PANCREAS, BILIARY TRACT, AND LIVER

An Automated Model Using Electronic Medical Record Data Identifies Patients With Cirrhosis at High Risk for Readmission

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BACKGROUND & AIMS: **Patients with cirrhosis have 1-month rates of readmission as high as 35%. Early identification of high-risk patients could permit interventions to reduce readmission. The aim of our study was to construct an automated 30-day readmission risk model for cirrhotic patients using electronic medical record (EMR) data available early during hospitalization.**

METHODS: **We identified patients with cirrhosis admitted to a large safety-net hospital from January 2008 through December 2009. A multiple logistic regression model for 30-day rehospitalization was developed using medical and socioeconomic factors available within 48 hours of admission and tested on a validation cohort. Discrimination was assessed using receiver operator characteristic curve analysis.**

RESULTS: **We identified 836 cirrhotic patients with 1291 unique admission encounters. Rehospitalization occurred within 30 days for 27% of patients. Significant predictors of 30-day readmission included the number of address changes in the prior year (odds ratio [OR], 1.13; 95% confidence interval [CI], 1.05–1.21), number of admissions in the prior year (OR, 1.14; 95% CI, 1.05–1.24), Medicaid insurance (OR, 1.53; 95% CI, 1.10–2.13), thrombocytopenia (OR, 0.50; 95% CI, 0.35–0.72), low level of alanine aminotransferase (OR, 2.56; 95% CI, 1.09–6.00), anemia (OR, 1.63; 95% CI, 1.17–2.27), hyponatremia (OR, 1.78; 95% CI, 1.14–2.80), and Model for End-stage Liver Disease score (OR, 1.04; 95% CI, 1.01–1.06). The risk model predicted 30-day readmission, with c-statistics of 0.68 (95% CI, 0.64–0.72) and 0.66 (95% CI, 0.59–0.73) in the derivation and validation cohorts, respectively.**

CONCLUSIONS: **Clinical and social factors available early during admission and extractable from an EMR predicted 30-day readmission in cirrhotic patients with moderate accuracy. Decision support tools that use EMR-automated data are useful for risk stratification of patients with cirrhosis early during hospitalization.**

Keywords: Rehospitalization; Risk Model; Liver Disease; Quality of Care; Hepatic Informatics.

Cirrhosis affects more than 5.5 million patients and costs nearly $4 billion annually.[1] The burden of cirrhosis is anticipated to increase over the next 10 years, beyond the 1 million hospitalizations per year currently attributed to liver disease.[2] Unfortunately, our episodic system of health care delivery is suboptimal for patients with chronic disease, such as cirrhosis.[3] Patients with cirrhosis remain at high risk for frequent readmissions, with more than one third of patients being rehospitalized within 1 month of discharge.[4]

Readmission within 30 days of hospitalization has emerged as a focus of quality improvement and payment reform.[5,6] The Center for Medicare and Medicaid Services estimates that more than 13% of readmissions may be avoidable and will reduce reimbursements to hospital systems with excess readmissions.[7] Although interventions such as careful discharge planning can prevent readmissions, these programs are challenging to sustain because of competing financial needs.[8]

Abbreviations used in this paper: ALT, alanine aminotransferase; CI, confidence interval; EMR, electronic medical record; ICD-9, International Classification of Diseases, 9th revision; IDI, integrated discrimination improvement; INR, international normalized ratio; MELD, Model for End-stage Liver Disease; OR, odds ratio.

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Hospitals and health systems across the United States are in the midst of an unprecedented implementation of electronic medical records (EMRs).[9] The opportunities that these systems might afford to improve the care of patients with cirrhosis have not been explored fully.[3] The use of real-time EMR data available on admission, instead of administratively coded data from discharge (which often is not verified until 2–3 mo after discharge), can facilitate early identification of high-risk patients, allowing implementation of interventions during a hospitalization to reduce readmission. Although low-risk patients could be considered for early discharge, high-risk patients might be triaged to specialized hospital services, intensive case management, and earlier clinic visits after discharge. Furthermore, decision support systems that incorporate EMR-based risk models may help allocate limited resources. Electronic predictive models are particularly attractive because they may be introduced quickly and cheaply, after implementation of an EMR. Although several studies have attempted early risk stratification of patients with chronic diseases, such as congestive heart failure, to identify subjects for targeted interventions during hospitalization, this area has not been evaluated extensively in patients with cirrhosis.[10–13]

We hypothesized that an automated model using both clinical and nonclinical factors, available within 48 hours of admission, could stratify readmission risk among patients with cirrhosis, drawing on the explanatory power of social, behavioral, and utilization factors. In this study, we constructed an electronic model of 30-day readmission risk, using present-on-admission data, which commonly is available to hospitals with an EMR.

