Prediction of Mortality Rate After Major Hepatectomy in Patients Without Cirrhosis

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Objective: To assess the ability of preoperative biological parameters to predict a fatal outcome after a major liver resection in patients without cirrhosis.

Design: Retrospective descriptive cohort study.

Setting: Department of Digestive Surgery and Transplantation, University of Strasbourg.


Main Outcome Measures: Perioperative data were prospectively recorded, and predictors of postoperative mortality rate and liver failure were analyzed.

Results: Five patients (7%) died after a mean (SD) of 32.4 (11.8) postoperative days. The overall morbidity was 73% (49 patients). Univariate analysis revealed that a preoperative alanine aminotransferase blood level greater than 40 U/L (to convert to microkatalas per liter, multiply by 0.0167), a preoperative prothrombin ratio less than 70%, a preoperative Indocyanine green retention rate at 15 minutes of greater than 15%, preoperative biliary drainage, and performance of extrahepatic bile duct resection significantly predict the occurrence of in-hospital death. The number of preoperative biological parameters in each patient significantly increased the mortality rate. Indeed, the mortalities were 0%, 3%, and 67% in patients presenting with none, 1, and 2 or more risk factors, respectively.

Conclusions: This study shows that preoperative liver tests and function can predict postoperative fatal outcome in patients presenting with biliary carcinomas and requiring a major liver resection. On the basis of these preoperative biological parameters, a decision-making algorithm is provided.

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LIVER RESECTION REMAINS THE standard therapeutic option for a variety of liver tumors. Improvements in surgical technique that allow for extended parenchymal and vascular resections have expanded the indications for major liver resection. However, postoperative liver failure and/or septic complications remain a major concern. Capussotti et al demonstrated that the association of postoperative liver dysfunction and sepsis were the main determinants of in-hospital mortality rate after liver resection.

Several studies have attempted to predict outcome for patients undergoing major liver resection. These attempts included volumetric, functional, and pathologic evaluations of the nontumoral liver parenchyma. Unfortunately, these methods cannot reliably predict the risk of complications and mortality rate in patients without cirrhosis. Despite careful patient selection and the use of preventive perioperative strategies, such as portal vein embolization (PVE), biliary drainage, and immunonutrition, the risk of postoperative liver failure and sepsis after major hepatectomy remains high. This finding indicates that our current criteria for patient selection and prediction of outcome are insufficient. The aims of the present study are to find better preoperative predictors of mortality and morbidity rates in patients without cirrhosis undergoing major liver resection and redefine the indications and selection criteria for these patients.

METHODS

STUDY POPULATION

On the basis of a prospectively maintained database, 361 liver resections were performed in 361 patients from January 1, 2004, through December 31, 2007. Of these, 67 patients without cirrhosis underwent liver resections of at least 4 contiguous liver segments. Their
clinical data were prospectively collected and retrospectively analyzed.

PREOPERATIVE EVALUATION

All patients underwent abdominal and thoracic computed tomography and liver magnetic resonance imaging. Preoperative staging by positron emission tomography was not routinely performed during the study period. Patients underwent a preoperative right PVE when the future remnant liver volume was less than 30%. Patients with biliary obstruction and jaundice underwent preoperative percutaneous biliary drainage. To reduce the risk of septic complications in patients requiring both biliary drainage and PVE, biliary drainage was accomplished first, followed by PVE a few days later. Indocyanine green retention rate at 15 minutes (ICGR-15) was determined preoperatively in all patients with total bilirubin levels in the reference range (<1 mg/dL) [to convert to micromoles per liter, multiply by 17.104]. Patients with malnutrition (weight loss >10% during the last 3 months before surgery) received glutamine-enriched parenteral nutrition (25 kcal/kg/d) for at least 7 days preoperatively.

SURGICAL RESECTION

Our technique for liver resection has been previously reported. Briefly, a bilateral subcostal incision with midline extension and intraoperative ultrasonography were routinely used. Parenchymal transection was performed with an ultrasonic dissector. Hepatic pedicle clamping and hepatic vein outflow control were optional. A radical hepatic pedicle lymph node dissection was routinely performed when indicated.

