Assessing the Impact of Early Albumin Administration in Patients Requiring Intravascular Resuscitation: Application of Machine Learning Techniques to Electronic Health Record (EHR) Data

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BACKGROUND

- Patients with decompensated cirrhosis present with various complications that are associated with increased morbidity and mortality
- Albumin administration has been associated with reduced mortality when used for managing cirrhosis-related complications, particularly spontaneous bacterial peritonitis and hepatorenal syndrome, and is effective in other conditions such as sepsis/septic shock and nephrotic syndrome[1,2,3,4]
- However, the impact of albumin administration and its timing on outcomes for other liver disease-associated complications and conditions requiring fluid resuscitation is unclear

OBJECTIVE

- Leverage machine learning (ML) techniques on electronic health records data from patients with gastrointestinal (GI) bleeding and anemia, alcoholic liver disease, hepatic failure, acute pancreatitis, and nephrotic syndrome, to identify subpopulations that may benefit from early albumin administration

DATA SOURCE AND PATIENT SELECTION

- The study was conducted using de-identified patient records from Cerner Real World Data (CRWD) which consists of more than 100 million unique patients and over 1.5 billion patient encounters across 117 health systems in the United States
- Adult patients (≥18 years) with encounters between October 2015 and March 2022 were identified and ICD-10-CM diagnosis codes were used to select five different cohorts of patients with the following conditions:
  1. GI bleeding with anemia
  2. Alcoholic liver disease
  3. Hepatic failure
  4. Acute pancreatitis
  5. Nephrotic syndrome

METHODS

- A cross-sectional ML-based study using CRWD was conducted. Exposure groups were 'early albumin' (infusion ≤ 24 hours of hospital admission) and 'late albumin/no albumin' (infusion > 24 hours after admission or no albumin at all)
- The two cohorts based on albumin timing were 1:1 propensity score matched on baseline patient characteristics, patient acuity measures such as Simplified Acute Physiology Score (SAPS), and qSOFA score using logistic regression and k-nearest neighbor models

METHODS (cont.)

- Decision Tree models predicted 4 outcomes: 30-day mortality, 90-day readmission, hospital length of stay (LOS), and hospital-free days in a 90-day period (HFDs), which is a composite measure accounting for mortality, readmission, and LOS during the 90-day period following an encounter. The models were trained on matched data and used to identify patient subgroups of interest by tracing back to the root of the decision tree
- Decision Tree models were visually assessed to identify relevant splits for patient subgroups. These conditions were then applied to the full dataset to validate model performance and extract subgroups of interest. Significance testing was conducted on subgroups using a Chi-square test

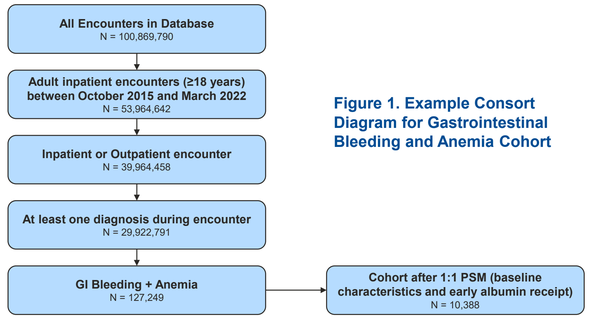
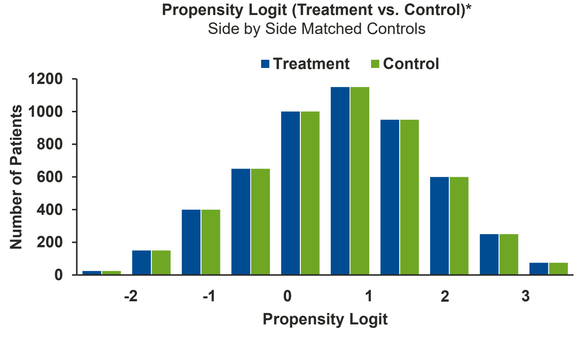


