Adaptive Temperature Controller in Hemodialysis – Essential for Next-Gens

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Introduction:

- **Exponential growth** in the number of patients on dialysis treatment.
- High tendency to raise the body temperature during dialysis – sufficient to cause **life-threatening complications**[1].
- Long term studies have shown adverse effects due to fluctuation in post-dialysis body temperature[2].
- In addition to heat loss from blood line to environment, analysis of **heat transfer in dialyzer** need to be considered.
- To analyze the heat transfer in a dialyzer, a 2D axisymmetric model of **Polyflux™ 210H membrane** is investigated using COMSOL Multiphysics®.

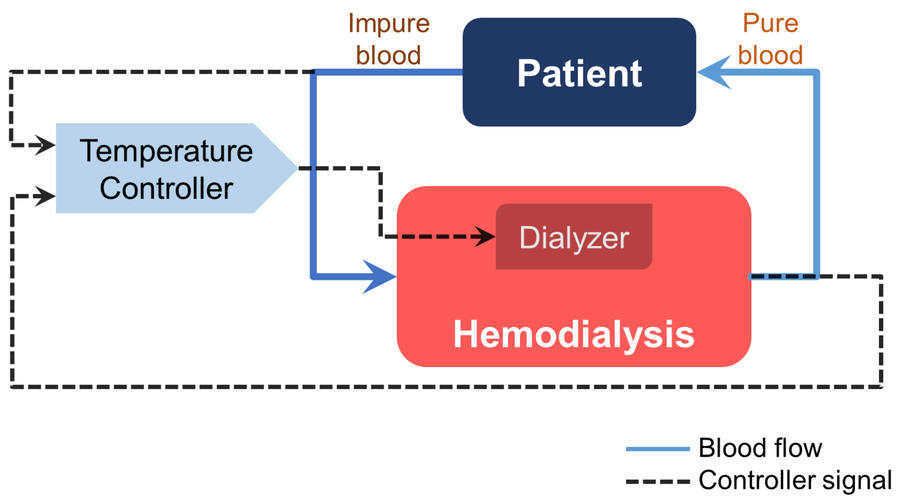


Figure 1. An overview of the proposed dialysate temperature controller.

Computational Methods:

The model described covers ***Heat Transfer in Fluids*** and ***Heat Transfer in Porous Media*** for blood-dialysate and membrane characteristics. The effective thermal conductivity of porous media is estimated based on volume averaging theory, while transfer of heat through membrane is defined as convective heat flux.

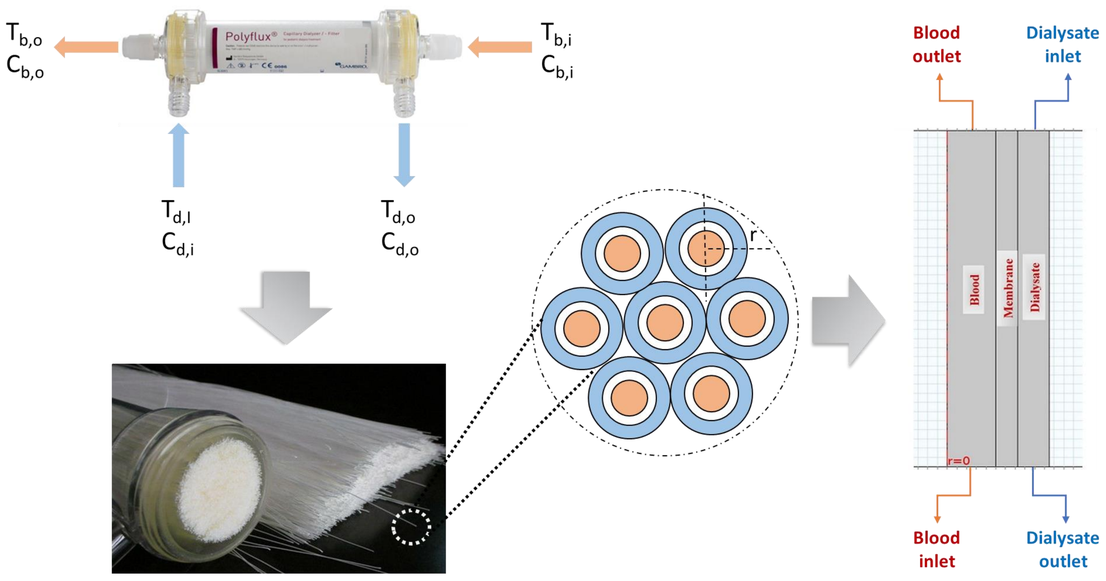


Figure 2. An overview of Polyflux™ 210H dialyzer from bundle of hollow fibers to single fiber model.