POSTOPERATIVE CARE

All patients were treated in the intensive care unit by the same team of surgeons using a standard postoperative clinical pathway. This included a prophylactic antibiotic regimen and parenteral nutritional support (25 kcal/kg/d) enriched in glutamine for 1 week postoperatively. In addition, patients received early postoperative oral feedings. Patients developing a temperature higher than 38.5°C and/or a white blood cell count greater than 12 000/µL (to convert to x10^9/L, multiply by 0.001) were investigated for septic complications by chest x-ray examination, blood culture, and urine culture. Bile cultures were obtained only in patients with an intraoperatively placed biliary drain.

MAIN OUTCOMES

Recorded postoperative clinical data included in-hospital mortality rate, morbidity rate, temperature higher than 38.5°C, white blood cell count greater than 12 000/µL, peak of postoperative total bilirubin level, total bilirubin and prothrombin ratio (normal >70%) at postoperative days 5 and 7, and presence of bacteremia. The presence of both a temperature higher than 38.5°C and an elevated white blood cell count greater than 12 000/µL was considered sepsis-like syndrome (SLS).

DEFINITION OF SURGICAL MORTALITY AND MORBIDITY

Surgical mortality included intraoperative death, death within 90 days after surgery, and in-hospital death. All postoperative complications that affected the outcome or lengthened the hospital stay were recorded. Liver failure was diagnosed according to the Belghiti 50-30 criteria on postoperative day 5 (serum bilirubin level >2.9 mg/dL and prothrombin ratio <50%).

and the Vauthey criterion of postoperative peak serum bilirubin level greater than 7 mg/dL.

STATISTICAL ANALYSES

Results are expressed as mean (SD). The Fisher exact, χ², and Mann-Whitney tests were used. Predictors of outcome were defined by using a univariate logistic regression analysis. Because of the sample size, a multivariate analysis was not performed. A difference was considered significant when P < .05. All statistical calculations were performed with SPSS statistical software, version 10.0 (SPSS Inc, Chicago, Illinois).

PATIENT CHARACTERISTICS

A total of 67 patients (35 men and 32 women) participated in the study. Their mean age was 63.4 (11.8) years (range, 24.0-85.0 years; median, 66.0 years). Twenty-five patients had an American Society of Anesthesiologists score of 1, 36 had a score of 2, 5 had a score of 3, and 1 had a score of 4. The mean body mass index (calculated as weight in kilograms divided by height in meters squared) was 24.6 (4.3) (range, 18.6-40.4; median, 24.2). Thirty-five patients (52%) had identifiable preoperative comorbidity: arterial hypertension in 18, cardiovascular diseases in 13, diabetes mellitus in 8, pulmonary disorder in 6, neurologic disorder in 4, and chronic kidney failure in 1 patient. Four patients (6%) had benign diseases, including local nodular hyperplasia in 2, abscess in 1, and congenital bile duct dilation (Todani type 5) in 1. Forty-two patients presented with primary hepatobiliary malignant neoplasms, including hilar cholangiocarcinoma in 18, peripheral intrahepatic cholangiocarcinoma in 17, gallbladder adenocarcinoma in 4, and hepatocellular carcinoma in 3. The remaining 21 patients had metastatic disease: 18 from colorectal, 2 from endocrine, and 1 from mammary carcinoma. Preoperative right PVE and preoperative biliary drainage were performed in 23 and 13 patients, respectively. Twenty-seven patients (40%) were malnourished and received parenteral nutritional support. The mean preoperative creatinine level was 1.03 (0.23) mg/dL (range, 0.58-1.89 mg/dL; median, 0.98 mg/dL) [to convert to micromoles per liter, multiply by 88.4]. Three patients had abnormal preoperative creatinine levels (range, 1.62-1.89 mg/dL). In 50 patients with a preoperative total bilirubin level below 2 mg/dL, liver resection was performed. The remaining 17 patients had a mean preoperative total bilirubin level of 10.2 (6.8) mg/dL (range, 2.54-28.79 mg/dL; median, 10.02 mg/dL). The mean future remnant liver volume was 676 (239) mL (range, 383-1623 mL; median, 593 mL). The mean ratio of the future remnant liver volume to total liver volume was 0.37 (0.13) (range, 0.27-1.03; median, 0.33).

