Clinical Science

The impact of Model for End-Stage Liver Disease-Na in predicting morbidity and mortality following elective colon cancer surgery irrespective of underlying liver disease

Marlin Wayne Causey, M.D.a, Daniel Nelson, D.O.a, Eric K. Johnson, M.D.a, Justin Maykel, M.D.e, Brad Davis, M.D.b, David E. Rivadeneira, M.D.c, Brad Champagne, M.D.d, Scott R. Steele, M.D.a,*

aDepartment of Surgery, Madigan Army Medical System, Madigan Health System, 9040a Fitzsimmons Dr, Tacoma, WA 98431, USA; bUniversity of Cincinnati, Cincinnati, OH, USA; cCatholic Health Services of Long Island, Rockville Centre, NY, USA; dCase Western, Cleveland, OH, USA; eUniversity of Massachusetts Memorial Medical Center, Worcester, MA, USA

Abstract

BACKGROUND: The Model for End-Stage Liver Disease Sodium Model (MELD-Na) is a validated scoring system that uses bilirubin, international normalized ratio, serum creatinine, and sodium to predict mortality in cirrhotic patients awaiting liver transplantation. The aim of this study was to identify the utility of MELD-Na to predict patient outcomes, with and without liver disease, after elective colon cancer surgery.

METHODS: A review of the American College of Surgeons National Surgical Quality Improvement Program database (2005 to 2010) was conducted to calculate risk-adjusted 30-day outcomes using regression modeling.

RESULTS: A total of 10,842 patients (mean age, 68 years; 51% women) were included. MELD-Na scores were higher in men (10.2 vs 9.1, P < .001) and in open procedures (9.9 vs 9.1, P < .001). The overall complication and mortality rates were 26.3% and 3.3%, respectively. Incremental increases in MELD-Na score correlated with a 1.2% increase in mortality and a 1.1% increase in complications. On multivariate analysis, complications increased with MELD-Na score (odds ratio [OR], 1.05 per 1 point increase; 95% confidence interval [CI], 1.038 to 1.066). MELD-Na score was also associated with increased mortality (OR, 1.13; 95% CI, 1.1 to 1.16), along with ascites (OR, 5.7; 95% CI, 3.7 to 8.8) and corticosteroids (OR, 2.1; 95% CI, 1.3 to 3.3).

The investigators have adhered to the policies for the protection of human subjects as prescribed in 45 CFR 46. The views expressed are those of the authors and do not reflect the official policy of the US Department of the Army, the US Department of Defense, or the US government. This report has been approved by the Madigan Army Medical Center Human Use Institutional Review Board. The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in it are the sources of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

The authors declare no conflicts of interest.

* Corresponding author. Tel.: +1-253-968-2200; fax: +1-253-968-0232.
E-mail address: harkersteele@mac.com

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The medical community has attempted to quantify surgical risk for decades, resulting in a wide array of configurations that encompass several different variables. The most common risk stratification tests use patient preoperative comorbidities, physiologic laboratory data, or a combination of both. No more is this more apparent than in transplantation surgery, in which risk assessment plays a major role in the selection of organ recipients. Yet a major limitation of many of these assessment methods involved the inclusion of subjective measures, which led to the adoption of a more standardized approach and use of newer risk adjustment tools.

The Model for End-Stage Liver Disease (MELD) was developed and validated originally as an accurate predictor of survival in patients with chronic liver disease. The success achieved with this method led to a broader application of MELD in predicting operative mortality for cirrhotic patients undergoing various surgical procedures as a more generalized risk assessment tool. Current evidence demonstrates that a revised MELD formula incorporating serum sodium is superior compared with the original model, especially in those patients with lower MELD scores. One advantage of the MELD Sodium Model (MELD-Na) scoring system is that it uses the readily available laboratory values of bilirubin, international normalized ratio (INR), serum creatinine, and serum sodium. Because of the simplicity of the scoring system and success in other settings, we sought to study the effectiveness of MELD-Na in predicting postoperative adverse outcomes after elective colon cancer surgery.

Methods

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database (2005 to 2010) was used to calculate risk-adjusted 30-day outcomes using regression modeling, accounting for patient demographics, comorbidities, and surgical procedures. The ACS-NSQIP database gathers information on health care quality through a compilation of preoperative risk factors, intraoperative factors, and postoperative 30-day morbidity and mortality in patients who undergo major surgical procedures. The data are collected by a dedicated surgical clinical nurse reviewer at each site after both inpatient and outpatient procedures for 30 days postoperatively on 21 defined complications. Data in the ACS-NSQIP database are deidentified to ensure no patient identifiable factors. The Madigan Healthcare System Institutional Review Board approved this study. Specific details of the data collection, inclusion and exclusion criteria, training of the actuaries, and the method of random sampling are described by the ACS-NSQIP.

