Evaluation of Surgical Risk in Patients with Liver Disease

Stefano Fagiuoli
USC Gastroenterologia
Ospedali Riuniti di Bergamo
There is no such thing as a good cirrhotic patient....
Frequency of elective surgery on pts with and without cirrhosis
1998-2005

Stable over study period
Nationalwide Volume and Mortality after Elective Surgery in Cirrhotic Patients

Nicholas G. Cseikesz, BS, Louis N. Nguyen, MD, MBA, MPH, Jennifer F. Tseng, MD, MPH, FACS, Shurmul A. Shah, MD


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**Lenght of Stay**

- **A**
  - Chole
  - Colectomy
  - CABG
  - AAA

**Total Charges**

- **B**
  - Chole
  - Colectomy
  - CABG
  - AAA

**Mortality Rate %**

- **C**
  - Chole
  - Colectomy
  - CABG
  - AAA
Cirrhosis and Surgery

Preoperative Risk Assessment for Patients with Liver Disease
Shahid M. Malik, MD, Jawad Ahmad, MD, MRCP*

Suspect liver disease from history/physical

Blood tests
Bilirubin
INR
Creatinine
Albumin
ALT/AST/ALP

Imaging
CT/MRI/US

Endoscopy
Cirrhosis and Surgery

Preoperative Risk Assessment for Patients with Liver Disease
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Suspect liver disease from history/physical

Blood tests
Bilirubin
INR
Creatinine
Albumin
ALT/AST/ALP

Imaging
CT/MRI/US

Endoscopy

No evidence of cirrhosis or portal hypertension or acute hepatitis/acute liver failure

Proceed with surgery

Cirrhosis/PHTN confirmed Proceed as in figure 2

Refer for outpatient GI/hepatology assessment
Cirrhosis and Surgery

Liver Disease

No cirrhosis or PHTN

- Proceed with surgery

Cirrhosis and/or PHTN

- Assess severity

MELD score/Child's Score Imaging/EGD for PHTN

- MELD <10
  - Child's A
  - No PHTN
  - Proceed with surgery

- MELD 10-15
  - Child's B
  - +/- PHTN

- MELD >15
  - Child's C
  - +PHTN
Cirrhosis and Surgery

Liver Disease

- No cirrhosis or PHTN
  - Proceed with surgery

- Cirrhosis and/or PHTN
  - Assess severity
    - MELD score/Child’s Score
      - Imaging/EGD for PHTN

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  - No PHTN
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- MELD 10-15
  - Child’s B
  - +/- PHTN

- MELD >15
  - Child’s C
  - +PHTN

Type of surgery and degree of urgency

- Elective
  - Low risk surgery (orthopedic)
    - Consider evaluation for liver transplant
    - Proceed with caution

- Emergent/potentially life saving
  - High risk surgery (abdominal/cardiothoracic)
    - Defer surgery until/unless clinical situation changes
  - Inform patient/family of risk and proceed with surgery
**Dysfunctions in cirrhosis**

- **Coagulopathy**
  - Up Risk of Bleeding

- **Impaired Reticuloendothelial System**
  - Up Risk of Infections

- **Portal Hypertension**
  - Bleeding, Hypotension, Infections

- **Impaired Metabolism / Detoxification**
  - Up Drug Toxicity
Cirrhosis and Surgery

Assessment prior to Surgery in Cirrhotics

- Type of Surgery
- Assessment of Liver Dysfunction
- Comorbidity
- Nutritional status
Assessment prior to Surgery in Cirrhotics

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Cirrhosis and Surgery

Type of Surgery

URGENT

HIGH RISK
- Abdominal Surgery
  - Cholecistectomy, Gastrectomy, Colectomy
- CardioThoracic
- Hepatic Resection

LOW-RISK
- Extra Thoracic-Abdominal

Is it really Necessary?

Timing?

Experience of Clinical Team
Cirrhosis and Surgery: ELECTIVE vs URGENT

30-day Mortality

Elective  Emergency

<table>
<thead>
<tr>
<th>Study</th>
<th>Elective</th>
<th>Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wong 1994</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Mansour 1997</td>
<td>18</td>
<td>50</td>
</tr>
<tr>
<td>del Olmo 2003</td>
<td>3,5</td>
<td>16,3</td>
</tr>
<tr>
<td>Lenhert 1993</td>
<td>29</td>
<td>64</td>
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<td>Ziser 1999</td>
<td>9</td>
<td>38</td>
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<tr>
<td>Doberneck, 1983</td>
<td>11</td>
<td>45</td>
</tr>
<tr>
<td>Garrison, 1984</td>
<td>10</td>
<td>54</td>
</tr>
<tr>
<td>Aranha, 1986</td>
<td>41</td>
<td>86</td>
</tr>
</tbody>
</table>
Cirrhosis and Surgery: ELECTIVE vs URGENT

Combined effect of Risk Factors

Mansour, Surgery 1997
### Independent Risk Factors for Adverse Outcome After Multivariate Analysis of Significant Univariate Variables

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OR</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative transfusion</td>
<td>16.8</td>
<td>2.1–38.7</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Albumin &lt;3 mg/dL</td>
<td>15.0</td>
<td>2.2–36.8</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>ASA score &gt;3</td>
<td>10.5</td>
<td>2.8–39.2</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Total bilirubin &gt;1.5 mg/dL</td>
<td>9.8</td>
<td>3.5–27.6</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Emergent procedure</td>
<td>7.0</td>
<td>2.7–18.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Presence of ascites</td>
<td>6.1</td>
<td>2.2–17.3</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Blood loss &gt;150 mL</td>
<td>3.9</td>
<td>1.2–10.96</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>
### Postoperative Mortality

#### MELD

**Surgery**

- **MELD Score**
  - 5: 0.1
  - 10: 0.3
  - 15: 0.6
  - 20: 0.9
  - 25: 1.2
  - 30: 1.5
  - 35: 1.8
  - 40: 2.1
  - 45: 2.4

- **Probability of Death (%)**
  - 5: 10%
  - 10: 30%
  - 15: 60%
  - 20: 90%
  - 25: 120%
  - 30: 150%
  - 35: 180%
  - 40: 210%
  - 45: 240%

- **95% CI**
  - 5: 1-3
  - 10: 2-6
  - 15: 3-9
  - 20: 4-12
  - 25: 5-15
  - 30: 6-18
  - 35: 7-21
  - 40: 8-24
  - 45: 9-27

*Predicted probabilities derived from regression model with c-statistic = 0.72 and 71.6% concordance rate.*