SURGICAL DETAILS

The types of liver resection were distributed as follows: a right hepatectomy extended to segments I and IV in 22 patients, a right hepatectomy extended to segment IV in 11, a right hepatectomy extended to segment I in 8, a standard left hepatectomy was performed in 21, and a left he-
patectomy extended to segments V and VIII in 5. Forty-
three patients had 1 or more associated procedures: 17
patients had 1, 19 had 2, and 7 had 3 associated pro-
decisions. Extrahepatic bile duct resections and portal vein
resections were performed in 37 patients (55%) and 24 pa-
tients (36%), respectively. Two patients (3%) had an
additional retrohepatic vena cava resection. Ten patients
had associated resection of peritoneal carcinomatosis, 6 of
other visceral metastases (eg, diaphragmatic, duodenopa-
creatic, and jejunal), 2 of colorectal tumor recurrence, and
1 of primary colonic tumor. Hepatic pedicle lymph node
dissection was performed in 60 patients. Metastatic nodal
disease was found in 18 patients. The mean operative time
was 449.0 (128.5) minutes (range, 230.0-755.0 minutes;
median, 450.0 minutes). Forty-three patients (64%) re-
quired intraoperative blood transfusion and 12 (18%) in
the postoperative period.

EARLY POSTOPERATIVE OUTCOME

The mean hospital stay after liver resection was 18.8 (10.4)
days (range, 7.0-57.0 days; median, 15.0 days). Five patients
(7%) died of liver failure after a mean of 32.4 (11.8) post-
operative days (range, 14.0-46.0 days). All of them under-
went an extended right hepatectomy with extrahepatic bile
duct resection, whereas additional portal vein resection
was performed in 3. Among these 5 patients, positive blood
cultures were found in only 1 patient (Escherichia coli).

The postoperative course was uneventful in 18 pa-
tients. One or more postoperative complications oc-
curred in the remaining 49 patients (73%). They were
pleural effusion (n = 29), cardiovascular complications
(n = 13), acute cholangitis (n = 12), liver failure (n = 12),
deep abscesses or fluid collections (n = 11), postopera-
tive ileus (n = 8), urinary tract infections (n = 7), renal fail-
ure (n = 5), abdominal wall complications (n = 5), pneu-
monia (n = 4), hyperglycemia (n = 4), liver necrosis and
vascular thrombosis (n = 3), lower limb thrombophlebi-
tis (n = 3), stroke (n = 1), pancreatic fistula (n = 1), bili-
ary fistula (n = 1), bleeding (n = 1), and pulmonary em-
bolism (n = 1). Three patients required percutaneous drainage of abdominal collections, 3 patients had drain-
age of a pleural effusion, and 1 patient underwent sub-
sequent laparotomy for biliary peritonitis.

SEPTICLIKE SYNDROME

Twenty-three patients had a temperature higher than
38.5°C, and 46 had elevated white blood cell counts higher
than 12 000/µL. Nineteen patients had both fever and el-
evated white blood cell counts (>12 000/µL) defined as
SLS, 31 had either fever or elevated white blood cell count,
and 17 had neither fever nor elevated white blood cell
count. Elevated white blood cell count greater than
12 000/µL occurred after a mean of 2.9 (2.8) postopera-
tive days (range, 1.0-11.0 days). Only 7 patients (10%)
had bacteremia with an identifiable blood pathogen; their
characteristics are summarized in Table 1. The mean
interval between liver resection and bacteremia was 13.2
(8.8) days (range, 7.0-31.0 days; median, 8.0 days). Thirty-
seven patients had a normal postoperative total biliru-
bin level of less than 2 mg/dL on day 5. In the remaining
30 patients, the mean postoperative total bilirubin level
on day 5 was elevated to 6.8 (4.6) mg/dL (range, 2.24-
19.18 mg/dL; median, 5.35 mg/dL). Liver failure accord-
ing to the Vauthey criterion (peak postoperative biliru-
bin >7 mg/dL) occurred in 20 patients. Fifty-two patients
had a prothrombin ratio greater than 50% on postoperative day 5. In the remaining 15 patients, the mean
prothrombin ratio on postoperative day 5 was 39.2
(6.1%) (range, 26.0%-50.0%; median, 40.0%). Liver fail-
ure according to the 50-50 Belghiti criteria occurred in
15 patients. All 5 postoperative mortalities fulfilled the
definition for SLS and the Vauthey criterion, whereas only
4 fulfilled the Belghiti criteria. Liver insufficiency ac-
cording to the Belghiti and Vauthey criteria in patients
presenting with and without SLS is analyzed in a 2-tingency table (Table 2).

