Sodium MRI for the Prognosis of Acute Kidney Injury

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Background & Rationale:
An important function of the kidney is to maintain solute and water balance. The corticomedullary salt gradient (CM SG) is an increasing osmolar gradient from the kidney cortex to the inner medulla. The CM SG draws water from the tubules and helps to concentrate urine. In patients with acute kidney injury (AKI), there is a decrease in sodium reabsorption from the tubules and a consequent decrease in the CM SG. Currently, AKI affects up to 67% of patients in the intensive care unit with a mortality rate of 60%\(^1\). At present, a biopsy of the kidney to obtain tissue is the gold standard to prognosticate kidney recovery in patients with AKI. Unfortunately, this is an invasive procedure with risks of bleeding, discomfort, and sampling error. The abundance of sodium in the kidney makes imaging with sodium MRI (\(^{23}\)Na-MRI) a feasible, non-invasive, prognostic tool in these patients.

Study Hypotheses:
We hypothesize that the sodium gradient will be decreased in patients with AKI compared to controls. We hypothesize that patients with reconstitution of the sodium gradient will have improved clinical markers of kidney function compared to those that do not.

Methods & Analysis:
This study includes 20 patients age 18 years or greater with AKI, defined as an increase in serum creatinine by 26.5\(\mu\)mol/L within 48 hours, or an increase in serum creatinine by 1.5 times the baseline value within 7 days, or a decrease in urine output to less than 0.5mL/kg/hr over 7 hours. There are two separate study visits. The first visit occurs within 7 to 10 days of the diagnosis of AKI. The second visit occurs within 21 to 28 days of the diagnosis of AKI. The study protocol for both visits is the same. There is a control group of 10 patients without known kidney disease to whom the experimental AKI group will be compared.

Patients receive bloodwork for kidney function and electrolytes, as well as urine testing. Imaging is done using the 3T MRI scanner with a pulse sequence adapted for sodium imaging. A T2-weighted proton MRI allows for anatomic localization of the kidney. Subsequently, the patient undergoes \(^{23}\)Na-MRI the kidney for visualization of the CM SG, as well as quantification of the salt gradient using comparison to a biologic phantom with a known sodium concentration. Direct comparison of the CM SG will be done using t-test statistics between the AKI and control group. We will use statistical methods of correlation to assess for a relationship between CM SG values and clinical markers of kidney recovery in patients with AKI.

Expected Results:
This project has not yet started enrolment, but we expect to find similar results to previous literature that suggests that there is a linear increase in sodium from the cortex of the kidney to the inner medulla. We expect that patients with a greater loss of sodium concentration and gradient at 7 to 10 days post-diagnosis will not show clinical signs of kidney recovery at 21-28 days, compared to those with less severe, or preserved sodium concentration at 7 to 10 days post-diagnosis. This project will advance the literature by reimaging patients with AKI at two different time points in their disease process and correlating these results to clinical kidney recovery.

References: