Adaptive Temperature Controller in Hemodialysis - Essential for Next-Gens

Mohamed Haroon Abdul Jabbar[1]

[1]University of Nottingham, Malaysia

Abstract

Nowadays, abnormal decline in blood pressure are common in end stage renal disease (ESRD) patients during hemodialysis treatment. The patient's temperature instability plays a vital role in the onset of intradialytic hypotension, which implies that a slight variation in body temperature is sufficient to cause life threatening complications. In contrast to the heat loss from blood lines to environment, there is also heat exchange taking place between blood and dialysate in the dialyzer, which could interrupt the patient's thermal equilibrium. Recent studies show that the active regulation of body temperature by altering dialysate temperature would reduce the complications. The analysis of thermal energy exchange in dialyzer is significant to provide constant body temperature, which also benefits for the development of an effective temperature controller.

In this study, the main aim is to investigate the effect of heat transfer that takes place in a dialyzer during hemodialysis. A 2D axisymmetric Polyflux 210H (Gambro, Hechingen, Germany) dialyzer membrane model was developed using COMSOL Multiphysics®. The types of physics applied for this study were The Heat Transfer in Fluids and Porous Media. The Heat Transfer in Fluids interface was used for both blood and dialysate flow. Likewise, The Heat Transfer in Porous Media was used for the dialyzer membrane. However, COMSOL Multiphysics® provide many conditions to approximate the value of convective heat transfer coefficient. Since this model has two membrane boundaries, the blood side boundary was considered as the internal forced convection, while the dialysate side boundary was considered as the external forced convection.

The model exhibited a trend in temperature profile across the dialyzer membrane and the blood temperature has decreased up to 1.15°C using cool dialysate settings. It can also be seen that the temperature of the blood returning to the body is influenced by that of the dialysate, which confirms that the dialyzer acts as an almost perfect heat exchanger. However, the temperature trend on various dialysate temperatures has shown strong agreement with the literatures. Moreover, the model shows that the blood flow rate has insignificant dependency on the effect of heat transfer in dialyzer. The study further strengthens our research that heat transfer in the dialyzer necessitates a system to control and regulate the dialysate temperature. Further studies on adaptive temperature controller in hemodialysis machine by incorporating the heat loss/gain will reduce the hypotension episodes and improve the patients' quality of life.

Figures used in the abstract

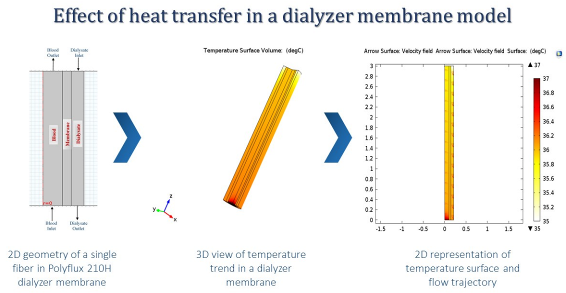

Figure 1: Effect of heat transfer in a dialyzer membrane model