**Abdominal Surgery**

- **MELD Score**
  - 5: 0.2
  - 10: 0.6
  - 15: 1.0
  - 20: 1.4
  - 25: 1.8
  - 30: 2.2
  - 35: 2.6
  - 40: 3.0
  - 45: 3.4

- **Probability of Death (%)**
  - 5: 20%
  - 10: 60%
  - 15: 100%
  - 20: 140%
  - 25: 180%
  - 30: 220%
  - 35: 260%
  - 40: 300%
  - 45: 340%

- **95% CI**
  - 5: 2-6
  - 10: 3-12
  - 15: 4-20
  - 20: 5-28
  - 25: 6-36
  - 30: 7-44
  - 35: 8-52
  - 40: 9-60
  - 45: 10-68

*Predicted probabilities derived from regression model with c-statistic = 0.80 and 80.3% concordance rate.*

---

*Northup, Ann. Surg. 2005*
Blood Flow Reciprocity

Portal Blood Flow 70%

\[ \text{O}_2 \text{ Portal Supply 50\%} \]

\[ \text{O}_2 \text{ Arterial Supply 50\%} \]

In cirrhosis
Hyperdynamic Circulation
↓Cardiac output ↑Vascular resistance
DECREASED BASELINE
HEPATIC PERFUSION

Reduced due to
Portal Hypertension
Arterovenous shunting

Impaired autoregulation

Can Increase over 50% via Compensatory Vasodilation

Abdominal SURGERY

Manipulation during splanchnic surgery

INCREASED Susceptibility to ISCHEMIA

Hepatic Artery Blood Flow 30%

Type of Anesthetic (alcohol)
Anesthetic Concentration
Rischio Operatorio nel Cirrotico

**CHOLECYSTECTOMY: Laparoscopy vs Laparotomy**

Cholecystectomy in patients with cirrhosis: comparative studies (laparotomy vs. laparoscopy)—review of the literature

<table>
<thead>
<tr>
<th></th>
<th>Yerdel (14)</th>
<th>Saeki (17)</th>
<th>Poggio (19)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laparoscopy</td>
<td>Laparotomy</td>
<td>Laparoscopy</td>
</tr>
<tr>
<td>(n = 7)</td>
<td>(n = 7)</td>
<td>(n = 6)†</td>
<td>(n = 6)</td>
</tr>
<tr>
<td><strong>Bleeding (mL)</strong></td>
<td>128.5*</td>
<td>642*</td>
<td>97.5</td>
</tr>
<tr>
<td>Transfusion</td>
<td>0* unit/patient</td>
<td>0.85* unit/patient</td>
<td>NA</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>155*</td>
<td>103*</td>
<td>134.8</td>
</tr>
<tr>
<td>Morbidity rates (%)</td>
<td>0*</td>
<td>42.8*</td>
<td>NA</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>6.7*</td>
<td>17.4*</td>
<td>8.3*</td>
</tr>
</tbody>
</table>

Laparoscopy:
  - Less
  - **Bleeding**
  - **Morbidity**
  - **Hospital Stay**

Tuech, 2002
Assessment prior to Surgery in Cirrhotics

- Type of Surgery

- Assessment of Liver Dysfunction
  - Prognostic Scores
  - Evaluation of Functional Reserve
  - Hepatic Volumetry
  - Dynamic “Functional Volumetry”

- Comorbidity
- Nutritional status
## Cirrhosis and Surgery

### Hepatic Evaluation

- **Prognostic Score**
  - Child-Pugh
  - MELD
- Synthetic Hepatic Function
- Biotransformation Capacity (*Xenobiotics*)
- Metabolic Activity
- Hepatic Volumetry

### General Evaluation

- Extra-Hepatic Diseases
- Immunitary Status
- Renal Function
- Portal Hypertension
- Neurologic Function
- Nutritional Status
### Contraindications to Elective Surgery in Patients With Liver Disease

<table>
<thead>
<tr>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute liver failure</td>
</tr>
<tr>
<td>Acute renal failure</td>
</tr>
<tr>
<td>Acute viral hepatitis</td>
</tr>
<tr>
<td>Alcoholic hepatitis</td>
</tr>
<tr>
<td>Cardiomyopathy</td>
</tr>
<tr>
<td>Hypoxemia</td>
</tr>
<tr>
<td>Severe coagulopathy (despite treatment)</td>
</tr>
</tbody>
</table>
Child-Turcotte:
Developed in 1964 (Modified by Pugh in 1973): Death risk after surgical porto-caval procedure in cirrhotics

MELD:
Developed in 1999 for TIPS procedure in cirrhotics
**Child-Pugh Classification**

useful as a general assessment of the severity of liver disease

<table>
<thead>
<tr>
<th>Variable</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>A. The original Child-Turcotte classification</strong></td>
<td></td>
</tr>
<tr>
<td>Bilirubin level (mg/dL)</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Albumin level (g/dL)</td>
<td>&gt;3.5</td>
</tr>
<tr>
<td>Encephalopathy grade</td>
<td>None</td>
</tr>
<tr>
<td>Ascites</td>
<td>None</td>
</tr>
<tr>
<td>Nutritional status</td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>B. Pugh's modification of the Child-Turcotte classification</strong></td>
<td></td>
</tr>
<tr>
<td>Encephalopathy grade</td>
<td>None</td>
</tr>
<tr>
<td>Ascites</td>
<td>Absent</td>
</tr>
<tr>
<td>Albumin level (g/dL)</td>
<td>&gt;3.5</td>
</tr>
<tr>
<td>Prothrombin time (seconds prolonged)</td>
<td>&lt;4</td>
</tr>
<tr>
<td>Bilirubin level (mg/dL)</td>
<td>&lt;2</td>
</tr>
<tr>
<td>For cholestatic diseases</td>
<td>(&lt;4)</td>
</tr>
</tbody>
</table>

*Child-Pugh class A, score = 5 or 6; class B = 7 to 9; class C = 10 to 15.*
The MELD Model, UNOS Modification

What is the INR?  
What is the bilirubin? (mg/dl)  
What is the creatinine? (mg/dl)  
Has the patient had dialysis at least twice in the past week?  
No  
Yes  

MELD score:  

MELD Score | 3-month Mortality  
---|---  
≥ 40 | 100%  
30-39 | 83%  
20-29 | 76%  
10-19 | 27%  
<10 | 4%  

http://www.mayoclinic.org/gi-rst/mayomodel.html
### Mortality Rates Associated With Specific Types of Surgery in Patients With Cirrhosis

