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Investigating the Relationship Between Mean Arterial Pressure and Acute Kidney Injury in the ICU

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 severely higher mortality rates (Chertow, et al.).

Studies in experimental animals have demonstrated a relationship between hypotension and AKI, but this relationship is less well understood in clinical ICU settings. 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 a MAP threshold below which patients are considered at-risk for AKI.

Research Hypotheses

A higher proportion of patients with low mean arterial pressure (MAP) on admission to the ICU develop acute kidney injury than patients with average mean arterial pressure.

Research Question and Objectives

This study aims to investigate the relationship between MAP on admission to the ICU and acute kidney injury in septic ICU patients. In particular, this study will determine whether a higher proportion of patients with low MAP require dialysis than corresponding patients with average MAP. Additionally, this study will determine whether a higher proportion of patients with low MAP have elevated creatinine on discharge. These results will be reported separately for patients taking 0, 1, or 2 vasopressors during the first 72 hours of stay in the ICU. Additionally, this study will control for variation in systolic blood pressure.

After this relationship is analyzed, the results will be used to determine appropriate MAP thresholds for considering a patient at risk for acute kidney injury.

Data Sources

Data will be drawn from the MIMIC-III database. MIMIC-III is an open access database that stores deidentified clinical records of patients at Beth Israel Deaconess Medical Center (BIDMC). All of the data required for this study is available within the MIMIC-III database and does not require additional data linkages (Johnson, et al.).

Study Population

The study population will be chosen from 38,597 unique adult patients 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 5 days.

Study Outcomes

This study will analyze whether or not patients required dialysis during and after their ICU stay as well as patients' creatinine levels upon discharge. In particular, patients will be labeled as requiring dialysis if one of the following ITEMIDs are present: 152, 148, 149, 146, 147, 151, or 150. Patients will also be labeled as requiring dialysis of one of the following text strings is logged in Metavision: 'Dialysis Line', 'CAVH Start', 'CAVH D/C','CVVHD Start','CVVHD D/C','Hemodialysis st'. Patients will be labeled as having high creatinine on discharge if their final recorded creatinine measurement is above 2.0 mg/dL.

Covariate of Interest

Patients will be sorted according to two covariates: mean arterial pressure and the number of vasopressors taken by the patient within the first 72 hours of the ICU stay. In particular, patients will be divided into subgroups based on whether they received 0, 1, or 2 vasopressors over the course of the first 72 hours of their ICU stay. Within these subgroups, patients will be binned into one of the following ranges by mean arterial pressure on admission to the ICU: 55-60 mmHg, 60-65 mmHg, 65-70 mmHg, and 70-75 mmHg.

Confounders

Systolic blood pressure correlates closely with MAP, but these two measurements can diverge from each other. Systolic blood pressure measurements for patients will be divided into the same bins as MAP: 55-60 mmHg, 60-65 mmHg, 65-70 mmHg, and 70-75 mmHg. Then, variations in systolic blood pressure will be controlled for.

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. 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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