We executed various simulations to analyze the heat transfer in dialyzer to optimize dialysate temperature controller. A parametric sweep of the dialysate temperature and blood flow rate, along with boundary conditions results in thermal characterization of dialyzer.

Results:

Post-processing of the results reveals the heat transfer between blood and dialysate through Polyflux™ 210H membrane.

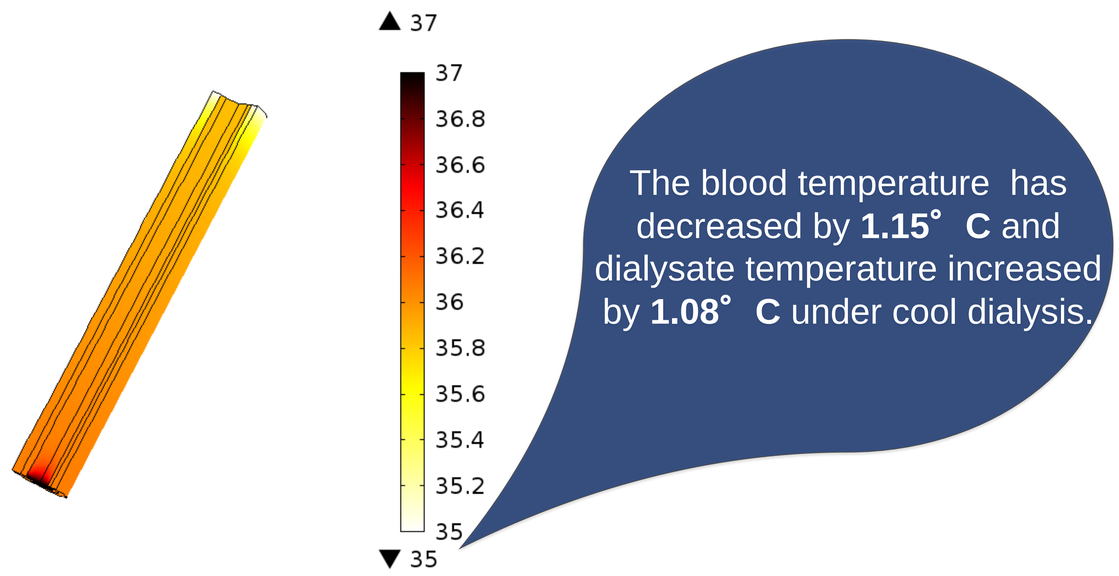


Figure 3. 3D representation of Temperature surface.

Blood leaves the dialyzer in **thermal equilibrium** with dialysate – heat exchanger[1].

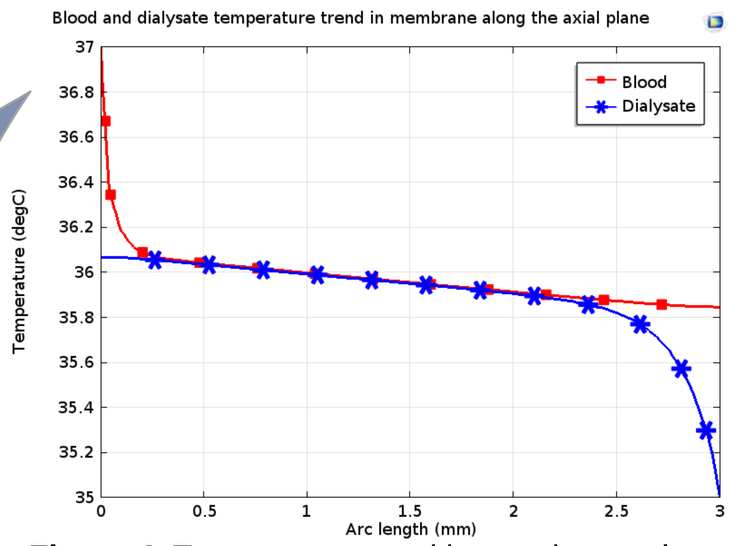
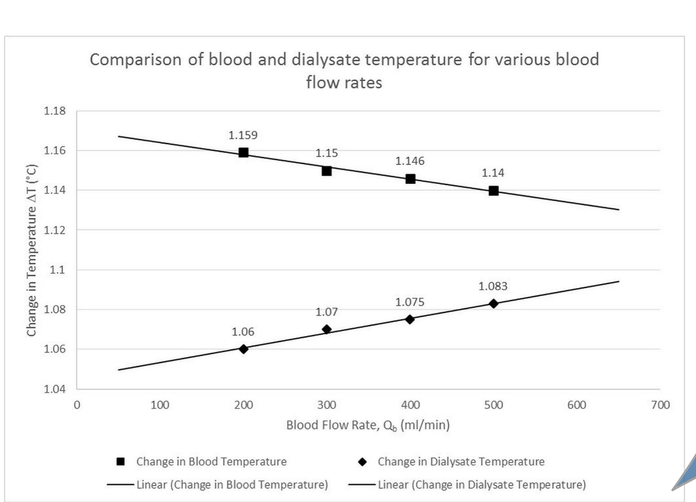