ANALYSIS OF PREDICTORS
OF POSTOPERATIVE MORTALITY

Univariate analysis showed that a preoperative alanine
aminotransferase (ALT) blood level greater than 40 U/L
(to convert to microkatal per liter, multiply by 0.0167),
a preoperative prothrombin ratio less than 70%, a pre-
operative ICGR-15 greater than 15%, preoperative bili-
ary drainage, and performance of extrahepatic bile duct
resection were significantly associated with increased post-

Table 1. Characteristics of Patients Presenting With Positive Blood Culture Results

<table>
<thead>
<tr>
<th>Patient No./Sex/Age, y</th>
<th>Type of Liver Resection</th>
<th>Associated Procedure</th>
<th>Disease</th>
<th>Liver Insufficiency</th>
<th>Blood Culture Result</th>
<th>Hospital Stay, d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/61</td>
<td>RH and S4</td>
<td></td>
<td>CLM</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2/F/67</td>
<td>RH and S1</td>
<td></td>
<td>CLM</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3/M/62</td>
<td>RH and S4</td>
<td>EHBD</td>
<td>Gallbladder cholangiocarcinoma</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>4/M/44</td>
<td>RH, S1, and S4</td>
<td>EHBD and PV</td>
<td>Intrahepatic cholangiocarcinoma</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>5/M/47</td>
<td>RH, S1, and S4</td>
<td>EHBD and PV</td>
<td>HCC</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6/M/40</td>
<td>LH, S5, and S8</td>
<td>EHBD and PV</td>
<td>CLM</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>7/F/73</td>
<td>LH and wedge</td>
<td>EHBD</td>
<td>CLM</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Abbreviations: CLM, colorectal liver metastases; EHBD, extrahepatic bile duct resection; HCC, hepatocellular carcinoma; LH, left hepatectomy; PV, portal vein resection; RH, right hepatectomy; S, liver segment; SLS, septiclike syndrome.
operative death (Table 3). Because postoperative mortality occurred exclusively among patients who underwent an extended right hepatectomy, a separate univariate analysis was performed in this group (41 patients). The analysis produced similar results with postoperative mortality rate significantly associated with (1) a preoperative ALT blood level greater than 40 U/L $(P = .01)$, (2) a preoperative prothrombin ratio less than 70% $(P = .002)$, (3) a preoperative ICGR-15 greater than 15% $(P = .01)$, and (4) patients presenting with a hilar cholangiocarcinoma $(P = .02)$ or (5) requiring an extrahepatic bile duct resection $(P = .04)$. The distribution of the first 3 biological risk factors in the study population showed that 28 patients had no risk factors, 33 had 1 risk factor, 5 had 2 risk factors, and 1 had 3 risk factors. The cumulative number of these preoperative biological risk factors significantly increased the postoperative mortality rate $(P < .001)$. The mortalities were 0%, 3%, and 67% in patients presenting with none, 1, and 2 or more risk factors, respectively. Finally, a preoperative ALT blood level greater than 40 U/L and a preoperative prothrombin ratio less than 70% were significantly associated with the occurrence of postoperative liver failure (Table 4 and Table 5), whereas a preoperative ICGR-15 was not.

### Table 2. Two-Contingency Analyses for Liver Insufficiency in Patients Presenting With SLS

<table>
<thead>
<tr>
<th>Criteria</th>
<th>With SLS</th>
<th>Without SLS</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-50 Belghiti criteria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes $(n = 15)$</td>
<td>9</td>
<td>6</td>
<td>.002</td>
</tr>
<tr>
<td>No $(n = 52)$</td>
<td>10</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Vauthey criterion for liver failure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes $(n = 20)$</td>
<td>10</td>
<td>10</td>
<td>.01</td>
</tr>
<tr>
<td>No $(n = 48)$</td>
<td>9</td>
<td>38</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: SLS, septiclike syndrome.

The present study suggests that patients at high risk for postoperative death after a major hepatectomy may be identified preoperatively by evaluation of liver function (ICGR-15) and tests (ALT and prothrombin ratio). Furthermore, the occurrence of SLS in patients with postoperative liver failure seems to be the main complication leading to death after an extended right hepatectomy associated with an extrahepatic bile duct resection.

