Preoperative model for end-stage liver disease score as a predictor for posthemihepatectomy complications

Article *in* European Journal of Gastroenterology & Hepatology · April 2014

DOI: 10.1097/MEG.0000000000000035 · Source: PubMed

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Preoperative model for end-stage liver disease score as a predictor for posthemihepatectomy complications

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Background As diagnostic techniques advance and surgical outcomes improve, the rate of utilization of liver hemihepatectomy for various indications will continue to increase.

Objectives To explore the preoperative predictors of liver hemihepatectomy postoperative complications.

Patients and methods This study included retrospective analysis of the clinical data of patients who underwent either liver hemihepatectomy or extended hemihepatectomy at Georg August University Hospital-Goettingen for the period 2002–2012. The outcomes were either postoperative complications or death of the patient (within 3 months from the end of the operation). Modified classification of surgical complications was adopted in the current study. The preoperative model for end-stage liver disease (MELD) score, aspartate aminotransferase, creatinine, international normalized ratio, and bilirubin in addition to the demographic characteristics of the patients and intraoperative blood loss were analyzed as predictive for postliver hemihepatectomy complications.

Results The study included 144 patients who underwent liver hemiheptectomy or extended hemihepatectomy through the study period (2002–2012). Postoperative complications were reported among patients out of 144 (52.1%). The most frequent complications were pleural effusion (26.7%), biliary leakage (21.3%), wound dehiscence (13.3%), ascites, and intra-abdominal abscess (6.7%). Death was reported among six patients of those who developed complications (8%). There were four cases of hepatic cirrhosis (one macroscopic and three microscopic). Two of the microscopic cases had no postoperative complications (grade 1), whereas one case had grade 3a and the macroscopic case had postoperative complication grade 1. Their MELD scores ranged between 6 and 10 preoperatively. The association between preoperative MELD score and development of posthemihepatetomy was statistically significant, $P=0.002$. Death was reported in six cases, yielding a mortality rate of 4.17%. MELD score preoperatively was the only significant predictor for postoperative complications.

Conclusion The rate of complications following hemihepatectomy remains high, with 52.1% of the patients in the current study having at least one complication as all of our patients underwent either hemihepatectomy or extended hemihepatectomy. A 4.17% mortality rate has been reported. A higher preoperative MELD score is the only significant predictor for the development of posthemihepatectomy complications. *Eur J Gastroenterol Hepatol* 26:668–675 © 2014 Wolters Kluwer Health | Lippincott Williams & Wilkins.

European Journal of Gastroenterology & Hepatology 2014, 26:668–675

Keywords: hemihepatectomy, MELD score, postoperative complication

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Received 31 October 2013 Accepted 6 December 2013

Introduction

Liver surgery is performed nowadays more frequently than in previous decades [1]. Analysis of the Nationwide Inpatient Sample (NIS) shows that the number of liver operations almost doubled from 1988 to 2000, with ~7000 operations performed in the USA in 2000. As diagnostic techniques advance and surgical outcomes improve, the rate of utilization of liver surgery for various indications will continue to increase. Published literature suggests a reduction in morbidity and mortality rates in recent years, with many high-volume centers reporting mortality rates less than 5% [2–5]. Advances in perioperative management and surgical techniques have reduced mortality rates; however, reported morbidity rates remain high and range from 23 to 56% depending on indication for surgery [6,7].

In 2008, Sokol and Wilson [8] attempted to provide a sophisticated definition of surgical complications; they defined a complication as an undesirable, unintended, and direct result of an operation affecting the patient that would not have occurred had the operation gone as well as could reasonably be hoped. Dindo and Clavien [9] defined complication in 2008 as any deviation from the ideal postoperative course that is not inherent in the procedure and does not comprise a failure to cure.

Classification of surgical complications

Modified classification of surgical complications [10] was adopted in the current study. Table 1 shows its components.

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Table 1 Classification of surgical complications [10]

Grade	Definition
Grade I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions. Allowed therapeutic regimens are drugs as antiemetics, antipyretics, analgetics, diuretics, electrolytes, and physiotherapy. This grade also includes opening of wound infections at the bedside.
Grade II	Requiring pharmacological treatment with drugs other than those allowed for grade I complications. Blood transfusions and total parenteral nutrition are also included.
Grade III	Requiring surgical, endoscopic, or radiological intervention
Grade IIIa	Intervention not under general anesthesia
Grade IIIb	Intervention under general anesthesia
Grade IV	Life-threatening complication (including CNS complications)[a] requiring IC/ICU management
Grade IVa	Single-organ dysfunction (including dialysis)
Grade IVb	Multiorgan dysfunction
Grade V	Death of a patient
Suffix 'd'	If the patient develops a complication at the time of discharge (see examples in Table 2), the suffix 'd' (for 'disability') is added to the respective grade of complication. This label indicates the need for a follow-up to fully evaluate the complication.

CNS, central nervous system; IC, intermediate care.
[a]Brain hemorrhage, ischemic stroke, subarachnoid bleeding, but excluding transient ischemic attacks.

History of MELD score

Model for end-stage liver disease (MELD) was originally developed at the Mayo Clinic, and at that point, was called the 'Mayo End-stage Liver Disease' score. It was derived in a series of patients undergoing transjugular intrahepatic portosystemic shunt procedures. The original version also included a variable based on the underlying etiology (cause) of the liver disease [11]. The score turned out to be predictive of prognosis in chronic liver disease in general, and – with some modifications – came to be applied as an objective tool in assigning need for a liver transplant. The etiology turned out to be relatively unimportant and was also considered as relatively subjective; it was therefore removed from the score [12]. Schroeder *et al.* [13] evaluated the predictive indices of the MELD in 2006 for all liver resection including minor hepatic resection; they disputed the conclusion that MELD should not be used in the setting of elective hepatic resection.

As the extended hepatic surgery can be performed with a low morbidity and mortality in the hands of trained and experienced hepatic surgeons, the present study attempted to explore the preoperative and intraoperative predictors of postoperative complications including preoperative MELD score after major hepatic resection only (hemihepatectomy and extended hemihepatectomy operations).

Patients and methods

Study design

This study included a retrospective analysis of the clinical data of 144 patients who underwent either right hemihepatectomy, left hemihepatectomy, extended right hemihepatectomy, or extended left hemihepatectomy, provided that these data were as complete as possible.

Source of data

The data were obtained from the medical records of Georg August University Hospital 2002–2012.

Outcome variables

All cases of atypical liver resection or any liver resection smaller than hemihepatectomy were excluded. The outcomes were either postoperative complications or death of the patient (within 3 months from the end of the operation). The complications included either in-hospital or out-of-hospital occurrences. Mortality is defined as death within 3 months of surgery.

The MELD is a scoring system for assessing the severity of chronic liver disease. It was initially developed to predict death within 3 months of surgery in patients who had undergone a transjugular intrahepatic portosystemic shunt procedure [11], and was subsequently found to be useful in determining prognosis and prioritizing for recipients of a liver transplant [12,14]. This score is now used by the United Network for Organ Sharing [15] and Eurotransplant for prioritizing allocation of liver transplants instead of the older Child–Pugh score.

Determination of MELD score

MELD uses the patient's values for serum bilirubin, serum creatinine, and the international normalized ratio (INR) for prothrombin time (PT) to predict survival. It is calculated according to the following formula: [14]

$$\begin{aligned} MELD = {} & 3.78\,[\text{Ln serum bilirubin (mg/dl)}]+11.2 \\ & \times [\text{Ln INR}]+9.57 \\ & \times [\text{Ln serum creatinine (mg/dl)}]+6.43. \end{aligned}$$

United Network for Organ Sharing has made the following modifications to the score [15]:

If the patient has been dialyzed twice within the last 7 days, then the value for serum creatinine used should be 4.0.

Any value less than one is assigned a value of 1 (i.e. if bilirubin is 0.8, a value of 1.0 is used) to prevent the occurrence of scores below 0 (the natural logarithm of 1 is 0, and any value below 1 would yield a negative result).

Patients with a diagnosis of liver cancer will be assigned a MELD score on the basis of how advanced the cancer is.

INR results were not available at Georg August University Hospital and were calculated on the basis of PT.

Measurement of prothrombin time/international normalized ratio

Patient samples for PT/INR estimation in this study were collected using 3.0 ml plastic plasma tubes (S-Monovettes) with sodium citrate, predosed as a 0.106 molar solution, which is equivalent to 3.2% trisodium citrate (Sarstedt AG & Co., Nümbrecht, Germany). PT was measured at 37°C on an ACL TOP 700 system using the HemosIL RecombiPlasTin 2G reagents on the basis of recombinant human tissue factor (Instrumentation Laboratory Company, Bedford, Massachusetts, USA).

The INR is the PT ratio of a test sample compared with a normal PT (derived from the log mean normal prothrombin time of 20 normal donors) corrected for the sensitivity of the thromboplastin used in the test. It is the value for the PT ratio that has been obtained using the first WHO reference thromboplastin with an international sensitivity index (ISI) of 1.0.

The INR value was calculated according to the following equation:

$$\left[INR = \left(\frac{PT_{\text{patient plasma}}}{PT_{\text{normal plasma}}}\right) \exp ISI\right].$$

The ISI web software and the certified plasmas of the HemosIL ISI Calibrate set (Instrumentation Laboratory Company) were used to establish a laboratory's instrument/reagent-specific local ISI.

Statistical analysis

Data were analyzed using SPSS software, version 19 (SPSS Inc., Chicago, Illinois, USA). Preoperative variables that correlated with postoperative complications were identified using bivariate analyses. Categorical variables were assessed using the χ^2-test and continuous variables were assessed using Student's *t*-test or Mann–Whitney test (abnormally distributed variables) for comparison of two groups and one-way analysis of variance test for comparison of more than two groups or the Kruskal–Wallis test (abnormally distributed variables). A cut-off level of 9 for the MELD score was utilized in the analysis (median value). A *P*-value less than 0.05 was considered statistically significant.

Results

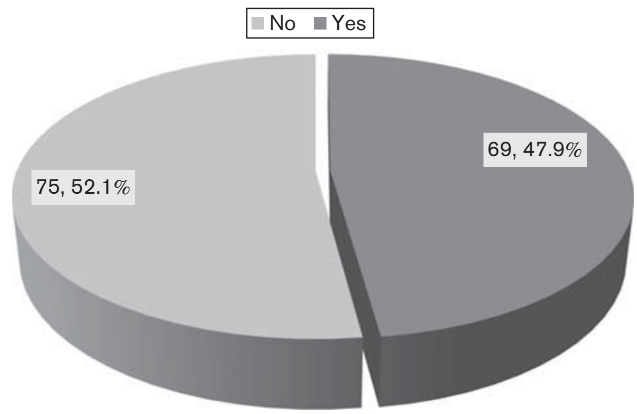
Prevalence of postoperative complications after hemihepatectomy

The study included 144 patients who underwent either right hemihepatectomy, left hemihepatectomy, extended right hemihepatectomy, or extended left hemihepatectomy during the study period (2002–2012). As can be seen in Fig. 1, postoperative complications were reported among 75 patients of 144 (52.1%).

Figure 2 shows that postoperative complication grades 1, 3a, 2, and 3b were reported among 49.3, 17.4, 12.5%, and 11.8 of patients, respectively.

Table 2 summarizes postoperative complications according to their sites. The most frequent complications were pleural effusion (26.7%), biliary leakage (21.3%), wound dehiscence (13.3%), ascites, and intra-abdominal abscess (6.7%). Death was reported among six cases (8%).

Fig. 1



Prevalence of postoperative complications after hemihepatectomy.

Association of preoperative MELD scores with posthemihepatectomy complications

As shown in Table 3, 46.8% of patients whose preoperative MELD score was below 9 developed posthemihepatectomy Complications compared with 84.2% of those whose preoperative MELD score ranged between 9 and 18. The association between preoperative MELD score and development of posthemihepatetomy was statistically significant, $P = 0.002$.

Association between preoperative MELD score and grades of postoperative complications after hemihepatectomy operations

The MELD score preoperatively was higher among patients with postoperative complications grades 5 and 3b than those of other grades. However, this difference was borderline statistically significant, $P = 0.057$ (Table 4).

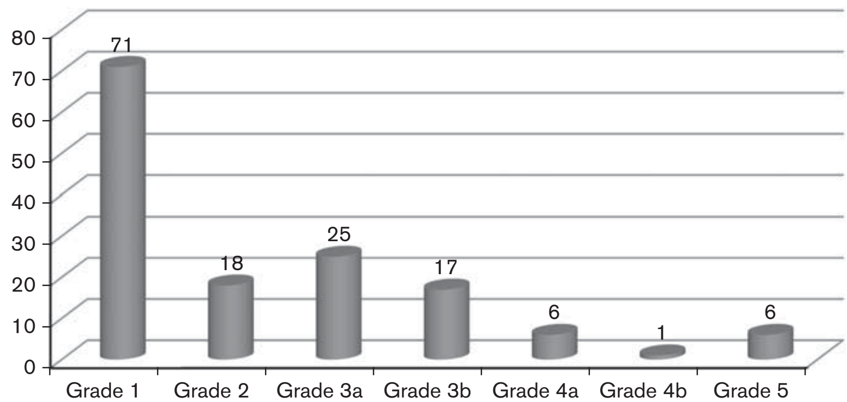
Association between preoperative AST, INR, creatinine, bilirubin levels, and posthemihepatectomy complications

Table 5 shows that there was no significant difference between preoperative aspartate aminotransferase (AST), bilirubin, creatinine, and INR levels among those who developed posthemihepatectomy complications and those who did not develop such complications.

The relationship between different factors and development of postoperative complications after hemihepatectomy operations

From Table 6, it is evident that exactly half of nonmalignant cases (50%) and more than half of malignant cases (53.2%) compared with none of living donor liver transplantation cases developed postoperative complications after liver resection. However, this difference was

Fig. 2



Distribution of patients according to grades of postoperative complications.

