td>
</tr>
<tr>
<td>Sex (men:women)</td>
<td>13:2</td>
<td>83:14</td>
<td>.99</td>
</tr>
<tr>
<td>Serum HbsAg positive</td>
<td>14</td>
<td>67</td>
<td>.06</td>
</tr>
<tr>
<td>Serum HCVAb positive</td>
<td>2</td>
<td>25</td>
<td>.51</td>
</tr>
<tr>
<td>ICG R15, %</td>
<td>9.9 ± 2.6</td>
<td>14.5 ± 7.5</td>
<td>.03</td>
</tr>
<tr>
<td>Total serum bilirubin, ( \mu \text{mol/L (mg/dL)} )</td>
<td>(1.02 ± 0.87)</td>
<td>(1.48 ± 0.90)</td>
<td></td>
</tr>
<tr>
<td>Serum AST, ( \mu \text{u/L} )</td>
<td>48.6 ± 5.44</td>
<td>55.8 ± 4.92</td>
<td>.84</td>
</tr>
<tr>
<td>Serum ALT, ( \mu \text{u/L} )</td>
<td>48.2 ± 5.46</td>
<td>56.6 ± 3.49</td>
<td>.60</td>
</tr>
<tr>
<td>Prothrombin time, % of control</td>
<td>96.8 ± 1.2</td>
<td>92.4 ± 2.4</td>
<td>.04</td>
</tr>
<tr>
<td>Associated esophageal varices</td>
<td>3</td>
<td>19</td>
<td>.95</td>
</tr>
<tr>
<td>Associated cirrhosis</td>
<td>11</td>
<td>70</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Child-Pugh grade ratio, A:B:C</td>
<td>12:3:0</td>
<td>84:11:5</td>
<td>.56</td>
</tr>
<tr>
<td>Serum AFP &gt;=200 ng/mL</td>
<td>10</td>
<td>49</td>
<td>.28</td>
</tr>
</tbody>
</table>

**Table 3. Operative Morbidity and Mortality in Patients With HCC and Portal Vein Involvement**

<table>
<thead>
<tr>
<th>Complications</th>
<th>Group 1 (n = 15)</th>
<th>Group 2 (n = 97)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary tract infection</td>
<td>1</td>
<td>1</td>
<td>. . .</td>
</tr>
<tr>
<td>Bile leakage</td>
<td>4</td>
<td>6</td>
<td>. . .</td>
</tr>
<tr>
<td>Intra-abdominal abscess</td>
<td>1</td>
<td>5</td>
<td>. . .</td>
</tr>
<tr>
<td>Postoperative bleeding</td>
<td>1</td>
<td>0</td>
<td>. . .</td>
</tr>
<tr>
<td>Prolonged jaundice</td>
<td>1</td>
<td>2</td>
<td>. . .</td>
</tr>
<tr>
<td>Wound infection</td>
<td>0</td>
<td>2</td>
<td>. . .</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>0</td>
<td>3</td>
<td>. . .</td>
</tr>
<tr>
<td>Ascites</td>
<td>0</td>
<td>3</td>
<td>. . .</td>
</tr>
<tr>
<td>GIT perforation</td>
<td>0</td>
<td>3</td>
<td>. . .</td>
</tr>
<tr>
<td>Hypnotics overdose</td>
<td>0</td>
<td>1</td>
<td>. . .</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>20</td>
<td>.11</td>
</tr>
<tr>
<td>Deaths</td>
<td>0</td>
<td>3</td>
<td>&gt;.99</td>
</tr>
</tbody>
</table>

**Table 4. Pathological Characteristics of the Resected HCC With Portal Vein Involvement**

<table>
<thead>
<tr>
<th>Pathological Characteristics</th>
<th>Group 1 (n = 15)</th>
<th>Group 2 (n = 97)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tumor capsule formation</td>
<td>2</td>
<td>24</td>
<td>.51</td>
</tr>
<tr>
<td>Presence of satellite nodule</td>
<td>11</td>
<td>53</td>
<td>.26</td>
</tr>
<tr>
<td>Multicentric tumor</td>
<td>2</td>
<td>36</td>
<td>.08</td>
</tr>
<tr>
<td>Resection margin, mean ± SEM, mm</td>
<td>10.8 ± 4.7</td>
<td>8.8 ± 5.1</td>
<td>.30</td>
</tr>
<tr>
<td>TNM staging II:III:IV</td>
<td>0.0.15</td>
<td>3.54:40</td>
<td>.001</td>
</tr>
</tbody>
</table>

**Figure 4.** Histologic findings of the resected portal vein cuff with tumor thrombi grossly adhering to the portal vein wall, at the level of arrows in Figure 3A. A. Tumor (T) adhering to the intima of portal vein. B. Tumor (T) infiltrating the intima of the portal vein (hematoxylin-eosin, original magnification \( \times 100 \)).

