Development of a Computational Tool for a membrane Dialyzer by Computational Fluid Dynamic (CFD)

Most patients in need of renal replacement therapy use peritoneal or hemodialysis (HD) therapy. Major drawbacks of HD are the incomplete removal of uremic solutes (especially middle-sized uremic solutes and protein-bound uremic solutes, PBUTs) as well as the non-continuous therapy (3 times per week for 4h), causing large fluctuations in water balance and uremic waste, potassium, and phosphate. A key element of HD therapy is an artificial kidney, a membrane module containing thousands of hollow fibers (HF) for removal of uremic toxins.

In our group, (AOT) various project focus on developing new HF membranes which can provide improved blood purification. For our studies, we prepare small dialyzers with low membrane surface area (in comparison to the standard ones- of $1m^2$ or more) for making membrane screening *in vitro* and *in vivo*. To facilitate this development and eventually contribute to improved HD therapy, an investigation of the effect of dialyzer design and process variables on the toxin clearance rate is also required. It is not easy to translate the in vivo transfer process with in vitro experiments, as it involves a high cost to produce various designs and membranes for the dialyzer.

Assignment objective

The main objective of this study is the development of a computational model of membrane dialyzer using Computational Fluid Dynamic (CFD). The model would allow us to optimise the dialyzer characteristics (HF characteristics, packing density etc) and the optimal process conditions (flow rates blood / dialysate etc). The modelling results will be compared to available experimental results.

Relevant literature

"Portable, wearable and implantable artificial kidney systems: needs, opportunities and challenges", D. Loureiro Ramada, J. de Vries, J. Vollenbroek, N. Noor, O. ter Beek, S. M. Mihăilă, F. Wieringa, R. Masereeuw, K. Gerritsen and **D. Stamatialis**, Nature Reviews Nephrology, 19 (8) (2023) p481.

"Design and Development of a Computational Tool for aDialyzer by Using Computational Fluid Dynamic (CFD) Model", **T**. Yaqoob, M. Ahsan, S. Farrukh and I. Ahmad, Membranes 11 (2021) p916.

"Evaluation of the Toxin-to-Protein Binding Rates during Hemodialysis Using Sorbent-Loaded Mixed-Matrix Membranes", C S. Stiapis, E. D. Skouras, D. Pavlenko, **D. Stamatialis** and V. N. Burganos, Appl. Sci. 8 (2018) p536.