Table 2 Post hemihepatectomy complications ($n=75$)

Complications	*N* (%)
Intra-abdominal	
Biliary leakage	16 (21.3)
Peritonitis	4 (5.3)
Subhepatic seroma	4 (5.3)
Biliodigestive anastomosis insufficiency	2 (21.3)
Persistent increased liver parameter	4 (5.3)
Ascites	5 (6.7)
Small intestinal leakage	2 (2.7)
Colon perforation	2 (2.7)
Colon inflammation	1 (1.3)
Cholangitis	2 (2.7)
Acute pancreatitis	2 (2.7)
Paralytic ileus	2 (2.7)
Intra-abdominal abscess	5 (6.7)
Intrahepatic abscess	1 (1.3)
Gastric ulcer bleeding	1 (1.3)
Acute duodenal bleeding	1 (1.3)
Enterocutaneous fistula	1 (1.3)
Postoperative bleeding	3 (4.0)
Chylous fistula	1 (1.3)
Pulmonary	
Pleural effusion	20 (26.7)
Pneumothorax	1 (1.3)
Respiratory insufficiency	4 (5.3)
Hoarseness of voice	1 (1.3)
Pericardial effusion	1 (1.3)
Atelectasis	2 (2.7)
Pneumonia	1 (1.3)
Miscellaneous	
Wound dehiscence	10 (13.3)
Fascia dehiscence	3 (4.0)
Minimal wound infection	1 (1.3)
Acute renal failure	4 (5.3)
Coagulation disorder	4 (5.3)
Urinary tract infection	5 (6.7)
Postoperative reactive psychosis	5 (6.7)
Depression	1 (1.3)
Postoperative anemia	2 (2.7)
Thyrotoxic crisis	1 (1.3)
Sacral decubitus ulcer	1 (1.3)
DIC	2 (2.7)
Death	6 (8.0)

DIC, disseminated intravascular coagulopathy.

Table 3 Association of preoperative MELD score with posthemihepatectomy complications ($n=143$)

	Complications [*N* (%)]			
Preoperative MELD[a]	Yes	No	χ^2-value	*P*-value
<9 ($n=124$)	58 (46.8)	66 (53.2)	9.25	0.002
9–18 ($n=19$)	16 (84.2)	3 (15.8)		

MELD, model for end-stage liver disease.
[a]One missed case.

Table 4 Association between preoperative MELD score and grades of postoperative complications after hemihepatectomy operations

MELD	Mean (SD)	*F*-value	*P*-value
Preoperative		2.20	0.057
Grade 1 ($n=71$)	7.0 (1.4)		
Grade 2 ($n=18$)	7.6 (2.9)		
Grade 3a ($n=24$)	7.3 (2.4)		
Grade 3b ($n=17$)	8.6 (3.6)		
Grades 4 ($n=7$)	7.3 (2.2)		
Grade 5 ($n=6$)	9.2 (4.3)		

MELD, model for end-stage liver disease.

Table 5 Association between preoperative AST, INR, creatinine, levels, and posthemihepatectomy complications

	Posthemihepatectomy complications (mean±SD)		
Variables	Yes	No	*P*-value
AST	58.9±75.5	42.9±44.2	0.354[a]
Bilirubin	1.3±2.5	0.6±0.4	0.184[a]
Creatinine	0.9±0.3	0.8±0.2	0.581[a]
INR	0.99±0.13	0.98±0.1	0.755[b]

AST, aspartate aminotransferase; INR, international normalized ratio.
[a]Mann–Whitney test.
[b]Student's *t*-test.

statistically not significant, $P=0.323$. More than half (60%) of the patients in the age group 51–60 years and slightly more than half of those older than 60 years of age (52.5%) compared with only 40% of patients aged 50 years or younger had postliver hemihepatectomy complications, $P=0.405$. BMI, sex, and duration of the operation were not

Table 6 Relationship between different factors and development of postoperative complications after hemihepatectomy operations: bivariate analysis

	Complications [*n* (%)]		
	Yes (*n*=75)	No (*n*=69)	*P*-value
Group			0.323
Malignant (*n*=126)	67 (53.2)	59 (46.8)	
Nonmalignant (*n*=16)	8 (50.0)	8 (50.0)	
LDLT (*n*=2)	0 (0.0)	2 (100.0)	
Sex			0.064
Female (*n*=69)	41 (59.4)	28 (40.6)	
Male (*n*=75)	34 (45.3)	41 (54.7)	
Age (years)			0.405
≤ 50 (*n*=20)	8 (40.0)	12 (60.0)	
51–60 (*n*=25)	15 (60.0)	10 (40.0)	
>60 (*n*=99)	52 (52.5)	47 (47.5)	
BMI			0.220
Underweight (*n*=4)	3 (75.0)	1 (25.0)	
Normal (*n*=61)	33 (54.1)	28 (45.9)	
Overweight (*n*=46)	19 (41.3)	27 (58.7)	
Obese (*n*=20)	13 (65.0)	7 (35.0)	
Incision suture time (min)			0.787
25–200 (*n*=42)	21 (50.0)	21 (50.0)	
201–300 (*n*=41)	21 (51.2)	20 (48.8)	
>300 (*n*=30)	17 (43.3)	17 (56.7)	

LDLT, living donor liver transplantation.

significantly associated with the development of postoperative complications.