<table>
<thead>
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<th>Type of Surgery</th>
<th>Mortality</th>
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<td>Overall</td>
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<td>Appendectomy</td>
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<td>Cholecystectomy</td>
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<th>Child Class</th>
<th>MELD Score</th>
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<td>B</td>
</tr>
<tr>
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<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Cardiac</td>
<td>16–17%</td>
<td>0–3%</td>
<td>42–50%</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>1–3%</td>
<td>0.5%</td>
<td>3%</td>
</tr>
<tr>
<td>Colorectal cancer surgery</td>
<td>12.5%</td>
<td>6%</td>
<td>13%</td>
</tr>
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<td>17%</td>
<td>NA</td>
<td>NA</td>
</tr>
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<td>9%</td>
<td>9%</td>
<td>NA*</td>
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<td>26–30%</td>
<td>10%</td>
<td>30–31%</td>
</tr>
</tbody>
</table>
Cirrhosis and Surgery

772 patients with Cirrhosis who underwent Surgery (1980-2004)

For MELD > 8 each one-point increase in MELD

14% increase in both 30- and 90-day mortality

Teh SH et Al. Gastroenterology, 132:1261-9, 2007
Model for end-stage liver disease score versus Child score in predicting the outcome of surgical procedures in patients with cirrhosis

Maarouf A Hoteit, Amaar H Ghazale, Andrew J Bain, Eli S Rosenberg, Kirk A Easley, Frank A Anania, Robin E Rutherford

Emory University, Atlanta.

World J Gastroenterol. 2008 March 21; 14(11): 1774-1780

195 Pts
Surgery in Cirrhosis:

End-point:
• DEATH
• DECOMPENSATION

MELD

CTP

0
2
4
6
8
10
12
14
16
18
20
22
24
26

0
1
2
3
4
5
6
7
8
9
10
11

Endpoint reached: 
Urgent Elective

Endpoint reached: 
Urgent Elective
Factors That Predict Outcome of Abdominal Operations in Patients With Advanced Cirrhosis
DANA A. TELEM, THOMAS SCHIANO, ROBERT GOLDSTONE, DANIEL K. HAN, KERRI E. BUCH, EDWARD H. CHIN, SCOTT Q. NGUYEN, and CELIA M. DIVINO

*Division of General Surgery, Department of Surgery, and †Scarpa Miller Transplant Institute, Division of Liver Disease, The Mount Sinai Hospital, New York, New York

CLINICAL GASTROENTEROLOGY AND HEPATOLOGY 2010:8:451–457

**Child-Pugh Score**

**MELD Score**

Morbidity and mortality by CTP class.

Morbidity and mortality by MELD score.
Factors That Predict Outcome of Abdominal Operations in Patients With Advanced Cirrhosis

DANA A. TELEM,* THOMAS SCHIANO,† ROBERT GOLDSSTONE,* DANIEL K. HAN,* KERRI E. BUCH,* EDWARD H. CHIN,* SCOTT Q. NGUYEN,* and CELIA M. DIVINO*

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CLINICAL GASTROENTEROLOGY AND HEPATOLOGY 2010;8:451–457

Mortality After Abdominal surgery

- MELD > 15 & Albumin < 2.5: 60%
- MELD > 15 & Albumin > 2.5: 14%

*Telem, Gastroent & Hepatol. 2010
Mortality after surgery in patients with liver cirrhosis: comparison of Child–Turcotte–Pugh, MELD and MELDNa score

Hyun Chin Cho¹, Han Young Jung¹, Dong Hyun Sim³, Moon Seok Choi³, Kwang Cheol Koh¹, Seung Woon Paik¹, Byung Chul Yoo³, Seon Woo Kim³ and Joon Hyeok Lee³

European Journal of Gastroenterology & Hepatology 2011, Vol 23 No 1

90-days Mortality

![Graph showing 90-days Mortality with AUC and comparisons of CTP score, MELD score, MELDNa score with p-values]
Cirrhosis and Surgery

190 Cases (Urgent + Elective)

Value of MELD and MELD-Based Indices in Surgical Risk Evaluation of Cirrhotic Patients: Retrospective Analysis of 190 Cases
Beatriz P. Costa · F. Castro Sousa
Marco Serôdio · César Carvalho

ROC Curve

- Child's score 72%
- MELD 76%
- iMELD 77%
### Value of MELD and MELD-Based Indices in Surgical Risk Evaluation of Cirrhotic Patients: Retrospective Analysis of 190 Cases

Beatriz P. Costa · F. Castro Sousa
Marco Serôdio · César Carvalho


#### 113 Cases (Elective Surgery)

<table>
<thead>
<tr>
<th>Mortality vs</th>
<th>AUC (%)</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical risk scale</td>
<td>64</td>
<td>27–99</td>
<td>NS</td>
</tr>
<tr>
<td>Child’s score</td>
<td>54</td>
<td>24–84</td>
<td>NS</td>
</tr>
<tr>
<td>Modified Child’s score$^a$</td>
<td>54</td>
<td>24–84</td>
<td>NS</td>
</tr>
<tr>
<td>Creatinine-modified Child’s score$^b$</td>
<td>53</td>
<td>21–84</td>
<td>NS</td>
</tr>
<tr>
<td>MELD</td>
<td>61</td>
<td>27–94</td>
<td>NS</td>
</tr>
<tr>
<td>iMELD</td>
<td>80</td>
<td>63–97</td>
<td>0.044</td>
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<tr>
<td>MELD-Na</td>
<td>62</td>
<td>28–96</td>
<td>NS</td>
</tr>
<tr>
<td>MESO</td>
<td>53</td>
<td>14–91</td>
<td>NS</td>
</tr>
<tr>
<td>MELD-XI</td>
<td>62</td>
<td>29–95</td>
<td>NS</td>
</tr>
</tbody>
</table>
**CABG and Cirrhosis**

MELD > 13.5 Predictive of Post-Operative In-Hospital Mortality

MELD better than CTP and EUROScore

Risk prediction and outcomes in patients with liver cirrhosis undergoing open-heart surgery.

