Hepatocellular Carcinoma (HCC) is usually associated with liver cirrhosis and is the principal cause of death among patients with cirrhosis. Apart from liver transplantation that may cure both conditions, treatment of HCC and cirrhosis is complex because of the need to be oncologically radical but simultaneously conservative. In this sense, hepatectomy is considered an invasive approach and has a marginal role in the treatment of HCC. Hepatectomy can tolerate hepatic resection with low mortality, acceptable morbidity, and survival benefits if resection is performed under strict intraoperative ultrasonographic guidance. These results should prompt revision of the BCLC recommendations.
adjacent segments were removed. Postoperative death was analyzed at 30 and 90 days. Major postoperative morbidity was considered any complication that required additional surgery or any invasive procedure. Liver failure was considered mild if the serum total bilirubin level ranged from 2 to 5 mg/dL for more than 3 days after surgery, medium if it ranged from more than 5 to 10 mg/dL, and severe if it exceeded 10 mg/dL (to convert bilirubin level to micromoles per liter, multiply by 17.104).

PREOPERATIVE MANAGEMENT

The preoperative imaging workup included abdominal ultrasonography and spiral computed tomography for all patients, as well as magnetic resonance imaging for patients with doubtful lesions on ultrasonography and computed tomography. Chest radiographs were also routinely obtained.

**Figure 1** shows our selection flowchart. Patients were selected for surgery based on the presence or absence of ascites, their total serum bilirubin level, and the technical feasibility of success. Technical feasibility was established if residual liver volume with optimal blood inflow, blood outflow, and biliary drainage was expected to be sufficient. Liver volumes were calculated based on computed tomographic images.

Patients with HCC meeting the Milan criteria and younger than 60 years were referred for liver transplantation. Other surgery was considered only if the patient refused liver transplantation. Patients with unresectable HCC were referred for palliation.

The presence of esophageal varices on routinely performed upper gastrointestinal tract endoscopy was not considered an exclusion criterion. Furthermore, we did not exclude patients whose platelet counts were less than 100,000/µL (to convert platelet count to ×10⁹/L, multiply by 1.0).

INTRAOPERATIVE ULTRASONOGRAPHIC GUIDANCE

Intraoperative ultrasonography was routinely performed for staging and for resection guidance. Contrast-enhanced intraoperative ultrasonography was used for any new lesion detected on intraoperative ultrasonography.

For tumors associated with major intrahepatic vascular structures (first- and second-order portal vein branches and main hepatic veins), residual liver volume was maximized using intraoperative ultrasonography. For capsulated HCC in contact with a vein without discontinuation of its wall, the vessel was spared. Inversely, the vessel was not spared for capsulated HCC in contact with a portal branch with bile duct dilation. Hepatectomy was extended to include the parenchyma fed by portal branches to be resected. For hepatic vein resection, the tumor-vein relationship, the presence or absence of accessory hepatic veins, and the flow direction on color Doppler imaging of the portal branches were noted. The hepatic vein to be resected was clamped (if not already occluded). Intraoperative ultrasonographic findings were used to maximize sparing of the liver parenchyma.
OPERATIVE PROCEDURES

J-shaped or inverted T-shaped laparotomies were routinely performed. For patients with tumors involving segments 1, 4, 7, and 8 and the cranial segment close to the confluence of the hepatic vein into the inferior vena cava, J-shaped thoracophrenolaparotomy was considered.

Liver dissection was accomplished under intermittent clamping by the Pringle maneuver\(^1\) using crush clamping with Rochester-Péan forceps. Careful examination was made to rule out bile leakage, but cholangiography was not performed for this purpose.\(^1\) Closed 19F suction drains were inserted.

BCLC CLASSIFICATION

Patient disease was stratified according to the BCLC staging classification. The following categories were used.

**Stages 0/A**

Stage 0 includes single tumors smaller than 2 cm in diameter. Stage A includes single tumors smaller than 5 cm in diameter or up to 3 tumors all smaller than 3 cm in diameter.

**Stage B**

Stage B includes up to 3 tumors (≥1 of which is >3 cm in diameter) or more than 3 tumors of any size. Single tumors exceeding 5 cm in diameter are included in this stage based on the article by Bruix and Llovet.\(^2\)

**Stage C**

Stage C includes macrovascular invasion (major portal or hepatic veins). Alternatively, stage C involves lymph node metastases or distant metastases.

PATIENT FOLLOW-UP

Patients were followed up at our institution by an expert hepatobiliary team (G.T., A.P., and D.D.F.) every 3 months. Physical examination, liver function tests, serum \(\alpha\)-fetoprotein level, ultrasonography (twice a year), and computed tomography (twice a year) were included.

END POINTS

The study end points were as follows: (1) postoperative morbidity and mortality, (2) rate of blood transfusions, (3) histologic review of surgical margins, (4) rate of cut edge recurrence, (5) long-term survival according to the BCLC classification, (6) disease-free survival according to the BCLC classification, and (7) hepatic disease–free survival according to the BCLC classification.

**PATIENTS**

From June 30, 2001, to November 1, 2006, a total of 163 patients with HCC were referred to our outpatient clinic. One hundred twenty (73.6%) were selected for surgery; 43 (26.4%) were excluded for advanced disease (n=18) or impaired functional reserve (n=18) or were referred for percutaneous ablation therapy (PAT) (n=7) of single HCC tumors smaller than 2 cm in diameter. Among 18 patients excluded for advanced HCC, 12 had BCLC stage C disease with tumor thrombus in the main portal trunk, 3 had BCLC stage C disease with distant metastasis, and 3 had BCLC stage B disease. Among 120 patients who underwent surgery, 113 (94.2%) underwent resection, and 7 (6%) underwent exploratory laparotomy. Figure 2 shows the therapeutic output. There were 90 men and 23 women, and the median age was 67 years (age range, 36-87 years).

Table 1. Classification of Patients With Barcelona Clinic Liver Cancer (BCLC) Stage 0 and A and Stage B Hepatocellular Carcinoma

<table>
<thead>
<tr>
<th>BCLC Stage</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/A (n = 61)</td>
<td></td>
</tr>
<tr>
<td>Single tumor ≤2 cm</td>
<td>5 (8.2)</td>
</tr>
<tr>
<td>≤5 cm</td>
<td>43 (70.5)</td>
</tr>
<tr>
<td>≤3 Tumors, none &gt;3 cm</td>
<td>13 (21.3)</td>
</tr>
<tr>
<td>B (n = 24)</td>
<td></td>
</tr>
<tr>
<td>Single tumor &gt;5 cm</td>
<td>9 (37.5)</td>
</tr>
<tr>
<td>2-3 Tumors, any &gt;3 cm</td>
<td>10 (41.7)</td>
</tr>
<tr>
<td>&gt;3 Tumors</td>
<td>5 (20.8)</td>
</tr>
</tbody>
</table>

Table 2. Classification of Macrovascular Invasion Among Patients With Barcelona Clinic Liver Cancer Stage C Hepatocellular Carcinoma

<table>
<thead>
<tr>
<th>Variable</th>
<th>With Thrombosis</th>
<th>Without Thrombosis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV or IVC invasion</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>PV invasion</td>
<td>7</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>First-order branch</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Second-order branch</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Third-order branch</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PV plus HV or IVC invasion</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>First-order PV branch</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Second-order PV branch</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Third-order PV branch</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>19</td>
<td>28</td>
</tr>
</tbody>
</table>

Abbreviations: HV, hepatic vein; IVC, inferior vena cava; PV, portal vein.
younger than 60 years and were referred for liver transplantation. They refused transplantation and subsequently underwent hepatectomy. All 28 patients with BCLC stage C HCC had concomitant macrovascular invasion evident on imaging, and none had involved lymph nodes or distant metastasis.

### STATISTICAL ANALYSIS

Continuous variables are presented as median (range), and discrete variables are given as number (percentage). Survival time started from the date of hepatic resection until death; disease-free and hepatic disease-free survival started from the date of hepatic resection until the diagnosis of recurrence. Survival rates were obtained by the Kaplan-Meier method and were compared using the log-rank test. All significance tests were 2-tailed. Univariate analysis was performed for the following variables: age, sex, tumor number, tumor size, macrovascular invasion, tumor grade, cirrhosis, esophageal varices, clinical portal hypertension, serum \( \alpha \)-fetoprotein level, extent of hepatectomy, and BCLC classification. All variables significant on univariate analysis were submitted to multivariate analysis using the Cox proportional hazards model. \( P < .05 \) was considered statistically significant.

### RESULTS

#### SURGICAL PROCEDURE

Preoperative endoscopic banding of F2 and F3 esophageal varices was performed in 6 patients. In 14 patients (12.4%), J-shaped thoracophrenolaparotomy was performed.

#### POSTOPERATIVE OUTCOMES

Thirty-day hospital mortality occurred in 1 patient. This represented a mortality rate of 0.9%. The overall morbidity rate was 27.4% (31 of 113 patients). Major morbidity occurred in 4 patients (3.5%), including 3 pleural effusions that required thoracentec-
sis and 1 pneumothorax that required chest tube insertion. No reoperations were needed. Minor morbidity consisted of transient ascites in 12 patients, superficial wound dehiscence in 7 patients, pleural effusion in 3 patients, transient fever in 3 patients, and mild liver failure in 2 patients. Mild liver failure occurred after limited resections in 2 patients with preoperative bilirubin levels ranging from 1.5 to 2 mg/dL.

Table 5 summarizes the complications and short-term outcomes.

The median hospital stay was 9 days. The range was 7 to 20 days.

**PATHOLOGIC FINDINGS**

The overall median tumor-free margin was 2 mm (range, 0-10 mm). Zero-millimeter margins were obtained in 28 patients with capsulated HCC in contact with hepatic veins or with first- or second-order portal branches. Twenty-eight patients (24.8%) had macrovascular invasion that was established before surgery by imaging and confirmed after surgery by histologic examination (Tables 2 and 3).

**LONG-TERM FOLLOW-UP**

Among 113 patients, 45 (39.8%) developed recurrences, including 22 with BCLC stage 0 or A disease, 10 with stage B disease, and 13 with stage C disease. Thirty-four patients (30.1%) (19 with stage A disease, 6 with stage B disease, and 9 with stage C disease) had intrahepatic recurrence only, 8 patients (7.1%) (2 with stage A disease, 3 with stage B disease, and 3 with stage C disease) had extrahepatic recurrence only, and 3 patients (2.7%) (1 with stage A disease, 1 with stage B disease, and 1 with stage C disease) had intrahepatic and extrahepatic recurrence. Recurrences were treated in 29 of 45 patients (64.4%), including 16 with BCLC stage 0 or A disease, 7 with stage B disease, and 6 with stage C disease. Intrahepatic recurrence neces-

### Table 4. Surgical Procedures of Patients Having Hepatocellular Carcinoma Treated With Curative Resection Stratified According to the Barcelona Clinic Liver Cancer (BCLC) Classification

<table>
<thead>
<tr>
<th>Variable</th>
<th>BCLC Stage</th>
<th>P Valueb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0/A (n=61)</td>
<td>B (n=24)</td>
</tr>
<tr>
<td>Surgery, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoracotomy</td>
<td>6 (9.8)</td>
<td>2 (8.3)</td>
</tr>
<tr>
<td>Minor resection</td>
<td>58 (95.1)</td>
<td>20 (83.3)</td>
</tr>
<tr>
<td>&lt;1 Segment</td>
<td>36</td>
<td>13</td>
</tr>
<tr>
<td>1-2 Segments</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>Major resection</td>
<td>2 (3.3)</td>
<td>4 (16.7)</td>
</tr>
<tr>
<td>3 Segments</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>&gt;3 Segments</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Duration of operation, median (range), min</td>
<td>306 (180-620)</td>
<td>390 (240-660)</td>
</tr>
<tr>
<td>Duration of Pringle maneuver, median (range), min</td>
<td>45 (15-198)</td>
<td>75 (30-165)</td>
</tr>
<tr>
<td>Blood loss, median (range), mL</td>
<td>200 (10-1500)</td>
<td>200 (80-1200)</td>
</tr>
<tr>
<td>Blood transfusions, No. (%)</td>
<td>6 (9.8)</td>
<td>3 (12.5)</td>
</tr>
<tr>
<td>Drains, median (range)</td>
<td>2 (1-3)</td>
<td>2 (1-3)</td>
</tr>
</tbody>
</table>

a See Table 1 and the “Stage C” subsection of the “BCLC Classification” subsection in the “Methods” section for an explanation of the Barcelona Clinic Liver Cancer stages.

b $\chi^2$ Test and Kruskal-Wallis test where appropriate.

### Table 5. Morbidity, Mortality, and Short-term Outcomes of Patients Having Hepatocellular Carcinoma Treated With Curative Resection Stratified According to the Barcelona Clinic Liver Cancer (BCLC) Classification

<table>
<thead>
<tr>
<th>Variable</th>
<th>BCLC Stage</th>
<th>P Valueb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0/A (n=61)</td>
<td>B (n=24)</td>
</tr>
<tr>
<td>Overall morbidity, No. (%)</td>
<td>13 (21.3)</td>
<td>7 (29.2)</td>
</tr>
<tr>
<td>Complications, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>2 (3.3)</td>
<td>1 (4.2)</td>
</tr>
<tr>
<td>Minor</td>
<td>11 (18.0)</td>
<td>6 (25.0)</td>
</tr>
<tr>
<td>Mortality, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 d</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>90 d</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Length of stay, median (range), d</td>
<td>9 (8-26)</td>
<td>10 (8-17)</td>
</tr>
</tbody>
</table>

a See Table 1 and the “Stage C” subsection of the “BCLC Classification” subsection in the “Methods” section for an explanation of the Barcelona Clinic Liver Cancer stages.