Association between preoperative AST level and postoperative grade of complications after hemihepatectomy operations

Table 7 shows that the AST level preoperatively was not significantly associated with posthemihepatectomy grade of complications, $P=0.130$.

Association between preoperative creatinine level and postoperative grade of complications after hemihepatectomy operations

As can be seen in Table 8, the preoperative creatinine level was not significantly associated with the grade of posthemihepatectomy complications, $P=0.138$.

Association between bilirubin level and postoperative grade of complications after hemihepatectomy operations

The preoperative bilirubin level was not significantly associated with the grade of posthemihepatectomy complications as can be seen in Table 9.

Association between INR level and postoperative grade of complications after hemihepatectomy operations

The INR level preoperatively was not significantly associated with grades of postoperative complications (Table 10).

There were four cases of hepatic cirrhosis (one macroscopic and three microscopic). Two of the microscopic cases had no postoperative complications (grade 1), whereas one case had grade 3a and the macroscopic case had postoperative complication grade 1. Their MELD scores ranged between 6 and 10 preoperatively. Death was reported in six cases, yielding a mortality rate of 4.17%.

Table 7 Association between preoperative AST level and postoperative grade of complications after hemihepatectomy operations

AST	Mean (SD)	*P*-value[a]
Preoperative		0.130
Grade 1 (*n*=68)	42.5 (43.7)	
Grade 2 (*n*=17)	43.3 (38.0)	
Grade 3a (*n*=24)	79.0 (118.9)	
Grade 3b (*n*=15)	57.3 (38.5)	
Grades 4 (*n*=7)	54.1 (38.0)	
Grade 5 (*n*=6)	43.2 (26.0)	

AST, aspartate aminotransferase.
[a]Kruskal–Wallis test.

Table 8 Association between preoperative creatinine level and postoperative complications after hemihepatectomy operations

Creatinine	Mean (SD)	*F*-value	*P*-value
Preoperative		1.702	0.138
Grade 1 (*n*=71)	0.84 (0.22)		
Grade 2 (*n*=18)	0.88 (0.33)		
Grade 3a (*n*=24)	0.82 (0.18)		
Grade 3b (*n*=17)	0.89 (0.26)		
Grades 4 (*n*=7)	0.94 (0.25)		
Grade 5 (*n*=6)	1.15 (0.73)		

Table 9 Association between bilirubin level and postoperative complications after hemihepatectomy operations

Bilirubin	Mean (SD)	*P*-value[a]
Preoperative		0.648
Grade 1 (*n*=71)	0.64 (0.37)	
Grade 2 (*n*=18)	1.26 (2.57)	
Grade 3a (*n*=24)	0.95 (1.28)	
Grade 3b (*n*=17)	1.89 (4.03)	
Grade 4 (*n*=7)	0.97 (1.08)	
Grade 5 (*n*=6)	1.55 (2.10)	

[a]Kruskal–Wallis test.

Table 10 Association between INR level and postoperative grade of complications after hemihepatectomy operations

INR	Mean (SD)	*F*-value	*P*-value
Preoperative		1.456	0.208
Grade 1 (*n*=71)	0.99 (0.1)		
Grade 2 (*n*=18)	0.98 (0.06)		
Grade 3a (*n*=24)	1.02 (0.17)		
Grade 3b (*n*=17)	1.01(0.18)		
Grade 4 (*n*=7)	0.91 (0.04)		
Grade 5 (*n*=6)	0.93 (0.06)		

INR, international normalized ratio.

Discussion

Careful preoperative evaluations of the patients' condition are essential for the successful surgical management of patients who have undergone hepatic resection [16].

Liver surgery involves various operations of the liver for different disorders. The most common operation performed on the liver is a resection (removal of a portion of the liver). The most typical indication for liver resection is a malignant tumor [17].