Matthias Thielmann, Achmet Mechmet, Markus Neuhäuser, Daniel Wendt, Paschalis Tossios, Ali Canbay, Parwiz Massoudy, Heinz Jakob

Cirrhosis and Surgery

Assessment prior to Surgery in Cirrhotics

- Type of Surgery

- Assessment of Liver Dysfunction
  - Prognostic Scores
  - Evaluation of Functional Reserve
  - Hepatic Volumetry
  - Dynamic “Functional Volumetry”

- Comorbidity
- Nutritional status
Hepatic Volumetry

In Healthy Individuals:

70-75% Hepatectomy = No Consequences  
> 87.5% Hepatectomy = Inevitable Death

ASSUMPTION(?!):

When synthetic alterations are present in a cirrhotic patient, >75% of the liver is dysfunctional
Liver Volumetry

MEVIS-CT
Virtual Resection

3-D-reconstruction of functional liver anatomy
Volume calculation of portal vein segments and hepatic artery segments

![Images of liver anatomy with volume percentages: RLV = 27%, RLV = 34%, RLV = 61%]

Resection on cirrhosis:

*even in compensated patients, a minimum of 40% of the whole liver must remain...*

**Clearance Tests**

- **Indocyanin Green Dye**
- Jaluronic acid
- Galactose elimination Capacity (GEC)
- Lidocaine/Monoethylglycinexylide (MEGx)
- Redox tolerance Index
- Arterial Ketone Body Ratio
- Breath Tests
  - Aminopyrine, Methionine, Caffeine, Methacetine, Chetoisocaproic, Galactose
ICG-R14 Pulse Dye Densitometry

- I.V. ICG is eliminated into the bile
  - Correlating with liver cell function without enterohepatic recirculation
- Noninvasive method
- Arterial ICG concentration: by pulse-dye densitometry (Pulse Oximetry)
  - Based on difference in absorbance between oxyhemoglobin (940 WL) and ICG (805 WL)

METHOD
- Set System with Height, Body weight, Hemoglobin level of patient
- I.V. Bolus of 25 mg of ICG and flushing
- Blood ICG Concentration monitored every pulse via optical probe (patient’ nose)
- ICG-R15 is automatically calculated within 5’ (decay curve)

Normal function: Retention < 10%
**Indocyanin Green (ICG)**

**Prediction of Resecability in Cirrhotics**

- **>30%**: NO Sub-segmentectomy
- **>20%**: NO Segmentectomy
- **11-20%**: 1 Segment until 15%
- **0-10%**: 2 Segments or until 30%

% ICG Retention at 15 min. from 0.5 mg/Kg i.v. bolus

Hasegawa, 1987 - Watanabe, 1999
Assessment of liver function for safe hepatic resection

Yasuji Seyama and Norihiro Kokudo
Hepato-Biliary-Pancreatic Surgery Division, Department of Surgery, Graduate School of Medicine, University of Tokyo, Tokyo, Japan


Figure 2  Makuuchi criteria for safe hepatic resection. (From Makuuchi et al., with permission.)
Assessment of liver function for safe hepatic resection

Makuuchi criteria for safe hepatic resection. (From Makuuchi et al., with permission.)
Assessment of liver function for safe hepatic resection

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Hepato-Biliary-Pancreatic Surgery Division, Department of Surgery, Graduate School of Medicine, University of Tokyo, Tokyo, Japan


Cirrhosis and Liver Resection

Ascites

No or controllable

Total bilirubin

Normal

1.1–1.5mg/dl

1.6–1.9mg/dl

≤2.0mg/dl

IGG15

Limited resection

Enucleation

No hepatectomy

No hepatectomy

K = 0.15

K = 0.11

K = 0.08

K = 0.06

10–19%

20–29%

30–39%

≤40%

Trisegmentectomy

Bisegmentectomy

Lobectomy

Rt monosegmentectomy

Subsegmentectomy (segment of Couinaud)

Limited resection

Enucleation

Makuuchi criteria for safe hepatic resection. (From Makuuchi et al., with permission.)
Relationship between ICG R15 and parenchymal hepatic resection rate relative to outcome

Survivors
NonSurvivors
Non Cirrhotics

Assessment of liver function for safe hepatic resection

Yasuji Seyama and Norihiro Kokudo

Hepato-Biliary-Pancreatic Surgery Division, Department of Surgery, Graduate School of Medicine, University of Tokyo, Tokyo, Japan

Cirrhosis and Liver Resection

Real-Time Intraoperative Assessment of Residual Liver Functional Reserve Using Pulse Dye Densitometry

Hirofumi Akita · Yo Sasaki · Terumasa Yamada · Kunihito Gotoh · Hiroaki Obigashi · Hidetoshi Eguchi · Masahiko Yano · Osamu Ishikawa · Shingi Imaoka


P = 0.0005

P = 0.014

P = 0.151

The value of ICG-R15 (mean ± SD)(%)

12.3 ± 6.0  9.3 ± 7.0
18.8 ± 11.6  20.1 ± 10.9

Preoperation  Laparotomy Clamped Resected
phase  phase  phase  phase
Valuable Tool to plan Intraoperative decisions on extent of Resection

The value of ICG-R15 of the Clamped phase (%)

R = 0.929  R^2 = 0.864  p < 0.0001
Cirrhosis and Liver Resection

Real-Time Intraoperative Assessment of Residual Liver Functional Reserve Using Pulse Dye Densitometry

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Post-operative Bilirubin increase

Post-operative Stay

P=0.046

17.9±9.2

27.5±14.1

the group of under 20% of ICG-R15 of the clamped phase

the group of over 20% of ICG-R15 of the clamped phase

R=.637  R^2 = .405  p=0.0002
**Prediction of posthepatectomy hepatic functional reserve by serum hyaluronate**

S. Yachida, H. Wakabayashi, K. Okano and Y. Suzuki


---

**Fig. 1** a Serum hyaluronate levels and b indocyanine green retention rate at 15 min (ICG R15) in patients categorized by background liver disease. The boxes represent 25–75 percentiles, with median (heavy line) and maximum and minimum values within 1.5 times the interquartile range (whiskers). *P < 0.001, †P = 0.006, ‡P = 0.040, §P = 0.042, ¶P = 0.082, #P = 0.098 and **P = 0.115
Prediction of posthepatectomy hepatic functional reserve by serum hyaluronate

S. Yachida, H. Wakabayashi, K. Okano and Y. Suzuki


Fig. 4 Discriminatory capacity of preoperative serum hyaluronate levels and indocyanine green retention rate at 15 min (ICG R15)
**FRL Dynamic Evaluation**

**GSA-Scintigraphy**
- $^{99m}$Tc-labeled diethylenetriaminepentaacetic acid
- Galactosyl Human Serum Albumin

**HBS**
- Hepatobiliary Scintigraphy
- $^{99m}$Tc-labeled Mebrofenin

**Receptor-mediated**
- Asialoglycoprotein Receptors only on Hepatocytes

**Hepatic Uptake & Excretion**
- Hepatic + Biliary System

- Uptake Reduced by ↓ Hepatocytes
- Cirrhosis
- Cholestasis

- Uptake/Excretion Reduced by ↓ Blood flow
- Hypoalbuminemia
- Liver Function

**Combined with SPECT/CT cameras**
- for 3-dimensional Evaluation
**FRL Dynamic Evaluation**

Anterior projection of CeCT reconstruction

Portal/hepatic veins used as landmarks for FRL & CeCT scans

Delineated FRL of CeCT scans was used as constant reference

On SPECT image, FRL manually outlined on CTlow scans linked to SPECT images

Planar dynamic 99mTc-mebrofenin HBS images
Cirrhosis and Surgery

Assessment of Future Remnant Liver Function Using Hepatobiliary Scintigraphy in Patients Undergoing Major Liver Resection