b $\chi^2$ Test and Kruskal-Wallis test where appropriate.
situated treatment in 23 of 34 patients (67.6%) as follows: transarterial chemoembolization (TACE) in 13 patients (9 with stage A disease, 2 with stage B disease, and 2 with stage C disease), resection in 5 patients (4 with stage A disease and 1 with stage B disease), PAT in 3 patients (2 with stage A disease and 1 with stage B disease), PAT and surgery in 1 patient (with stage C disease), and PAT and TACE in 1 patient (with stage C disease). Extrahepatic recurrences required treatment in 3 of 8 patients (37.5%), including 2 patients (with stage B disease) who underwent surgery for pelvic metastasis and for adrenal metastasis and 1 patient (with stage C disease) who received chemotherapy. All 3 patients with intrahepatic and extrahepatic recurrence (1 with stage A disease, 1 with stage B disease, and 1 with stage C disease) received TACE. The median follow-up for the entire series was 24 months (range, 1-65 months).

For patients with BCLC stage 0 or A, stage B, and stage C disease, the 1-year and 3-year overall survival rates were 93% and 81%, 85% and 74%, respectively ($P = .24$) (Figure 3). The median follow-up periods were 24 months (range, 1-61 months) for patients with stage 0 or A disease, 22 months (range, 7-65 months) for patients with stage B disease, and 20 months (range, 7-44 months) for patients with stage C disease. Combining 52 patients with BCLC stage B or stage C HCC, the 1-year and 3-year overall survival rates were 82% and 70%, respectively ($P = .09$). The median follow-up was 20 months (range, 7-65 months).

For patients with BCLC stage 0 or A, stage B, and stage C disease, the 1-year and 3-year disease-free survival rates were 77% and 30%, 75% and 35%, and 66% and 15%, respectively ($P = .85$) (Figure 4). Combining 52 patients with BCLC stage B or stage C HCC, the 1-year and 3-year disease-free survival rates were 70% and 28%, respectively ($P = .76$).

For patients with BCLC stage 0 or A, stage B, and stage C disease, the 1-year and 3-year hepatic disease-free survival rates were 81% and 39%, 85% and 44%, and 77% and 17%, respectively ($P = .79$) (Figure 5). Grouping 52 patients with BCLC stage B or stage C HCC, the 1-year and 3-year hepatic disease-free survival rates were 81% and 34%, respectively ($P = .90$).

**UNIVARIATE AND MULTIVARIATE ANALYSES**

The univariate analysis of outcome was performed on 13 variables. Tumor size ($P = .02$) and tumor grade ($P = .001$) were statistically correlated with overall survival (Table 6). Both remained statistically significant on multivariate analysis (hazard ratio, 1.487; 95% confidence interval, 1.134-1.949 [$P = .004$] for tumor size; and hazard ratio, 1.388; 95% confidence interval, 1.083-1.777 [$P = .009$] for tumor grade).
The BCLC classification is considered one of the most reliable staging systems for HCC because it considers tumor stage, liver function, and physical status. Based on this staging system, surgical treatment should be reserved for patients with single lesions not exceeding 5 cm and without portal hypertension or hyperbilirubinemia. The estimated 3-year survival for patients with untreated stage B or C HCC ranges from 8% to 50%; for these patients, the BCLC classification recommends palliation using TACE or new therapeutic agents. The rationale for this policy is based on the fact that a more aggressive approach would be too risky and that surgical treatment of HCC is associated in many medical centers with mortality and morbidity. However, the definition of resectability is equivocal: similar patients are submitted to resection by some authors and by other authors are considered unresectable and are treated during surgery with thermal ablation. Because the surgical indications are confusing, it is understandable that the nonsurgical scientific community does not officially recommend surgery (any guideline) for advanced HCC. However, physicians often refer patients who would not normally be considered for surgery. Indeed, large numbers of patients with BCLC stage B and stage C HCC are described herein, despite referral primarily by oncologists, hepatologists, and interventional radiologists. In fact, some recent studies supporting the BCLC classification did not follow its therapeutic recommendations.

The truth is that safe and effective surgical intervention in patients having HCC is possible even in those with concomitant cirrhosis. Surgical policy is key, as many series with greater mortality had higher rates of major resections. For patients with cirrhosis, the extent of parenchymal removal should be considered. A similar dilemma occurred with TACE, which is now selectively recommended; this was not the case in the past, when the mortality and morbidity of TACE were thought to be more extensive. Surgery achieves an even higher standard of safety than TACE when selectively and conservatively performed.