Although the rates of complications following liver resection have decreased over the years, complication rates remain high, with 52.1% of the patients in the current study developing at least one complication. In the National Surgical Quality Improvement Programme-Patient Safety Study (NSQIP PSS) sample, 22.6% of patients experienced at least one complication and 5.2% underwent a second operation for complications [18]. There has been significant variation in both the reported rates and the definitions of complication across the literature. Complication rates in large studies of unselected patients range from 22 to 45% [2–7]. Furthermore, definitions for complications are not standardized and varying criteria for complication make the results of different studies difficult to compare. In addition, all patients in the present work underwent hemihepatectomy and extended hemihepatectomy, which are the more extensive operations that can be performed on the liver. Also, the results of single-center studies may not be reliable indicators of population-wide results as single-center studies are more sensitive to institution-specific case mix.

In 2007, Enrico *et al.* [19] analyzed the causes and foreseeable risk factors for liver resective surgery linked to postoperative morbidity on the basis of data derived from a single-center surgical population. The morbidity rate was 47.7%, caused by an increase in ascites (10%), temporary hepatic insufficiency (19%), biliary fistula (6%), hepatic abscess (25%), hemoperitoneum (10%), and pleural effusion (30%), or sometimes a combination [19].

The most frequent complications in our study were pleural effusion (26.7%), biliary leakage (21.3%), wound dehiscence (13.3%), ascites, and intra-abdominal abscess (6.7%).

The 4.17% overall 3-month mortality rate in this study is slightly higher than other mortality rates published on the basis of population-wide data for unselected patients. For example, on the basis of data from the NIS, Dimick *et al.* [1] reported that the rate of mortality for liver resection decreased from 10.4% (1988–1999) to 5.3% (1998–2000). A mortality rate of 2.6% has been reported in the NSQIP PSS study. High-volume hospitals (17) (> 10 resections per year) in the NIS data set reported a 3.9% overall mortality rate from 1998 to 2000, although there are important differences between NSQIP, NIS, and our study data sets (e.g. the 3-month mortality rate reported in the current study, 30-day mortality reported in the NSQIP study, and in-hospital mortality reported in NIS). Because the majority of hospitals included in the NSQIP PSS data set reported more than 30 liver resections over the 3-year time period, the results of that study are representative of 'high-volume' hospitals.

Schroeder *et al.* [13] evaluated the predictive indices of the MELD, Child–Turcotte–Pugh scores, and the American Society of Anesthesiology physical status classification on morbidity and mortality for patients after hepatic resection. American Society of Anesthesiology and Child–Turcotte–Pugh scores were predictive of mortality but not morbidity, but MELD had no predictive value [13]. Nagorney and Kamath [20] reported that the application of MELD as a prognostic tool for patients other than those awaiting hepatic transplantation requires further investigation before clinical application. In addition, they disputed the conclusion that MELD should not be used in the setting of elective hepatic resection [20]. The contradiction between our results and the aforementioned results could be attributed to the fact that in our study, we included the preoperative MELD score as a predictive value of morbidity after hemihepatectomy or extended hemihepatectomy.

MELD was developed as a reliable objective method to determine the risk of mortality in patients with cirrhosis only [11]. Nagorney and Kamath [20] documented that the conclusion on MELD cannot be drawn without data on the specific number of patients with cirrhosis and the exclusion of patients with chronic renal failure and anticoagulants that affect serum creatinine and INR (essential components of MELD score calculation). However, the applicability of MELD in patients without cirrhosis, irrespective of intervention, is unknown [20].

Nagorney and Kamath concluded from their study in 2006 that there was no index that is clinically useful in predicting operative risk, either morbidity or mortality, in this group of patients [20].

In the present work, the preoperative MELD score was significantly associated with posthemihepatectomy complications after adjusting for other confounders in a logistic-regression model and confirmation that there are no associations between bilirubin, serum creatinine, and INR and posthemihepatectomy complications.

In our study, only four cases of hepatic cirrhosis (one macroscopic and three microscopic) were included. Two of the microscopic cases had no postoperative complications (grade 1), whereas one case had grade 3a and the macroscopic case had postoperative complication grade 1; the patient was a known case of hepatitis C. Their MELD scores ranged between 6 and 10 preoperatively. Death was reported in six cases, yielding a mortality rate of 4.17%. In our study, the preoperative MELD score was not significantly associated with posthemihepatectomy mortality as four of the patients had MELD scores below 9 and two had MELD scores of 13 and 16.

Teh *et al.* [21] showed that the MELD score is predictive of postoperative mortality after hepatic resection for patients with cirrhosis and hepatocellular cancer. However, others have shown that MELD is predictive of perioperative mortality after other operations in patients with cirrhosis [22–24]. Our study could not confirm any of the aforementioned findings because there were six deaths and four patients with cirrhosis in our cohort as it was an exclusion criterion as mentioned before. We did not focus on the cirrhotic patients; our aim was to determine the significance of the MELD score even in noncirrhotic patients undergoing major hepatic operations to predict complications.

