Mean Arterial Pressure and Acute Kidney Injury in the ICU

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Background

Acute kidney injury (AKI) is a syndrome describing a range of clinical conditions involving rapid loss of kidney function, largely diagnosed based on changes in serum creatinine and urine output (Mehta, et al.). AKI has been found to affect 36% of all patients admitted to some ICUs (Bagshaw, George, et al.), and small increases in serum creatinine content have been correlated with severe increases mortality rates (Chertow, et al.).

Studies in experimental animals have demonstrated a relationship between hypotension and AKI. However, this relationship is less well understood in septic patients in clinical ICU settings, even though previous studies have found AKI to be a frequent complication in septic patients (Hoste, et al.). Prior studies have investigated hypotension in septic patients with AKI, but focus on the effects of alternative treatments including antimicrobial therapy (Bagshaw, Lapinsky, et al.; Kumar, et al.). Lehman et al. directly describe a relationship between hypotension and AKI for the general adult ICU population. This study will replicate several of the key characteristics of the study performed by Lehman et al., but performs this analysis specifically for patients with sepsis. Additionally, this study applies the results to determine if there exists a MAP threshold below which patients are considered at-risk for AKI.

Research Hypothesis

Lower mean arterial pressure (MAP) on during the first 72 hours following admission to the ICU is associated with a higher risk of acute kidney injury. The MAP threshold under which a patient is considered at-risk for AKI differs for patients of different ethnicities, ages, and diagnoses on admission to the ICU.

Research Question and Objectives

This study aims to investigate the relationship between MAP on admission to the ICU and AKI in septic ICU patients. This study uses three different outcomes as indicators of AKI. In particular, this study will determine if a higher proportion of patients with low MAP:

- Require dialysis *during* the ICU stay
- Require dialysis *after* the ICU stay
- Have elevated creatinine on discharge

These results will be reported separately for patients who either do or do not take vasopressors during the first 72 hours of stay in the ICU, and for patients of different ethnicities, ages, and diagnoses on admission.

The results will be used to determine if there exist MAP thresholds above which a critical percentage of patients develop acute kidney injury. These thresholds will be calculated separately for each separate class of patients, with the ultimate goal of determining specialized MAP targets for different patient populations.

Data Sources

Data will be drawn from the MIMIC-III database, an open access database that stores deidentified clinical records from Beth Israel Deaconess Medical Center. All necessary data is available within the MIMIC-III database (Johnson, et al.).

Study Population

The study population will be chosen from 38,597 unique adult patients above age 18 admitted to BIDMC from the years 2001 to 2012. Amongst these patients, the study will analyze only the first admission of all patients who: (1) developed sepsis as defined by the Angus criteria during their stay in the ICU, (2) were not admitted to the ICU with end-stage renal disease, (3) were admitted with creatinine levels below 1.2 mg/dL, and (4) survive an ICU stay lasting at least 3 days.

Study Outcomes

This study will primarily analyze three outcomes in adult septic patients with low MAP measurements on admission to the ICU:

- *Whether patients required dialysis during their ICU stay:*
  Patients will be labeled as requiring dialysis during their ICU stay if any of the following strings are recorded in Metavision: 'Dialysis Line', 'CAVH Start', 'CAVH D/C','CVVHD Start','CVVHD'.
- *Whether patients required dialysis after their ICU stay:*
  Patients will be labeled as likely to require dialysis after the ICU stay on discharge if they begin CRRT during the ICU stay, transition to hemodialysis, and remain on hemodialysis up to 72 hours prior to discharge or later.
- *Creatinine levels upon patient discharge:*
  Patients will be labeled as having high creatinine on discharge if their final recorded creatinine measurement is above 2.0 mg/dL.

Additionally, urine output, lactate, and blood urea nitrogen will be recorded.

Covariate of Interest

Patients will be sorted according to several covariates. In particular, patients will be first divided into groups based on whether they did or did not receive vasopressors over the course of the first 72 hours of their ICU stay. Patients will be further divided into subgroups based on (1) ethnicity, (2) age, and (3) diagnosis on admission. Within these subgroups, the rate of occurrence of each outcome for patients from each category will be binned into quartiles based on several features of MAP readings from the first 72 hours of stay in the ICU. These features tentatively include the minimum observed MAP reading, integrated total MAP, and lowest MAP threshold under which patients spend at least 10 hours.

Confounders

Potential confounding variables for this study include patients' severity of illness scores as well as differences in measurement of MAP via arterial line versus measurement via traditional blood pressure cuff.

Conclusions

The results of this work will provide clinicians with guidance regarding the appropriate MAP threshold below which septic patients are considered at-risk for AKI, and thus affects the care received by these patients. This study only analyzes septic patients admitted to ICUs without end-stage renal disease or high serum creatinine content, and does not generalize to patient populations beyond these. Future studies could extend this analysis to predict the degree of severity of AKI or to correlate MAP with 90-day mortality in septic ICU patients.

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