The present series involves a prospectively enrolled cohort of patients who were candidates for hepatic resection. Curiously, half of the patients had disease classified as BCLC stage B or stage C, but the resectability rate among the outpatient referred population was 73.6% (69.3% after excluding 7 patients who underwent exploratory laparotomies). Our conservative approach, which resulted in the removal of more than 3 liver segments in only 13.3% of patients, and our algorithm for patient selection (Figure 1) allowed us to achieve this high rate of resectability, with 0.9% perioperative mortality and minimal major morbidity.

Some surgeons rely on the Child classification alone in selecting patients for surgery. This classification assists in ruling out patients for surgery who have Child class B and C disease rather, as opposed to selecting an operation for patients having Child class A disease. Indocyanine green retention rate at 15 minutes (ICGR-15), galactose elimination capacity, and the Model of End-stage Liver Disease score are also used to predict the risk of postoperative liver failure. However, no consensus exists, and mortality continues to be unacceptable, despite proposed methods. Our selection flowchart is a modified version of an algorithm based on serum bilirubin level and ICGR-15; we used residual liver volume estimation instead of ICGR-15. The results herein demonstrate that our algorithm predicts a safe outcome; indeed, the 2 patients with mild postoperative liver
failure would have received the same treatment if they had been selected using ICGR-15.

The 14.2% of patients who received blood transfusion is below the rates reported in the literature (range, 23%-49%).37-40 Although this is in part due to a policy restricting blood administration41,42 it is also a result of the conservativeness of our surgical approach.

Fifteen percent of patients in our series had esophageal varices, and almost one-third of them had endoscopic banding before surgery (Table 3). Two-thirds of these patients had BCLC stage 0 or A disease, and according to the BCLC classification they should not have been submitted for surgery. Capussotti et al53 reported in 2006 that treatment of esophageal varices did not significantly affect outcomes, and our data confirm this (Table 6). In our series, portal hypertension was not estimated using the hepatic vein pressure gradient,43 which is an invasive procedure for which the findings are not always useful.44,45 More important, adopting esophageal varices as the criterion for portal hypertension might simply have underestimated its degree.

In the present series, the high 3-year survival rates of patients with BCLC stage B and stage C HCC demonstrate that surgery provides prognostic benefits compared with PAT, TACE, or new therapeutic agents. The safety and radicality of PAT and TACE independently or in combination are incomparable with those reported herein. Indeed, patients undergoing these procedures (mostly patients with single tumors and without vascular invasion) experience mortality ranging from 2% to 4% and complete tumor ablation ranging from 9% to 57%.46,47 The present study reestablishes the fundamental role of oncologic surgery for survival of these patients during the midterm, despite disease progression. This was particularly evident for patients with BCLC stage B and stage C HCC. The results herein may suggest new therapeutic scenarios for these patients considering the ongoing improvements in medical treatment of HCC.48,49 Patients with BCLC stage C HCC had 74% survival at 3 years (Figure 3). The 15% disease-free survival (Figure 4) and 17% hepatic disease–free survival (Figure 5) may seem inadequate. However, the poor life expectancy of these patients if untreated should be considered,3 as well as the finding herein that 64.4% of them had treatable recurrences.

Several factors may explain our good results. Conservativeness as opposed to radicality might induce a lower expression of growth factors after surgery, which seems to be associated with liver regeneration and with tumor recurrence.50 Intraoperative staging based on intraoperative ultrasonography and contrast-enhanced intraoperative ultrasonography may influence the radicality of surgery51 and may explain our 39% survival at 3 years among patients with high-grade HCC (Table 6).

Extensive use of intraoperative ultrasonographic guidance allowed us to minimize tumor-free resection margins. Several patients had tumor exposed on the cut surface, but we did not observe any cut edge recurrence. Moreover, most authors agree that there is no need for a 1-cm safety margin if tumor clearance is obtained.52,53 Conversely, Shi et al52 in 2007 stated that a 2-cm margin should be obtained; however, they reported a 29% rate of local recurrence among patients with narrower resection margins, which is inconsistent with other series.54 A strength of this study was the strict postoperative follow-up. Furthermore, we were able to treat 67.6% of patients with intrahepatic recurrence, and the treatment was reresection in 21.7% of them.

In conclusion, the combination of radicality and conservativeness achievable with intraoperative ultrasonographic guidance has transferred to liver surgery the radical but conservative policy that has been successfully applied in the surgical treatment of breast cancer.55 Applying this concept, our study shows that in lieu of palliation a properly performed hepatic resection may offer increased life expectancies for patients with intermediate and advanced HCC.

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