Breitenstein *et al.* [25] developed a simple score in 2010 to predict postoperative complications by severity after liver resection using readily available preoperative risk factors. Complications were assessed prospectively in 615 consecutive noncirrhotic patients undergoing liver resection at the same institution. In a randomly selected 60% of the population, multivariate logistic-regression analysis was used to develop a score to predict severe complications defined as complication grades III, IV, and mortality (grade V) (Clavien–Dindo classification). The score was validated by calibration in the rest of the 40% of the patients. Grade III–V complications occurred in 159 (26%) of the 615 patients after liver resection; 90 (15%) were grade III, 48 (8%) were grade IV, and 21 (3%) were grade V. Four preoperative parameters were identified as independent predictors including American Society of Anesthesiologists category, transaminases levels (AST), extent of liver resection (> 3 vs. <3 segments), and the need for an additional hepaticojejunostomy or colon resection. A prediction score was calculated on the basis of 60% of the population (369 patients) using the four independent predictors ranging from 0 to 10 points. The risk of developing serious postoperative complications was 16% in 'low-risk' patients (0–2 points), 37% in 'intermediate-risk' patients (3–5 points), and 60% in 'high-risk' patients (6–10 points). The predicted mean for absolute risk for grade III–V complications was 27% in the validation population including 40% of the patients ($n = 246$), whereas the observed risk was 24%. Predicted and observed risks were similar throughout the different risk categories ($P = 0.8$). The score was significantly associated with hospital and intensive care unit stays. Costs of the entire procedure doubled among the three risk groups.

In the present work, grade III–V complications occurred in 54 (37.5%) of the 144 patients after hemihepatectomy or extended hemihepatectomy; 41 (28.5%) were grade IIIa and IIIb, 7 (4.9%) were grade IVa and b, and 6 (4.17%) were grade V.

AST level preoperatively was not significantly associated with posthemihepatectomy complications and grade of complication. One of the preoperative predictors in the previous study was a liver resection of more than three segments; however, all the patients in our study underwent hemihepatectomy or extended hemihepatectomy.

Preoperative hepatic function as assessed by the serum bilirubin level was a potent predictor of postoperative complication as reported by Sitzmann and Greene [26]. In the present survey, bilirubin was not a predictor for posthemihepatectomy complications.

In 2009, Armstrong *et al.* [27] evaluated the predictive indices of creatinine, that is, whether elevated preoperative serum creatinine increased the risk of renal failure and nonrenal complications after liver resection. Data were studied from 1535 consecutive liver resections. Outcomes in patients with preoperative creatinine up to 124 μmol/l (group 1) were compared with those with preoperative creatinine of at least 125 μmol/l (group 2). Despite the differences in age and comorbidity, this study showed no difference in the rate of surgical complications between the two groups. Systemic complications accounted for the higher rates of postoperative morbidity in patients with elevated serum creatinine [27]. In our study, creatinine was not significantly associated with posthemihepatectomy complications and also the grade of complication. In the present work, creatinine was also not associated with the mortality as five out of six patients who died had normal preoperative creatinine levels, whereas only one patient had a preoperative creatinine level of 2.6 mg/dl. This can most probably be attributed to the relatively small sample size in our research.

Acknowledgments

The authors thank PD Dr. med T. Lorf for his fruitful directions, useful advice, professional cooperation, and endless support during the conduction of this work and they also thank Prof. Moataz M. Abdel-Fattah for his great support during the statistical analysis of this research work.

Conflicts of interest

There are no conflicts of interest.

References

1 Dimick JB, Wainess RM, Cowan JA, Upchurch GR Jr., Knol JA, Colletti LM. National trends in the use and outcomes of hepatic resection. *J Am Coll Surg* 2004; **199**:31–38.
2 Belghiti J, Hiramatsu K, Benoist S, Massault P, Sauvanet A, Farges O. Seven hundred forty seven hepatectomies in the 1990s: an update to evaluate the actual risk of liver resection. *J Am Coll Surg* 2000; **191**:38–46.
3 Dimick JB, Cowan JA Jr., Knol JA, Upchurch GR Jr. Hepatic resection in the United States: indications, outcomes, and hospital procedural volumes from a nationally representative database. *Arch Surg* 2003; **138**:185–191.
4 Jarnagin WR, Gonen M, Fong Y, DeMatteo RP, Ben-Porat L, Little S, *et al.* Improvement in perioperative outcome after hepatic resection: analysis of 1803 consecutive cases over the past decade. *Ann Surg* 2002; **236**:397–406, discussion 7.
5 Poon RT, Fan ST, Lo CM, Liu CL, Lam CL, Yuen WK, *et al.* Improving perioperative outcome expands the role of hepatectomy in management of benign and malignant hepatobiliary diseases: analysis of 1222 consecutive patients from a prospective database. *Ann Surg* 2004; **240**:698–708.
6 Sun HC, Qin LX, Wang L, Ye QH, Wu ZQ, Fan J, *et al.* Risk factors for postoperative complications after liver resection. *Hepatobiliary Pancreat Dis Int* 2005; **4**:370–374.
7 Wei AC, Tung-Ping Poon R, Fan ST, Wong J. Risk factors for perioperative morbidity and mortality after extended hepatectomy for hepatocellular carcinoma. *Br J Surg* 2003; **90**:33–41.
8 Sokol DK, Wilson J. What is a surgical complication? *World J Surg* 2008; **12**:9471–9476.