Figure 4. Temperature trend in membrane along the axial plane



Blood flow rate is **insignificant** dependency on the effect of heat transfer.

Figure 5. Comparison of blood and dialysate temperature for various blood flow rates.

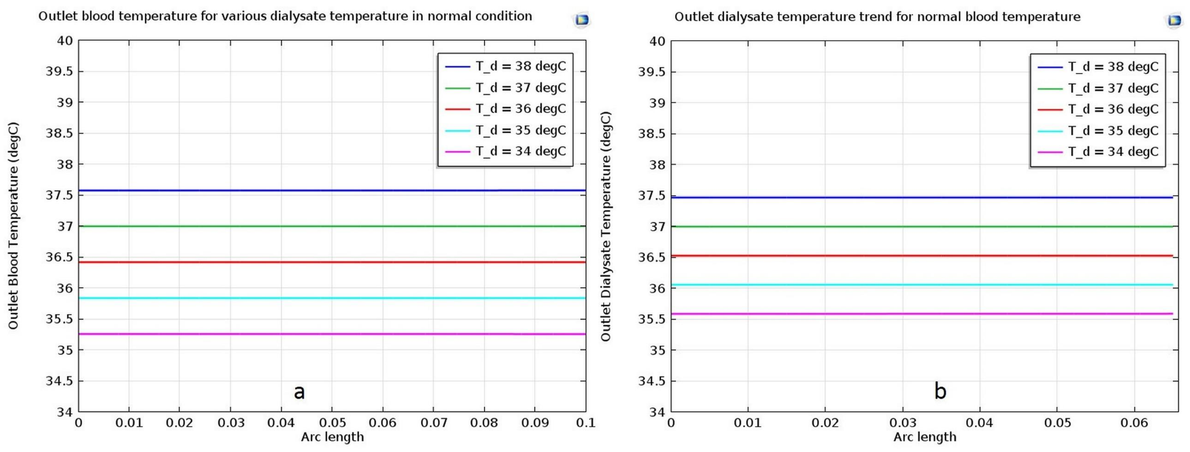


Figure 6. The outlet (a) blood temperature and (b) dialysate temperature for various dialysate temperatures under normal body temperature

References:

1. P. E. Pergola, N. M. Habiba, and J. M. Johnson, “Body temperature regulation during hemodialysis in long-term patients: Is it time to change dialysate temperature prescription?,” Am. J. Kidney Dis., vol. 44, no. 1, pp. 155–165, 2004.
2. L. A. Usvyat, J. G. Raimann, M. Carter, F. M. Van Der Sande, J. P. Kooman, P. Kotanko, and N. W. Levin, “Relation between trends in body temperature and outcome in incident hemodialysis patients,” Nephrol. Dial. Transplant., vol. 27, no. 8, pp. 3255–3263, 2012.

Conclusions:

The study further strengthens our research that heat transfer in the dialyzer due to its inherent mass transfer necessitates a **system to control and regulate the dialysate temperature**. Further studies on adaptive temperature controller in hemodialysis machine will improve the **patients’ quality of life**.

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