Patients were identified using Current Procedural Terminology codes for colectomy (44140, 44141, 44134, 44144, 44145, 44146, 44150, 44155, 44160, 44202, 44204, 44205, 44207, 44210, 44211, 44212, 45110, and 45123) and International Classification of Diseases, Ninth Revision, codes for colonic malignancy (230.3, 230.4, 230.5, 153.0, 153.1, 153.19, 153.2, 153.3, 153.4, 153.5, 153.7, 153.6, 153.69, 153.8, 153.9, 154.0, 154.19, 154.1, 154.2, 154.3, and 154.8). Only elective cases were included. Suspected liver disease was defined as patients with >2 drinks per day, esophageal varices, or ascites. Operative procedures were categorized into 4 separate categories: open partial colectomy, total abdominal colectomy, laparoscopic partial colectomy, and laparoscopic total abdominal colectomy. To calculate the MELD-Na score, we initially determined the MELD score using the following methodology: MELD score = 3.8 × [log (e) (bilirubin mg/dL)] + 11.2 × [log (e) (INR)] + 9.6 × [log (e) (creatinine mg/dL)] + 6.43, with a lower limit of 1 for all variables and with creatinine capped at 4; creatinine was set at 4 if the patient was receiving renal replacement therapy. The MELD score (rounded to the nearest integer) ranges from 6 to 40, with higher values indicating more severe disease. This was then applied to the MELD-Na equation (MELD-Na score = MELD score – Na – {0.025 × MELD score × [140 – Na]} + 140), where the serum sodium concentration (Na) is bound between 125 and 140 mmol/L. Like the MELD score, the MELD-Na score was rounded to the nearest integer.

A receiver operating characteristic curve was used to determine the optimal cutoff point for MELD-Na score for analysis of the primary end points of morbidity and mortality, and this was entered into the multivariate model. Statistical analysis was performed using PASW version 19.0 (SPSS, Inc, Chicago, IL). Categorical variables are represented as rates and continuous variables as mean ± SD. Categorical variables were analyzed using chi-square analysis and continuous variables using Student’s t tests. Preoperative comorbidities, physiologic data, and MELD-Na score were entered into multivariate logistic regression analysis a priori. Statistical significance was reported on the multivariate model using a 95% confidence interval with an z level of .05.

Results

Within the study period, 10,842 patients (mean age, 68 years; 51% women) met the inclusion criteria (Table 1). By procedure, 47% (n = 5,055) underwent open partial colectomy, 19% (n = 2,031) total abdominal colectomy, 34% (n = 3,685) laparoscopic partial colectomy, and .7%
(n = 71) laparoscopic total abdominal colectomy. Overall, 52% were white, 13.3% black, 6.9% unknown, 3.0% Asian or Pacific Islander, and 1.5% Hispanic. The primary lesion was left sided in 39% of operations, right sided in 46%, and in 16% was located in the transverse colon. Mean serum laboratory values were 139 ± 6 mEq/L for sodium, 1.01 ± 0.59 mg/dL for creatinine, 1.09 ± 0.24 for INR, and 0.59 ± 0.51 mg/dL for bilirubin. MELD-Na scores were slightly higher in men (10.2 vs 9.1, P < .001) and in open procedures (9.9 vs 9.1, P < .001). When stratified by type of procedure, MELD-Na was lowest for laparoscopic total abdominal colectomy (8.7), followed by laparoscopic partial colectomy (9.2), partial colectomy (9.9), and total abdominal colectomy (10.0).

Comorbidities were similar within the cohort on the basis of type of operation (Table 1). For the entire cohort,
the overall complication rate was 26.3%, and the mortality rate was 3.3%. Complication rates were significantly higher in open cases and patients undergoing total abdominal colec- 

tomy ($P < .001$; Table 2). Similarly, mortality was in- 

creased with open procedures and with extended resection 

compared with laparoscopic and segmental colectomies 

($P < .001$). With each incremental increase in MELD-Na 

score, there was a significant unadjusted increase of 1% 

for mortality and a 1.6% increase in complication develop- 

ment (Fig. 1).