9 Dindo D, Clavien PA. What is a surgical complication? *World J Surg* 2008; **32**:939–941.
10 Dindo D, Demartines N, Clavien P. Classification of surgical complications; a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004; **240**:205–213.
11 Malinchoc M, Kamath PS, Gordon FD, Peine CJ, Rank J, ter Borg PC. A model to predict poor survival in patients undergoing transjugular intrahepatic portosystemic shunts. *Hepatology* 2000; **31**:864–871.
12 Kamath PS, Wiesner RH, Malinchoc M, Kremers W, Therneau TM, Kosberg CL, *et al*. A model to predict survival in patients with end-stage liver disease. *Hepatology* 2001; **33**:464–470.
13 Schroeder RA, Marroquini CE, Phillips Bute B, Khuri S, Henderson WG, Kuo PC. Predictive indices of morbidity and mortality after liver resection. *Ann Surg* 2006; **243**:373–379.
14 Kamath PS, Kim WR. The model for end-stage liver disease (MELD). *Hepatology* 2007; **45**:797–805.
15 UNOS (28.01.2009). MELD/PELD calculator documentation (PDF). Available at: *http://www.unos.org/*. [Accessed 28 January 2009].
16 Liu CI. Hepatic resection for hepatocellular carcinoma. *Med Bull* 2005; **10**:15–17.
17 Gupta S. 2012 Liver surgery. Health base online. Available at: *www.healthbase.com/resources/organ-transplant/liver-transplantation/liver-surgery.html*.
18 Virani S, Michaelson JS, Hutter MM, Lancaster RT, Warshaw AL, Henderson WG, *et al*. Morbidity and mortality after liver resection: results of the patient safety in surgery study. *J Am Coll Surg* 2007; **204**:1284–1292.
19 Enrico B, Alessandro C, Dario L, Gian Luigi A, Umberto B, Alessandro F, *et al*. Liver resective surgery: a multivariate analysis of postoperative outcome and complication. *Langenbecks Arch Surg* 2007; **392**:45–54.
20 Nagorney DM, Kamath PS. Predictive indices of morbidity and mortality after liver resection. *Ann Surg* 2006; **244**:635.
21 Teh SH, Christein J, Donohue J, Que F, Kendrick M, Farnell M, *et al*. Hepatic resection of hepatcellular carcinoma in patients with cirrhosis: model for end-stage liver disease (MELD score predicts perioperative mortality). *J Gastrointest Surg* 2005; **9**:1207–1215.
22 Suman A, Barnes DS, Zein NN, Levinthal GN, Connor JT, Carey WD. Predicting outcome after cardiac surgery in patients with cirrhosis: a comparison of Child–Pugh and MELD scores. *Clin Gastroenterol Hepatol* 2004; **2**:719–723.
23 Befeler AS, Palmer DE, Hoffman M, Longo W, Solomon H, Di Bisceglie AM. The safety of intra-abdominal surgery in patients with cirrhosis: model for end-stage liver disease score is superior to Child–Turcotte–Paugh classification in predicting outcome. *Arch Surg* 2005; **140**:650–654.
24 Northup PG, Wanamaker PC, Lee VD, Adams RB, Berg CL. Model for end-stage liver disease (MELD) predicts non-transplant surgical mortality in patients with cirrhosis. *Ann Surg* 2005; **242**:244–251.
25 Breitenstein S, De Oliveira ML, Raptis DA, Slankamenac K, Kambakamba P, Nerl J, *et al*. Novel and simple preoperative score predicting complications after liver resection in noncirrhotic patients. *Ann Surg* 2010; **252**:726–734.
26 Sitzmann JV, Greene PS. Perioperative predictors of morbidity following hepatic resection for neoplasm, a multivariate analysis of a single surgeon: experience with 105 patients. *Ann Surg* 1994; **219**:13–17.
27 Armstrong TH, Welsh F, Wells J, Chandrakumaran K, John T, Rees M. The impact of pre-operative serum creatinine on short-term outcomes after liver resection. *HPB (Oxford)* 2009; **11**:622–628.