**COMMENT**

Advancements in nonoperative treatments for HCC, such as chemotherapy, transcatheter arterial chemoembolization, and ethanol injection, are usually ineffective or even impossible when tumor thrombi involve the major portal vein.3,4 Moreover, total hepatectomy with liver transplantation is not considered in patients with such advanced cancer because of the ominous prognosis and scarcity of organs.23

In the past, when tumor thrombi of HCC extended to major portal veins, surgical resection was only carried out when thrombi were located a considerable distance from the portal bifurcation as in some of the pa-
patients in group 2.1,2,4 In such cases, the cancer can be completely removed by major heptatectomy with resection of the ipsilateral portal vein branch containing the tumor thrombi. With this procedure, some patients may obtain long-term survival.1 When tumor thrombi extend to portal bifurcation or the main portal vein, resection is usually not recommended because of high surgical mortality and low survival benefit.1,2,4,7

Recently, some surgeons have proposed liver resection with direct removal of tumor thrombi in the major portal veins to decompress portal hypertension or prolong survival time of such patients with advanced HCC.8,10-13 However, the surgical risks and survival benefits of this strategy have not been satisfactory. Although some patients in these reports were treated by simultaneous liver and portal vein resection,8,10,11 patient selection criteria, operative procedures, pathological features, and long-term outcomes of this operation were not specifically discussed.

The risks of concomitant liver resection and main portal vein resection remain high.8,10-14 For hilar biliary cancers, the operative mortality reported by Nimura et al14 was 17% for patients with obstructive jaundice whose serum bilirubin level declined below 51 µmol/L (3 mg/dL) after percutaneous transhepatic biliary drainage. For patients undergoing thrombectomy of the portal vein during surgical resection of HCC, the reported surgical mortality rate is 11% to 35%.8,10-13 The main cause of death in these reports was liver failure.8,10-14

In Taiwan, most HCC patients have cirrhosis or chronic hepatitis.2,18,19 Because a great proportion of functioning nontumorous liver parenchyma must be removed during major heptatectomy and portal vein resection, patients in group 1 were selected to avoid postoperative liver failure. Because of reduced regeneration capacity, major heptatectomy usually caused postoperative liver failure in cirrhotic patients.1,2 However, Fan et al24 reported that selected patients with cirrhosis could tolerate a major heptatectomy (mostly right or extended right hepatectomy) without operative death if their ICG R15 was less than or equal to 14%. Likewise, Torzilli et al25 also achieved a no-mortality liver resection for HCC using similar criteria. No patients in our group 1 succumbed after the operation although most patients had liver cirrhosis.

Moreover, unlike other studies,10-13 we did not include patients for concomitant liver and portal vein resection whose main portal vein was totally occupied by tumor thrombi and/or who had tumor thrombi extending to contralateral portal vein branches. Only patients whose tumor thrombi just extended to or budded across the portal bifurcation were selected for this operation. The time span for portal vein resection and reconstruction was not too long and was tolerated by all patients. During this study period, only 4% (15/368) of resected HCC patients fulfilled our criteria for concomitant liver and portal vein resection for HCC. Because the conserved side of portal blood flow was kept intact, the function of the liver remnant was well preserved. Thus, all complications in patients in group 1 were treatable.

The prognosis after liver resection for HCC with vascular invasion is generally poor.1,2,7,15 The prognoses of our 2 groups were comparable to other reports regarding HCC with vascular invasion.1,6-8 The long-term results after hepatectomy for HCC with tumor thrombi involving the major portal vein were even poorer. The reported 3-year survival rate is around 11% to 18%.8,10-13 However, in those reports, HCC patients whose tumors occupied the main portal vein (treated by portal vein thrombectomy) and those whose tumor thrombi were located in the peripheral portal branches (without a need for portal vein resection) were included.