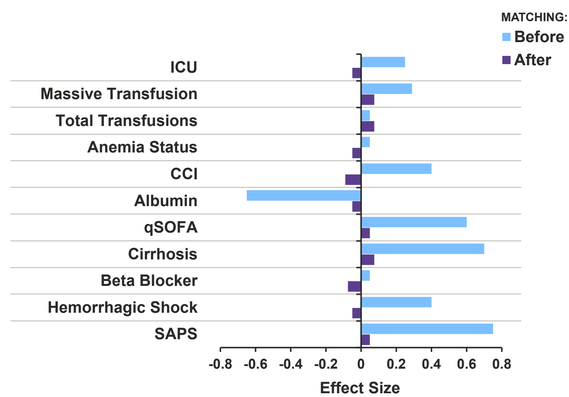
Figure 1. Example Consort Diagram for Gastrointestinal Bleeding and Anemia Cohort

Figure 2. Results of logistic regressions fitted on the two classes in a balanced fashion (multiple logits were used to compensate for class imbalance). Regressions were repeated until all entries from the larger class had a score



*early albumin group is treatment; late/no albumin group is control

Figure 3. Comparisons of the residual standardized mean differences before and after matching. Cohen's D calculations were used to determine the effects of the difference between the treatment and matched control groups on each covariate

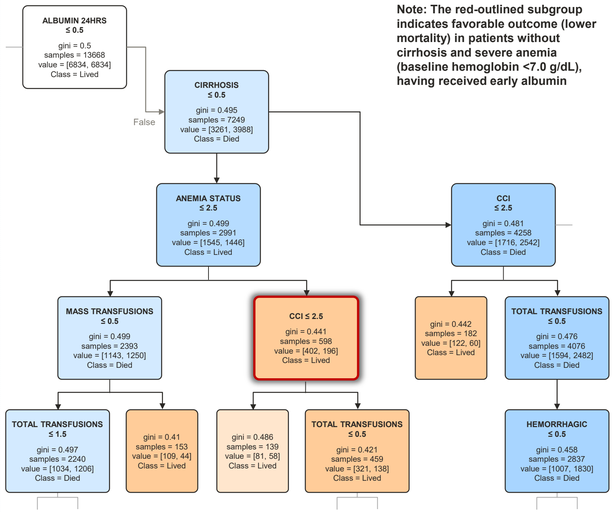


Abbreviations: CCI, Charlson Comorbidity Index; ICU, intensive care unit; SAPS, Simplified Acute Physiology Score; qSOFA, quick sequential organ failure assessment

RESULTS

- A total of 361,704 distinct patients were analyzed across five cohorts, with positive signals observed in the GI bleeding with anemia cohort. A 1:1 PSM yielded 10,388 patients (5,194 in each of the early albumin and late albumin/no albumin groups) in the GI bleeding with anemia cohort
- The propensity logit distributions between the treatment and control were similar (Fig 2), and effect sizes were substantially lower, indicating that the matching was successful (Fig 3)
- The decision tree model fit identified albumin timing (indicating whether a patient received early albumin) as the most important variable in predicting 30-day mortality. Additional variables with high importance to the model included cirrhosis, anemia status (ranging from mild to severe), and Charlson Comorbidity Index
- The model indicated lower 30-day mortality for the subgroup (n=598) with no cirrhosis and severe anemia (baseline hemoglobin <7.0 g/dL), in patients receiving early albumin. This prediction was validated using the full dataset, where this subgroup had a 25.8% lower 30-day mortality rate compared to those who did not receive early albumin (p=0.04)

Figure 4. Decision Tree excerpt for the GI bleeding and anemia cohort



Note: The red-outlined subgroup indicates favorable outcome (lower mortality) in patients without cirrhosis and severe anemia (baseline hemoglobin <7.0 g/dL), having received early albumin

CONCLUSIONS

- ML techniques were used to identify patient subgroups that may benefit from early albumin among five distinct cohorts and found that early albumin was associated with lower 30-day mortality in patients with severe anemia and no cirrhosis
- The study highlights the potential of supervised ML approaches in disease prediction and patient outcomes identification. Similar ML techniques could be applied to identify additional hidden patient populations likely to benefit from albumin administration

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