Methods

Study Population

We conducted a retrospective cohort study of patients with cirrhosis admitted to Parkland Memorial Hospital between January 2008 and December 2009. As the sole safety-net hospital for Dallas County, Parkland Hospital cares for a large portion of cirrhotic patients in the area. Patients initially were identified using International Classification of Diseases, 9th revision (ICD-9) codes: 571.2 (alcoholic cirrhosis), 571.5 (nonalcoholic cirrhosis), 572.3 (portal hypertension), 572.2 (hepatic encephalopathy), 456.0 to 456.2 (esophageal varices with and without bleeding), 789.5 (ascites), 789.59 (nonmalignant ascites), 567.23 (spontaneous bacterial peritonitis), and 572.4 (hepatorenal syndrome). The EMR was reviewed by one author (A.G.S.), who was blinded to readmission outcome, to confirm cirrhosis diagnosis, defined as consistent histology or a cirrhotic-appearing liver on imaging with portal hypertension (ascites, encephalopathy, varices, or splenomegaly with thrombocytopenia) (see the Supplementary Appendix for details).[14] The author was provided with a list of patients, identified by the ICD-9 code case-finding algorithm, but not provided with admission dates, or informed about readmission status. The author reviewed the pathology data, imaging studies, and laboratory data to determine the presence of cirrhosis, but did not access progress notes or encounters for this analysis. Patients were excluded if they died during the index (ie, initial) hospitalization, died within 30 days after discharge, or underwent liver transplantation. An index hospital encounter was defined as any nonelective admission, without prior admission within 30 days of the index admission date. The nature of admission (elective vs nonelective) is coded electronically, so exclusion of elective admission was possible using automated data. For patients with multiple admissions, each was considered as a separate admission if more than 30 days had elapsed between hospitalizations.

Outcome Variables

Our primary outcome was any-cause rehospitalization, excluding elective admissions, to any of the 136 hospitals in the Dallas–Fort Worth area within 30 days of the index hospitalization. We determined readmission to any of the hospitals using a probabilistic linkage service available through the Dallas–Fort Worth Hospital Council, a regional information sharing initiative (see the Supplementary Appendix for details). Although readmission data returned de-identified, we confirmed validity of the linkage by comparing readmissions with the index institution with an indicator variable precoded in the dataset, resulting in 100% agreement.

A secondary outcome was all-cause mortality within 90 days of discharge. Patients who died during the index hospitalization were excluded, but we included patients who died after discharge. We identified deceased patients by reviewing the last encounter in the EMR after discharge; patients without an encounter 90 days after discharge were classified using the Social Security Death Index.

Predictor Variables

Candidate risk factor variables for the electronic model had to meet 3 criteria: capable of extraction from the EMR, routinely available within 48 hours of hospitalization, and available to most hospitals with a basic EMR, as judged by consensus of an interdisciplinary team. A conceptual framework of readmission based on literature review and clinical expertise was developed.[15]

Clinical data were collected, using structured data and ICD-9 codes, including demographics (age, sex, race), alcohol and tobacco history, etiology of cirrhosis, history of decompensation (ascites, hepatic encephalopathy, or variceal bleeding), hepatocellular carcinoma, extrahepatic cancer, comorbid conditions, and reason for index hospitalization. Laboratory values of interest included white blood cell count, platelet count, sodium level, creatinine level, albumin level, aspartate aminotransferase level, alanine aminotransferase (ALT) level, bilirubin level, and international normalized ratio (INR) at admission. The Model for End-stage Liver Disease (MELD) score, which correlates with 90-day survival,[16] also served as a measure of illness at admission.

Markers of social, behavioral, and utilization activity available using electronic data sources on presentation were recorded (Table 1). These variables were hypothesized to represent measures of social instability or low socioeconomic status (eg, number of address changes in the prior year and insurance status), risky health behavior (eg, history of cocaine), or health care use patterns (eg, number of emergency room visits in the prior year) that could influence readmission risk. In addition, we identified the presence of depression and anxiety using ICD-9 CM codes because they have been linked to negative health behaviors. We also investigated 30-day readmission as a predictor for 90-day mortality. All variables were extracted from the hospital's EMR (EPIC Systems Corporation, Verona, WI)