Based on our pathological examination, direct removal of thrombi (thrombectomy) in the major portal vein could not be regarded as a curative resection for HCC because of a high incidence of intramural infiltration of cancer cells at the adhesion site of the portal vein cuff. Thus, the entire thrombi-adhering segment of the portal vein should be resected. In past reports, long-term survival was achieved in patients with HCC and major portal vein thrombi who underwent a concomitant resection of both the liver and the thrombi-involved segment of portal vein.1,25

Unlike portal vein resection for hilar bile duct cancer,14 it was hard to identify whether tumor thrombi adhered to the venous wall or were floating in the venous lumen, either by palpation or by intraoperative ultrasonography from the adventitial side of the portal vein, without opening the portal vein lumen. Thus, we suggest opening the portal vein to accurately identify the extent of portal vein thrombi and to examine the free border of thrombi from the intima side.

Figure 5. Long-term results of patients with hepatocellular carcinoma and portal vein involvement. A, Disease-free survival rate, group 1 vs group 2 (P = .19). B, Actuarial survival rate, group 1 vs group 2 (P = .33).
of the portal vein by direct observation. Moreover, this procedure may avoid squeezing or fragmenting the tumor thrombi with blunt application of the vascular clamps to the portal vein. We think that if this procedure is not done, cancer cells may easily be disseminated to the remnant liver during dissection of the liver hilum.

Since this study did not include patients with HCC whose tumor thrombi occupied the main portal vein or contralateral portal vein branch (ie, who required portal vein thrombectomy), despite poor tumor staging and a higher incidence of extrahepatic metastasis in group 1, the prognosis of this group of patients was not as poor as indicated in previous reports on HCC with major portal vein invasion. Long-term survival can be expected for some patients. Therefore, we conclude that HCC with tumor thrombi extending to the portal bifurcation should not be regarded as an untreatable disease, and hepatectomy with partial resection of the portal vein is justified in selected patients.

This study was supported in part by grant NSC 89-2314-B-075-012 from the National Science Council, Taipei, Taiwan.

We thank Ms F. L. Kuo, BS, for her statistical assistance.

Corresponding author: Cheng-Chung Wu, MD, Department of Surgery, Taichung Veterans General Hospital, Section 3, 160, Chung-Kang Rd, Taichung, Taiwan (e-mail: he@vghtc.vghtc.gov.tw).

REFERENCES


Invited Critique

It is well established that hepatocellular carcinoma carries a poorer prognosis when it invades the portal vein (PV). Nevertheless, many patients with involvement of a distal lobar PV still benefit from resection. However, the value of a hepatectomy when the tumor extends to the PV bifurcation has not been entirely defined. In the study by Wu and colleagues, 15 patients underwent PV resection for retrograde tumor extension to the PV bifurcation without occlusion of the main PV. This represented 4% of all resections performed by the authors for hepatocellular carcinoma during the period studied. It is not stated how many patients were deemed unsuitable for PV resection either prior to or during laparotomy; however, this is difficult to ascertain in a retrospective review. Preoperative angiography was performed routinely in these patients, but duplex ultrasonography may have provided comparable information at the hilus. Magnetic resonance or computed tomographic angiography will likely replace invasive investigation in the near future.

It should be emphasized that maximal mobility of the main PV and the contralateral lobar branch is paramount prior to venotomy. This includes division of caudate tributaries, complete posterior dissection at the hilus, and skeletonization of the main PV down to the pancreas. The pathologic analysis in this report demonstrates the inadequacy of merely performing PV tumor thrombectomy since intraluminal tumor thrombi adherent to the portal vein on gross inspection were sometimes found to be invasive of the vein wall on microscopic examination.

The authors point out the favorable clinical characteristics in this series. Careful patient selection was critical in achieving a 5-year actuarial survival rate similar to that of resected patients with only involvement of a distal lobar PV. Furthermore, only 2 patients required segmental resection of the main PV while 13 patients had lateral PV defects after resection that were primarily closed in 12 patients. The data demonstrate that tumor thrombi extending to the main PV should not be used alone to exclude a patient from resection. The authors’ approach should be broadly applied to suitable candidates.

Ronald P. DeMatteo, MD
New York, NY

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