A receiver operating characteristic curve (area under the 

curve, .58; 95% confidence interval, .57 to .59; $P < .001$; 

Fig. 2) for complications indicated that MELD-Na score 

had an optimal cutoff point of 9 and was significantly asso- 

ciated with a 1.3-fold increased risk for complications on 

multivariate analysis along with body mass index $\geq 30$ 

kg/m$^2$, preoperative transfusion, and history of myocardial 

infarction (full listing in Table 3). Similarly, MELD-Na 

score, when dichotomized at $\geq 8$ (area under the curve, 

.713; $P < .001$), was associated with a 2.7-fold increase 

in mortality, along with ascites, do-not-resuscitate orders, 

congestive heart failure, and preoperative weight loss 

$> 10\%$ (full listing in Table 3).

**Comments**

Proper preoperative risk assessment is essential in modern surgical practice to provide realistic estimates of outcomes during counseling as well to identify, and intervene if possible, on at-risk patients. Methods of stratifying patients on the basis of their risk and referral for preoperative consultation are often based on surgeons’ experience and their general assessments of patients. Other methods of risk stratification have proven successful, directing comprehen- 

sive evaluations for patients preparing for elective surgery; however, they can be cumbersome and variably interpreted by medical consultants. The development of a simple and easy-to-use formula to adequately identify surgical risk can minimize the overutilization of consultants, while identifying patients with higher than normal risk, many of whom are not under routine medical care. MELD and MELD-Na
are both methods that have been used successfully to evaluate patients for transplantation listing and organ prioritization. Our study further demonstrates that MELD-Na scoring can also be used to assess the preoperative risk for all patients, both with and without underlying liver disease, before elective colon surgery. On the basis of 4 laboratory values (sodium, creatinine, INR, and bilirubin), this method is easier to use than other published physiologic methods, such as Acute Physiology And Chronic Health Evaluation I, II, and III, and lends itself to less subjectivity compared with the Goldman and Eagle classifications.

Overall, patients undergoing elective colon surgery had a 26.2% complication rate, and this was lower in patients undergoing laparoscopic colon surgery. Additionally, mortality rates were low in the overall patient cohort at 3.3% with lower complication rates when stratifying into open (8.0%) and laparoscopic (3.1%) surgical technique. This difference might be due (at least in part) to the fact that patients undergoing laparoscopic operations had lower MELD-Na scores, reflecting their overall better physiologic states. This is important because most modern evidence-based studies seek to stratify patients only on the basis of demographic profiles, which may be misleading without additionally stratifying patients on the basis of their overall health and physiologic states (so-called physiographics).

This method of physiologic stratification may prove beneficial in identifying patients with preoperative risk factors that increase the risk for complications and death outside of the “clinical gestalt.” This study found that a MELD-Na score above the receiver operating characteristic curve–derived cutoff of 9 was associated with a 1.3-fold increase in complications and >8 with a 2.7-fold increased risk for death. Additional risk factors that increase the risk for both morbidity and mortality include significant preoperative weight loss and metastatic cancer. The complete list of preoperative factors leading to increased risk is outlined in Table 3. The importance of these factors is not just that they increase the risk for complications and death but that these factors, when combined with the MELD-Na scoring system, would identify patients at greatest risk for adverse postoperative complications. This would add yet another tool to the current clinical armamentarium, which might prove to some clinicians to be quicker and efficient, because only 4 laboratory values are needed to obtain a physiologic assessment.

There are, however, several limitations to using this type of formula in assessing patient risk. First, this method does not identify specific complications that might occur (ie, prolonged ventilation, myocardial infarction) and only broadly identifies patients with increased risk. However, when this method is combined with published risk
stratification models by subspecialty medical services, patient outcomes might be improved and surgical care enhanced. This technique of identifying patients with increased risk should be viewed more as an adjunct to clinical judgment and represents a manner in which busy surgeons may rapidly and easily identify patients with increased risk. High-risk patients may proceed with preoperative medical evaluations and appropriate patient counseling. Another limitation is that this method has not been studied in a prospective manner on this patient cohort (elective colectomies). Although this method helps accurately assess risk using retrospective data, further study is essential in a prospective manner to fully understand the importance of this type of risk stratification model.

### Conclusions

MELD-Na is a useful tool in assessing preoperative risk. Although it is most extensively studied and validated in the transplantation literature, we have shown that MELD-Na is also useful in assessing risk for postoperative morbidity and mortality after elective colon surgery. This study demonstrates the increased rate of complications and mortality that are directly proportional to the preoperative MELD-Na score. The addition of “physiographic” measurements adds to the current risk assessment process and should prove beneficial to surgeons as they assess preoperative risk and consider the need for preoperative interventions aimed at minimizing operative risk and optimizing outcomes.

### References