Wilmar de Graaf · Krijn P. van Lienden · Sander Dinant · Joris J. T. H. Roelofs · Olivier R. C. Busch · Dirk J. Gouma · Roelof J. Bennink · Thomas M. van Gulik


At 3° post-op day

Correlation FRL-F/FRL-V in Normal & cirrhotics

\[ p < 0.0001 \]

**FRL-V** = Future Remnant Liver – Volume

**FRL-F** = Future Remnant Liver – Uptake Function
ROC curve
FRL-F cut-off
2,69% min/m²
Identified Pts with Significant Risk of Post-op Liver Failure
**New Formula ??**

**Assessment of liver function for successful hepatectomy in patients with hepatocellular carcinoma with impaired hepatic function**

KAZUHISA UCHIYAMA, KAZUNARI MORI, KATSUYOSHI TABUSE, MASAKI UENO, SATORU OZAWA, TAKAYUKI NAKASE, MANABU KAWAI, MASAHITO TANI, HIROSHI TAMURA, and HIROKI YAMAE


**Original data:** 28 pts from 1981-1984  
**Training data set:** 207 pts between 1985-1999  
**Pre-operative evaluation:** 145 pts between 2000-2006

**FORMULA:**

\[
\text{Liver function score} = 164.8 - 0.58 \times \text{Alb} - 1.07 \times \text{HPT} + 0.062 \times \text{GOT} - 685 \times \text{K. ICG} - 3.57 \times \text{OGTT. LI} + 0.074 \times \text{RW}
\]

\[
\begin{align*}
\text{Alb} & \text{ is albumin (g/dl); } \\
\text{HPT} & \text{, hepaplastin test (%); } \\
\text{GOT} & \text{, (U/l); } \\
\text{KICG} & \text{, K, value of indocyanine green clearance test; } \\
\text{OGTT} & \text{, LI, 60-min/120-min glucose level in 75-g OGTT; } \\
\text{RW} & \text{, weight of resected liver (g). }
\end{align*}
\]
Assessment of liver function for successful hepatectomy in patients with hepatocellular carcinoma with impaired hepatic function

KAZUHIRO UCHIYAMA, KAZUNARI MORI, KATSUYOSHI TARUSE, MASAKI UENO, SATORU OZAWA, TAKAYUKI NAKASE, MANABU KAWAI, MASATI TANI, HIROSHI TAMIMURA, and HIROKI YAMAUE


<table>
<thead>
<tr>
<th>Liver function score</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>P value A vs B; B vs C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality and morbidity</td>
<td>&lt;25 (n = 165)</td>
<td>25–50 (n = 28)</td>
<td>≥50 (n = 14)</td>
<td></td>
</tr>
<tr>
<td>Hospital death (liver failure)</td>
<td>1 (0.6%)</td>
<td>4 (14.3%)</td>
<td>8 (57.1%)</td>
<td>P &lt; 0.0001; P = 0.0375</td>
</tr>
<tr>
<td>Intractable ascites</td>
<td>0</td>
<td>4 (14.3%)</td>
<td>10 (71.4%)</td>
<td>P &lt; 0.0001; P = 0.0265</td>
</tr>
<tr>
<td>Intractable pleural effusion</td>
<td>0</td>
<td>2 (7.1%)</td>
<td>6 (42.9%)</td>
<td>P = 0.0006; P = 0.0055</td>
</tr>
</tbody>
</table>

No Hepatectomy if score > 50

<table>
<thead>
<tr>
<th>Liver function score</th>
<th>Group A</th>
<th>Group B</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality and morbidity</td>
<td>&lt;25 (n = 107)</td>
<td>25–50 (n = 38)</td>
<td></td>
</tr>
<tr>
<td>Hospital death (liver failure)</td>
<td>1 (0.9%)</td>
<td>3 (7.9%)</td>
<td>P = 0.0224</td>
</tr>
<tr>
<td>Intractable ascites</td>
<td>0</td>
<td>3 (7.9%)</td>
<td>P = 0.0033</td>
</tr>
<tr>
<td>Intractable pleural effusion</td>
<td>0</td>
<td>3 (7.9%)</td>
<td>P = 0.0033</td>
</tr>
</tbody>
</table>
**Conclusions:** Faced with the same MELD score and extent of hepatectomy planning, presence of **portal hypertension should not be considered** as a contraindication for hepatic resection in cirrhotic patients.
To determine the risk of post-operative mortality for all types of major surgery, especially gastro-intestinal, orthopedic and cardiac surgery (includes open-heart procedures), please enter the following variables:

- What is the age? 
- What is the ASA score? (use 1-5) 
- What is the bilirubin? (mg/dl) 
- What is the creatinine? (mg/dl) 
- What is the INR? 
- What is the etiology of cirrhosis? Check one: Alcoholic or Cholestatic, Viral/Other

Compute
Reset Form

PROBABILITY OF MORTALITY
POST-OPERATIVE INTERVAL

7 days 30 days 90 days 1 year 5 years

Cirrhosis and Surgery

Assessment prior to Surgery in Cirrhotics

- Type of Surgery
- Assessment of Liver Dysfunction
- Comorbidity
- Nutritional status
Operatory Risk in Cirrhosis

Perioperative Complications
Risk Factors

- Child-Pugh
- Ascites
- Creatinine
- Cirrhosis # da CBP
- BPCO
- Infections
- Previous G.I. Bleeding
- ASA physical status
- Intraoperative Hypotension
- Surgery Severity Score

Ziser, anesthesiology, 1999
Operatory Risk in Cirrhosis

Postoperative MORTALITY
Risk Factors

Ziser, anesthesiology, 1999
Malnutrition and Surgery in Cirrhotcs

Matsumata, 1990
The Assessment of Surgical Risk in Cirrhosis Represents a Stimulating Challenge
**Limits of prognostic Scores**

- Standard MELD performs less at lower numbers
- Modified MELD scores are better
- Dynamic Scores are the answer?