The extent of liver resection, the quality of liver parenchyma, and the underlying tumoral disease are well-recognized risk factors for postoperative death. Postoperative mortality ranges from 7% to 20% after major or extended liver resection in patients with cirrhosis, in those presenting with a cholangiocarcinoma, or in those undergoing simultaneous resection of colorectal primary tumor and liver metastases. The present series, which intentionally included a homogeneous group of patients without cirrhosis undergoing major liver resection using standardized surgical and postoperative pathways, showed postoperative mortality (7%) similar to other reported large series. All postoperative deaths were related to postoperative liver failure, a complication mainly associated with the following 2 factors: the extent of liver resection and the inability of the liver to regenerate. In the present series, significant predictors of in-hospital death were abnormal preoperative values (ALT $> 40$ U/L and prothrombin ratio $< 70$%), preoperative altered liver function (ICGR-15 $> 15$%), presence of hilar cholangiocarcinoma, and the need to resect the extrahepatic bile duct. The measure of these simple and easily available factors facilitates evaluation of the postoperative mortality risk. Their presence constitutes an argument against proceeding immediately with extensive liver resections in patients without cirrhosis. Rather, liver resection should be postponed until recovery of balanced biochemical levels and ratios (ALT, prothrombin ratio, and ICGR-15), which may be expected after a reasonably short time. This postponement may trigger the treatment and correction of initially unrecognized preoperative cholangitis or chemotherapy-associated parenchymal injury.

Currently, the routine preoperative use of PVE to optimize hepatic function and regenerative liver capacity has gained acceptance as an important step in the preparation of these patients for surgery. The role of preoperative biliary drainage, however, is still controversial. Infectious complications and bacterobilia are more frequent after biliary drainage. Seyama et al reported a series of 58 patients who underwent a major liver resection for hilar cholangiocarcinoma without postoperative mortality and without liver failure. These results may be explained by a selection bias introduced by the authors to identify the best candidates for surgery. Their criteria included a higher-than-usual cutoff for PVE (future remnant liver volume of 50%), a preoperative total bilirubin level beyond 2 times the upper limit of normal, and a normal liver functional reserve estimated by the ICGR-15. These selection criteria may lead to a higher rate of patient dropout. In contrast, we used a future remnant liver volume cutoff for PVE of less than 30% of the total functional liver volume. An increased ICGR-15 rate did not limit our extent of liver resection. We and others realized that neither preoperative biliary drainage nor PVE can completely eliminate the risk of postoperative liver failure and death. Perioperative nutritional support also deserves special attention in patients undergoing a major or an extended major hepatectomy. Most of these patients developed anorexia, early satiety, reduced food intake, and malnutrition. The addition of parenteral nutritional support in the perioperative period has allowed patients to reach the recommended daily caloric intake to reduce the postoperative morbidity rate. Unfortunately, in the present series, because standardized perioperative nutritional support was adopted, its effect on postoperative outcome has not been statistically evaluated. All our patients were operated on electively, none was critically ill before the operation, and the caloric content of the nutritional support was determined according to the current recommendations to avoid the occurrence of a hypermetabolic response to overfeeding.
The present study showed that SLS occurred in one-third of the patients undergoing major liver resection and was significantly associated with postoperative liver failure and in-hospital deaths. Similar conclusions are reported by Capussotti et al.2 This is not surprising because the amount of Kupffer cells, which play a fundamental role in liver regeneration and immune defense, is depleted.20-22 A large single-institution study has demonstrated that the postoperative septic risk increased by 12.7 times in jaundiced patients undergoing extended hepatectomy.23 The data of the present series support these findings because the 5 patients who died of liver failure in the postoperative period had SLS. However, only 1 patient among those who experienced fatal outcome in the postoperative period had a blood culture positive to E coli. The occurrence of SLS and/or positive blood cultures or bile cultures in 31% of the patients demonstrates that our current antibiotic prophylaxis may not be adequate in patients without cirrhosis undergoing major extended liver resections. It appears that the clinical behavior of this subgroup of our study population mimics that of immunocompromised patients.

