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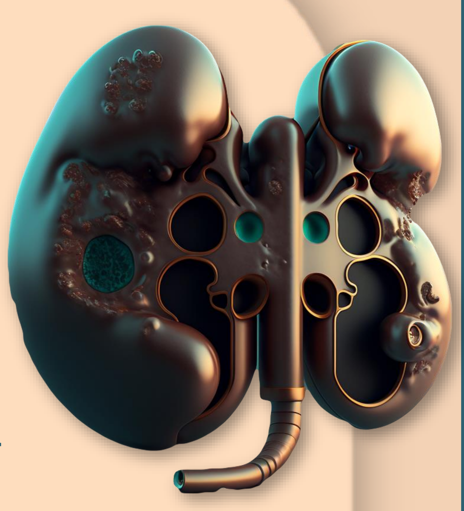
MTH2245

Hemo Dialysis

01 Abstract

• Kidney Disease

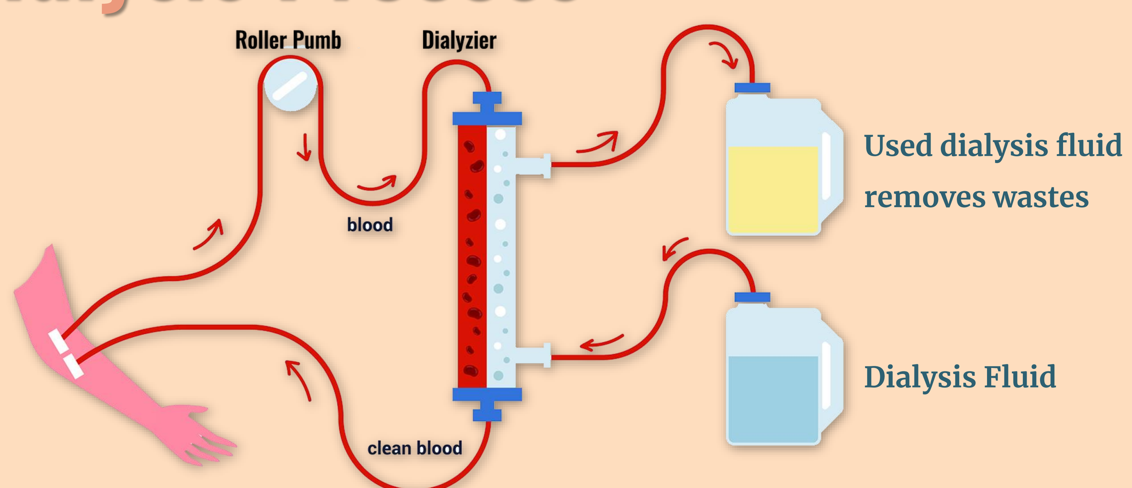


Chronic kidney disease (CKD) is a condition in which the kidneys are damaged and cannot filter blood as well as they should. Because of this, excess fluid and waste from blood remain in the body.

• Statistics

Worldwide, over 10% of people over twenty-year-old now have chronic kidney disease. The expected mortality (death rate) of an adult being on dialysis is 70% by five years, and 90% by 10 years.

• Dialysis Process



02 Literature

Thermodynamic Model

Developed: for water and solute transport through reverse osmosis membranes.
Capable: of accurately describing the nonlinear relationship between water flux and pressure

Urea Kinetic Model

Describe: urea concentration as it exponentially decays during dialysis
Usage: due to its math. formulation, it has not gained clinical acceptance among nephrologists

03 Model & Analysis

The model is built on **Mass Balance equation**

$$Accumulation = \text{in} - \text{out} + \text{Gen/Consumption}$$

The mass balance equation simply states that the total mass in any system is always conserved.

• Method of lines "Numerical Solution"

1. describe physical phenomena that occur in more than one dimension, by reducing it to a single continuous dimension.
2. PDE is discretized and the time variable is left continuous. This results in a system of ODE solved by Initial value ordinary equation

• Derived Model

For Blood: $$\frac{\partial u_1}{\partial t} = -\frac{v_1 \partial(u_1)}{\partial z} + \frac{k_m A_m}{\epsilon A}(u_2 - u_1)$$

For Dialysate: $$\frac{\partial u_2}{\partial t} = -\frac{v_2 \partial(u_2)}{\partial z} + \frac{k_m A_m}{(1-\epsilon) A}(u_1 - u_2)$$

• Parameters

$u_1(z,t)$: concentration of impurities in blood
$u_2(z,t)$: concentration of impurities in dialysate
Z: Length of dialyzer
A: cross sectional area of dialyzer
ϵ: fraction of Area
V: Superficial velocity
K_m: mass transfer coefficient

04 Experimental work

considering all the parameters of the dialyzer are constants, $u_1(z,t)$ and $u_2(z,t)$ will vary according to K_m which depends on (ϵ*A) for blood and [(1-ϵ)*A] for dialysate.

$K_m=0$	$K_m > 0$	K_m ↑
$u_{1R}(t) = u_2(0,t)$	$u_2(0,t) > u_{1R}(t)$	$u_2(0,t)$ ↑ $u_{1R}(t)$ ↓

Considering K_m is constant while changing diameter "D" and dialyzer length "Z_L"

D ↑ ⟶ V ↓ ⟶ Process ↓

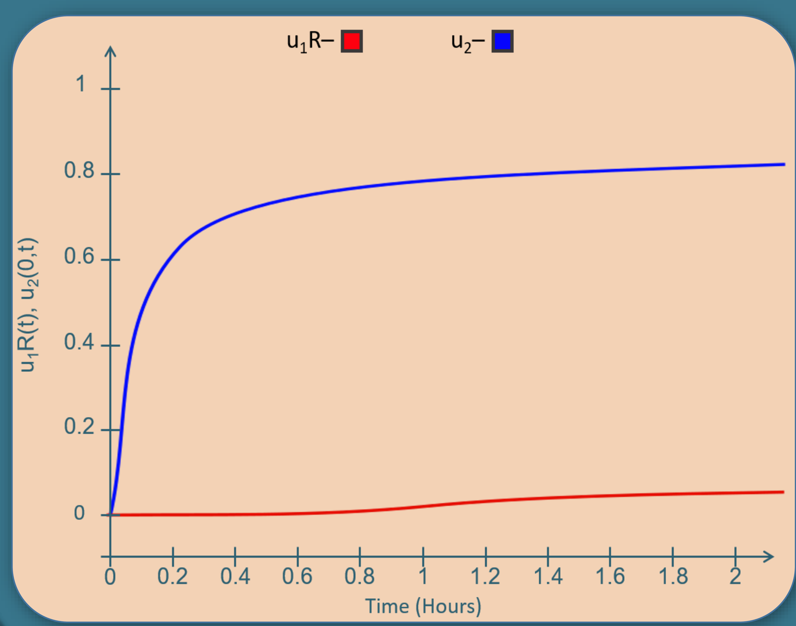
Z_L ↑ ⟶ Time ↓ ⟶ Process ↓

• Analysis

Considering K_m=0.001, while decreasing the diameter it's observed that the flow rate will increase proportionally and mass transfer process will decrease(the contact time between blood & dialysate decrease)

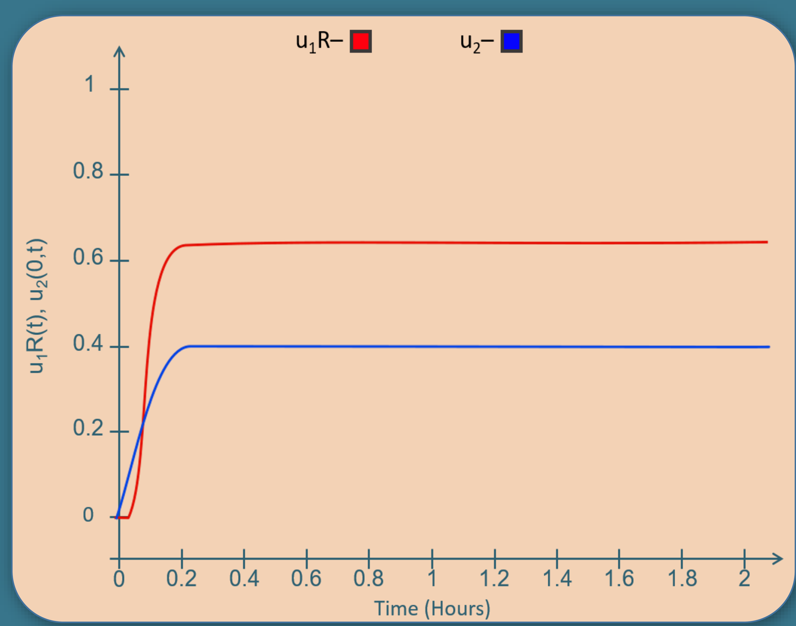
Case 1

At D= 4(cm) , t= 0.4(hrs)
$u_{1R}(t)=0.1144$, $u_2(0,t)=0.5672$



Case 2

At D= 2(cm) , t= 0.4(hrs)
$u_{1R}(t)=0.6141$, $u_2(0,t)=0.3858$



• Conclusion

I. Through system of PDEs/ODEs we could deduce the mass transfer coefficient (Km) of impurities during the hemodialysis process 1
II. the response of the blood concentration, u1(z , t) (with headers), slightly lags that for the dialysate, u2(z , t). 2
III. The development of an efficient membrane is the key step in the production of the dialyzer. 3

• References

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