**Lack of an “all-inclusive” Validated Score**

- Hepatic Function
- Comorbidity
- Team experience
- Type of surgery
- Role of PH
- Nutritional Status
Grazie dell’attenzione
### High-risk patients with liver disease for any type of surgery

- Child’s C
- MELD score greater than 15
- Acute liver failure
- Acute alcoholic hepatitis
- High serum bilirubin (>11 mg/dL)
Child-Pugh classification system e Rischio Operatorio nel cirrotico

Classe di Child e morbilità/mortalità perioperatoria (interventi chirurgici addominali)

<table>
<thead>
<tr>
<th>Child-Pugh</th>
<th>Rischio</th>
<th>Chirurgia</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7-10%</td>
<td>Ben tollerata</td>
</tr>
<tr>
<td></td>
<td>(rischio basso)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>23-30%</td>
<td>Possibile*</td>
</tr>
<tr>
<td></td>
<td>(rischio moderato)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>75-84%</td>
<td>Generalmente Controindicata</td>
</tr>
<tr>
<td></td>
<td>(rischio elevato)</td>
<td></td>
</tr>
</tbody>
</table>

* solo dopo adeguata preparazione

Garrison, Ann Surg 1984
Malnutrizione e Rischio Operatorio

Malnutrizione è un significativo fattore di rischio di morbidità e mortalità post-operatoria nel cirrotico

- Maggiore frequenza di complicanze post-operatorie (17 vs 7%; \( p<0.01 \))
  
  Merli, Nutrition 2002

- Aumentato rischio di mortalità operatoria precoce o tardiva (62 vs 22%; \( p<0.01 \))
  
  Garrison, Ann Surg 1984

...ma
...l’utilizzo della malnutrizione come unico fattore di rischio operatorio nel cirrotico ha dei limiti:

L’effetto della malnutrizione può essere mascherato da altri fattori associati a danno epatico che possono svolgere un ruolo predominante in tale condizione.

La malnutrizione è stata valutata con metodi eterogenei e spesso non confrontabili:

- **Parametri antropometrici** (massa magra: circonferenza muscolo braccio; massa grassa: spessore pieghe cutanee)
- **Bioelectrical impedance**
- **Calorimetria indiretta**
- **Subjective Global Assessment** (parametri clinici e di laboratorio)
- **Height z score** (età pediatrica: differenza tra altezza paziente e altezza media diviso SD)
Chirurgia nel Cirrotico

Anestesia

Ipotensione

Perdite ematiche

Trasfusioni

Laparotomia

Circolazione Extra-corporea

Toracotomia
Chirurgia cardiovascolare nel cirrotico

<table>
<thead>
<tr>
<th>Autore</th>
<th>n</th>
<th>CBP (bypass cardiop)</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klemperer, 1998</td>
<td>13</td>
<td>sì</td>
<td>0</td>
<td>80</td>
<td>-</td>
</tr>
<tr>
<td>Bizouarn, 1999</td>
<td>12</td>
<td>sì</td>
<td>0</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Kaplan, 2002</td>
<td>8</td>
<td>sì</td>
<td>0</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Hayashida, 2004</td>
<td>15</td>
<td>sì</td>
<td>0</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

Classi Child-Pugh: IC con CPB | IC senza CPB

A: Acceptabile
B: Controindicato*
C: Controindicato

* Se non strettamente necessario

Hayashida, Ann Thorac Car Sur 2004
Pre-operative Evaluation

- Stadiation/Type of Hepatopathy
- Screening of Complications
- Surgical Risk Factors
- Evaluation of Hepatic Function
- Nutritional Evaluation
Two-step strategy
TIPS 15-30 giorni pre-intervento chirurgico:

Potrebbe comportare

- Riduzione rischio di sanguinamento
- Riduzione emotrasfusioni
- Riduzione ipotensione intraoperatoria
- Riduzione tempi operatori
- Riduzione mortalità
**Tipo di anestetico e fegato cirrotico**

**Anestetici Volatili**

✓ **Alotano ed Enfluorano**

- Metabolizzati dal fegato (alotano: 20%; enfluorano: 3%)
- Riducono flusso attraverso l’arteria epatica (vasodilatazione sistemica)
- Hanno debole effetto inotropo negativo

✓ **Isofluorano**

- Metabolizzato dal fegato solo in minima parte (0.2%)
- Aumenta il flusso attraverso l’arteria epatica
- Rappresenta l’anestetico di scelta nei pazienti con malattie epatiche
**Tipo di anestetico e fegato cirrotico**

- **Agenti bloccanti neuromuscolari:**
  - Effetto prolungato nell’epatopatico per:
    - riduzione dell’attività pseudocolinesterasica
    - ridotta escrezione biliare
    - aumentato volume di distribuzione

- **Atracurio:**
  - Metabolismo indipendente dal fegato
  - Agente di scelta nei pazienti epatopatici

- **Doxacurio:**
  - Miorilassante a lunga durata d’azione
  - Raccomandato per interventi chirurgici prolungati (OLTx)
**Tipo di anestetico e fegato cirrotico**

**Narcotici:**
- Morfina e meperidina: riducono il flusso epatico
- Fentanil: narcotico di scelta nei pazienti epatopatici

**Sedativi:**
- Diazepam: metabolismo prolungato in pazienti epatopatici (totalmente epatico)
- Lorazepam: agente di scelta (non ha metabolismo epatico)
Cirrhosis “per se” is **NOT** a Contraindication to Surgery

**BUT**

Mandate a Rigorous Selection to prevent Morbidity and Mortality
**MEGx test**

- Lydocaine 1 mg/Kg i.v. bolus
- Samples at 0, 15, 30, 45 min.
  - Serum levels of mono-etil-glicine-xilodide (MEGX)
- Reflects cit. p450 Activity and Hepatic Flow
- USE (?):
  - Prognostic Evaluation in cirrhosis
  - Functional reserve in pts with liver metastasis
  - Evaluation of graft functionality
  - Pre/post-operative assessment
**MEGx test**

- **p < 0.05**
  - A vs C
  - B vs C

![Graph showing Persistant Hepatitis, Chronic Active, and Cirrhosis](image)

![Bar chart showing MEGx levels for Child A, B, and C](image)

- Child A: 25 mg/dl
- Child B: 16 mg/dl
- Child C: 8.9 mg/dl
**Aminopirina Breath Test (13C)**

- **Dose orale**: 2 mg/Kg (e.v.)
- **Distribuzione**: Uniforme
- **Metabolismo**:
  - Esclusivo epatico (c. p450)
  - NON correlato a flusso portale
  - NON influenzato da colestasi

**LIMITI**

- **Enzimi inducibili**
  - Alcol
  - Farmaci
- **Stato nutrizionale**
  - Folati
  - Glutatione
- **Età?**
- **Produzione endogena CO2**
  - Febbre
  - Alimenti
Aminopirina Breath Test ($^{13}$C)

$^{13}$CO$_2$ Espirato

% Dose Cumulativa a 2 ore

- **>8,4%**
  - ✓ Normale

- **< 8,4% - >2.3%**
  - ✓ Epatopatia / Cirrosi

- **< 2,3%**
  - ✓ Alta Mortalità Chirurgica

Minuti
**Cirrhosis and Nutritional Status**

- **Compensated Cirrhosis**
  - Normal Energetic Requests
  - 25-35 Kcal/Kg

- ** Decompensated Cirrhosis**
  - Increased Energetic Requests
  - Up to 40-45 Kcal/Kg
Grazie
### Non-Hepatic Surgery

**Table 2.** Morbidity and mortality in cirrhotic patients and controls after nonhepatic surgery.

<table>
<thead>
<tr>
<th>Data</th>
<th>Cirrhotics (n = 135)</th>
<th>Controls (n = 86)</th>
<th>Statistics</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of operation, min</td>
<td>116 ± 66</td>
<td>119 ± 66</td>
<td>$\chi^2 = 14.6, p = 0.002$</td>
<td>2.5 (1.5 to 4.4)</td>
</tr>
<tr>
<td>Intraoperative transfusion needs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>82 (60.7)</td>
<td>73 (84.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>25</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\geq 3$</td>
<td>7</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital stay, days, mean ± SD</td>
<td>18 ± 14.4</td>
<td>13.4 ± 13.4</td>
<td>$t = 2.4, p = 0.01$</td>
<td>2.8 (2.6 to 2.9)</td>
</tr>
<tr>
<td>Any complication</td>
<td>68 (50.4)</td>
<td>25 (29.1)</td>
<td>$\chi^2 = 9.7, p = 0.002$</td>
<td>2.4 (1.3 to 4.4)</td>
</tr>
<tr>
<td>Surgical wound complications</td>
<td>24 (17.8)</td>
<td>18 (20.9)</td>
<td>$\chi^2 = 0.3, p = 0.5$</td>
<td></td>
</tr>
<tr>
<td>Infection</td>
<td>9</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dehiscence</td>
<td>5</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eventration</td>
<td>6</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fistula</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abscess</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General complications</td>
<td>20 (14.8)</td>
<td>9 (10.5)</td>
<td>$\chi^2 = 2.2, p = 0.13$</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>5</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exacerbation of COPD</td>
<td>5</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paralytic ileus</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phlebitis</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cirrhosis-related complications</td>
<td>27 (20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascites</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encephalopathy</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper GI bleeding</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal failure</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liver failure</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortality, 30-day</td>
<td>22 (16.3)</td>
<td>3 (3.5)</td>
<td>$\chi^2 = 8.59, p = 0.003$</td>
<td>4.6 (1.4 to 13.2)</td>
</tr>
</tbody>
</table>

Percentages are in parentheses.

CI: confidence interval; COPD: chronic obstructive pulmonary disease; GI: gastrointestinal.

*Del Olmo, 2003*
## Table 3. Comparison of morbidity parameters in patients with cirrhosis according to Child-Pugh score and controls.

<table>
<thead>
<tr>
<th>Data</th>
<th>Controls (n = 86)</th>
<th>Preoperative Child-Pugh score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A (n = 83)</td>
</tr>
<tr>
<td>Intraoperative transfusion*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>73 (84.9)</td>
<td>52 (62.6)</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>≥ 3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Hospital stay, mean ± SD**</td>
<td>13.4 ± 13.4</td>
<td>17.3 ± 14.3</td>
</tr>
<tr>
<td>Any complication***</td>
<td>25 (29.1)</td>
<td>33 (39.7)</td>
</tr>
<tr>
<td>Mortality, 30-day***</td>
<td>3 (3.5)</td>
<td>3 (3.6)</td>
</tr>
</tbody>
</table>

*Controls versus grade A: $\chi^2 = 10.9, p = 0.01$; controls versus grade B: $\chi^2 = 10.8, p = 0.01$; controls versus grade C: $\chi^2 = 7, p = 0.07$.

**Controls versus grade A: $t = 1.8, p = 0.06$; controls versus grade B: $t = 2.2, p = 0.02$; controls versus grade C: $t = 1.2, p = 0.4$.

***Controls versus grade B: $\chi^2 = 17.5, p < 0.001$; controls versus grade C: $\chi^2 = 5.2, p = 0.02$.

****Controls versus grade B: $\chi^2 = 20, p < 0.001$; controls versus grade C: $\chi^2 = 30.2, p < 0.001$.
Table 5. Multivariate analysis of factors associated with outcome in patients with liver cirrhosis undergoing nonhepatic surgery.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Wald ($\chi^2$)</th>
<th>$p$ value</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>For the development of complications</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Child-Pugh score</td>
<td>10.5</td>
<td>0.001</td>
<td>10.4 (3.4 to 22.6)</td>
</tr>
<tr>
<td>Intraoperative blood transfusion</td>
<td>6.9</td>
<td>0.008</td>
<td>2.7 (2.3 to 4.2)</td>
</tr>
<tr>
<td><strong>For death within 30 days after surgery</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Child-Pugh score</td>
<td>18.08</td>
<td>0.0001</td>
<td>24.4 (5.5 to 106)</td>
</tr>
<tr>
<td>Duration of operation</td>
<td>5.23</td>
<td>0.0221</td>
<td>4.1 (1.2 to 15.6)</td>
</tr>
<tr>
<td>General complications</td>
<td>4.9</td>
<td>0.0268</td>
<td>3.7 (3.3 to 6.4)</td>
</tr>
</tbody>
</table>

Del Olmo, 2003
Cirrhosis and Type of Surgery (Hepatic resection)

Reduction of Functional Mass

↓ Syntesis
↓ Detossification

ASCITES

↑ Resistance Portal Flow

Portal Hypertension

↓ Albumin
↓ PT
↓ Complement

ENCEPHALOPATY

INFECTIONS

Hemorragic Risk

INFECTIONS

Portal Hypertension

INFECTIONS
Operative Risk in cirrhosis

Blood Flow Reciprocity

Portal Blood Flow
70%

0₂ Portal Supply
50%

Hepatic Artery Blood Flow
30%

0₂ Arterial Supply
50%

Reduced by:

↓ Cardiac Output
↓ Systemic Pressure (intraoperative)
↓ Manipulation due to splanic surgery

Increase over 50%

via Compensatory Vasodilation
(↓ Portal flow)
Operative Risk in cirrhosis

Blood Flow Reciprocity

$O_2$

Compensatory Splanchnic Arterial Vasodilation:

COMPROMIZED in cirrhosis

REDUCED BY:
- Type of Anesthetic (alothane)
- Anesthetic Concentration

INCREASED Susceptibility to ISCHEMIA
...Any degree of clinically evident liver dysfunction in a prospective surgical patient should raise concern.
Cirrhosis and Type of Surgery

ABDOMINAL SURGERY

LAPAROTOMY

- Hepatic Arterial Flow
  - *Visceral Traction induces reflexive hypotension*

- Hemorragic Risk
  - *Portal Hypertension*
  - *Previous Operations*
Cirrhosis and Type of Surgery

CARDIAC Surgery

Causes of Death
- Abdominal Sepsis
- G.I. Complications
- No cardiac deaths

Klemperer, Ann Thor. Surg, 1993
Quantitative Assessment of Hepatic Function and its Relevance to the Liver Surgeon
G. Morris-Stiff · D. Gomez · R. Prasad

- Ascites
  - Absent or Controlled
  - Not Controlled
    - Total Bilirubin
      - <1 mg/dL
        - Limited Resection
      - 1.1-1.5 mg/dL
        - Enucleation
      - 1.6-1.9 mg/dL
        - No Surgery
      - >2 mg/dL
        - No Surgery

ICGR-15
- <10% - Any Resection
  - 10-19% - Left Hemihepatectomy or Right Sectionectomy
  - 20-29% - Segmentectomy
  - 30-39% - Limited Resection
  - 40% - Enucleation
**Commonly Used $^{13}$CO$_2$ BREATH TESTS**

<table>
<thead>
<tr>
<th>Substance</th>
<th>Metabolic Pathway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aminopirine</td>
<td>P450 N-demetylation</td>
</tr>
<tr>
<td>Methacetine</td>
<td>P450 O-demetylation</td>
</tr>
<tr>
<td>Fenacetinae</td>
<td>P450 1A2 O-demetylation</td>
</tr>
<tr>
<td>Caffeine</td>
<td>P450 1A2 N-demetylation</td>
</tr>
<tr>
<td>Eritromycin</td>
<td>P450 IIIA N-demetylation</td>
</tr>
<tr>
<td>Fenylalanine</td>
<td>Cytoplasmic Hydroxylasis</td>
</tr>
<tr>
<td>Galactose</td>
<td>Membrane Esokinesis</td>
</tr>
<tr>
<td>Chetoisocaproic Acid</td>
<td>Mitocondrial Decarboxilation</td>
</tr>
<tr>
<td>Methionine</td>
<td>Mitocondrial Oxidation</td>
</tr>
<tr>
<td>Na-Ottanoate (MCFA)</td>
<td>Mitocondrial Beta-oxidation</td>
</tr>
</tbody>
</table>
### Multivariable Logistic Regression Analysis of Mortality in Patients With and Without Cirrhosis Undergoing Elective Surgery

<table>
<thead>
<tr>
<th>Factor</th>
<th>Cholecystectomy</th>
<th>Colectomy</th>
<th>CABG</th>
<th>AAA repair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR</td>
<td>95% CI</td>
<td>HR</td>
<td>95% CI</td>
</tr>
<tr>
<td>n</td>
<td>489,382</td>
<td></td>
<td>626,085</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1.1</td>
<td>1.0–1.1</td>
<td>1.1</td>
<td>1.1–1.1</td>
</tr>
<tr>
<td>Female gender</td>
<td>0.5</td>
<td>0.4–0.6</td>
<td>0.7</td>
<td>0.7–0.8</td>
</tr>
<tr>
<td>Comorbidity*</td>
<td>1.5</td>
<td>1.4–1.7</td>
<td>1.4</td>
<td>1.4–1.5</td>
</tr>
<tr>
<td>Liver status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NON-CIRR</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>CIRR</td>
<td>3.4</td>
<td>2.3–5.0</td>
<td>3.7</td>
<td>2.6–5.2</td>
</tr>
<tr>
<td>PHTN</td>
<td>12.3</td>
<td>7.6–19.9</td>
<td>14.3</td>
<td>9.7–21.0</td>
</tr>
</tbody>
</table>
Cirrhosis and Type of Surgery

URGENT

Predictive Factors

- Child Score 0.001
- Ascites 0.006
- Encephalopathy 0.002
- PT 0.02

Mansour, Surgery 1997
Liver Volumetry

**FIGURE 3.** Two examples of $^{99m}$Tc-mebrofenin SPECT, with CT scans on left and matching SPECT images on right. (A and B) Patient with large colorectal metastasis in left liver segments, visible on CT scan. SPECT image shows inhomogeneous distribution of mebrofenin, with decreased uptake in liver segments 2–4. (C and D) Patient with colorectal metastasis (not visible on this CT slide) in which tumor is compressing surrounding vessels and bile ducts, resulting in impaired liver function in segments 5–8.
Figure 1  An example is shown of summed HBS images from 150–300 s after i.v. injection of $^{99m}$Tc-mebrofenin (a). A ROI is drawn around the entire liver (red line) and around the mediastinum (blood pool; yellow line). A third ROI is drawn around the future remnant liver (green line). A blood pool corrected liver-uptake time–activity curve is shown in b. The hepatic $^{99m}$Tc-mebrofenin uptake is calculated as an increase of $^{99m}$Tc-mebrofenin uptake (y-axis) per minute over a time period of 200 s (x-axis). c The use of the anterior projection of the liver on the CT volumetry image as a guideline for delineating the FRL on the HBS image (d).
Assessment of Future Remnant Liver Function Using Hepatobiliary Scintigraphy in Patients Undergoing Major Liver Resection

Wilmar de Graaf · Krijn P. van Lienden · Sander Dinant · Joris J. T. H. Roelofs · Olivier R. C. Busch · Dirk J. Gouma · Roelof J. Bennink · Thomas M. van Gulik


Figure 4 Scatter plot showing the correlation between FRL-F and FRL-V. In patients with normal livers (black line), FRL-V correlated well with FRL-F (Pearson $r=0.71$, $P=0.0001$). Patients with compromised livers (gray line) showed a moderate correlation between FRL volume and FRL function (Pearson $r=0.61$, $P<0.0003$).

FRL-V= Future Remnant Liver – Volume
FRL-F= Future Remnant Liver – Uptake Function
Real Operative Risk in Cirrhotic Patient is Difficult to Assess

- Few “Good” Data
- Mostly Retrospective
- Confounding factors (type of surgery, underlying disease, anesthesia.....)

Friedman, Hepatology 1999