Prognostic scoring systems have been proposed to improve patient selection for surgery and to help stratify patients into ongoing clinical trials.24 Child-Pugh and

| Table 3. Univariate Analysis of Predictors of In-hospital Death (continued) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Predictor                  | With Postoperative Mortality (n = 5) | Without Postoperative Mortality (n = 62) | P Value |
| Age, y                    | 6.2             | .62             |                 |
| Sex                        |                | .57             |                 |
| Male (n = 35)              | 1               | 1               | .49             |
| Female (n = 32)            | 5               | 3               |                 |
| ASA score                  |                | .56             |                 |
| <2 (n = 6)                 | 5               | 3               |                 |
| BMI                        |                | .56             |                 |
| <24 (n = 32)               | 1               | 1               |                 |
| ≥24 (n = 35)               | 3               | 3               |                 |
| Comorbidities              |                | .77             |                 |
| Yes (n = 35)               | 2               | 2               |                 |
| No (n = 32)                | 1               | 5               |                 |
| Diabetes mellitus          |                | .77             |                 |
| Yes (n = 8)                | 1               | 1               |                 |
| No (n = 59)                | 1               | 5               |                 |
| Arterial hypertension      |                | .77             |                 |
| Yes (n = 18)               | 2               | 2               |                 |
| No (n = 49)                | 1               | 3               |                 |
| Cardiovascular disorders   |                | .77             |                 |
| Yes (n = 13)               | 0               | 0               |                 |
| No (n = 54)                | 5               | 4               |                 |
| Pulmonary disorders        |                | .77             |                 |
| Yes (n = 6)                | 0               | 0               |                 |
| No (n = 61)                | 5               | 5               |                 |
| Preoperative bilirubin serum level, mg/dL |                | .77             |                 |
| <1.99 (n = 50)             | 4               | 4               |                 |
| ≥1.99 (n = 17)             | 1               | 1               |                 |
| Preoperative ALT level, U/L |                | .77             |                 |
| ≤40 (n = 35)               | 0               | 0               |                 |
| >40 (n = 32)               | 5               | 5               |                 |
| Preoperative prothrombin rate, % |                | .77             |                 |
| ≥70 (n = 59)               | 2               | 2               |                 |
| <70 (n = 8)                | 3               | 3               |                 |
| Preoperative ICGR-15, %b   |                | .77             |                 |
| ≤15 (n = 41)               | 2               | 2               |                 |
| >15 (n = 6)                | 2               | 2               |                 |
| Extrahepatic bile duct resection |                | .77             |                 |
| Yes (n = 37)               | 5               | 5               |                 |
| No (n = 30)                | 0               | 0               |                 |

Abbreviations: ALT, alanine aminotransferase; ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); FRL/TL, future remnant liver/total liver; ICGR-15, indocyanine green retention rate at 15 minutes; U/L, units per liter. SI conversion factors: To convert bilirubin to micromoles per liter, multiply by 17.104; to convert ALT to microkatals per liter, multiply by 0.0167.

*Data are presented as number of patients unless otherwise indicated.

Reference ranges are 15 to 40 U/L for ALT and less than 10% for ICGR-15.

The data of the present series support these findings because the 5 patients who died of liver failure in the postoperative period had SLS. However, only 1 patient among those who experienced fatal outcome in the postoperative period had a blood culture positive to E coli. The occurrence of SLS and/or positive blood cultures or bile cultures in 31% of the patients demonstrates that our current antibiotic prophylaxis may not be adequate in patients without cirrhosis undergoing major extended liver resections. It appears that the clinical behavior of this subgroup of our study population mimics that of immunocompromised patients.

Prognostic scoring systems have been proposed to improve patient selection for surgery and to help stratify patients into ongoing clinical trials.24 Child-Pugh and
many other predictive outcome measures that are collected postoperatively, these predictors allow preoperative determination of risk and thus possibly accurate selection of patients for surgery. Our findings need to be tested and validated in a prospective study based on a larger cohort of patients.

In conclusion, the identification of simple and readily available preoperative parameters constitutes a step forward in the selection of appropriate surgical candidates among patients without cirrhosis for major liver resection. The apparent clinical usefulness of these parameters needs to be validated in a larger cohort.

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Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Oussoultzoglou and Rosso. Acquisition of data: Oussoultzoglou and Addeo. Analysis and interpretation of data: Oussoultzoglou, Jaec, Fuchshuber, Marzano, Rosso, Pessaux, and Bachellier. Drafting of the manuscript: Oussoultzoglou, Addeo, Fuchshuber, Marzano, and Rosso. Critical revision of the manuscript for important intellectual content: Oussoultzoglou, Jaec, Fuchshuber, Rosso, Pessaux, and Bachellier.
ellier. Study supervision: Oussoultzoglou, Jaecck, Pessaux, and Bachellier.

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