Title: Assessing Renal and Hepatic Hemodynamic Changes during Hemodialysis with CT Perfusion Imaging

Trainee Name: Raanan Marants

Supervisor(s): Ting-Yim Lee, Christopher W. McIntyre

Structured Abstract:
Unfortunately, 10% of Canadians develop chronic kidney disease. Patients progressing to end-stage renal disease (ESRD) and requiring hemodialysis (HD) cost the healthcare system over $60 000 per year of treatment. Although HD is a life-saving therapy, patients develop a wide range of complications, including cardio- and cerebrovascular disease. Previous work used multi-modal functional imaging to characterize the mechanisms behind these complications and evaluate potential therapeutic interventions. In most HD patients, the combination of intradialytic hypotension, circulating endotoxins and aggressive ultrafiltration results in significant circulatory stress and development of pathologies.

My PhD focuses on using CT perfusion (CTP) imaging to address several ESRD-related questions:
1) Although residual renal function (RRF) is linked to improved clinical outcomes, it characteristically declines upon HD initiation. While the reason behind this decline is not clear, recurrent renal ischemic insults are thought to be responsible.
2) While the effects of HD have been assessed for organs like the heart and brain, there is a paucity of data for the liver, an important organ in metabolism, detoxification and intradialytic fluid balance. Due to its unique dual blood supply, the liver may respond differently to HD-induced circulatory stress compared to other organs.
3) The current clinical protocol for measuring glomerular filtration rate (GFR) in HD patients is time-consuming, cumbersome and often inaccurate. Functional imaging has been used to measure GFR in various animal and human studies but never explored in HD patients.

To address these questions, HD patients were randomized to receive standard (36.5°C dialysate temperature) or cooled (35.0°C) HD first in a 2-visit crossover study. CTP imaging was performed before, during and after HD without any interruption to treatment. Imaging was done without breath-hold for 2 min immediately following a bolus injection of contrast agent. Renal perfusion maps were generated from registered CT images.

We determined that renal perfusion significantly decreases during HD, which represents the first step towards pathophysiologically characterizing HD-mediated RRF loss, and that cooling trended towards mitigating these effects. Also, we found that liver perfusion is largely unaffected by HD despite biochemical indication of hepatic dysfunction. This may be due to increased perfusion heterogeneity as quantified with texture analysis. However, cooled HD helps maintain hepatic function and minimize changes in perfusion heterogeneity. Work is ongoing to compute GFR from perfusion measurements.

Moving forward, these findings may form the basis of fully characterizing how intradialytic renal perfusion decline causes tissue injury and RRF loss. In addition, this work demonstrates the benefit of using CTP and other functional imaging techniques to further characterize and evaluate therapies for ESRD patient pathologies.