Modeling the Response of Microdialysis Probes in Glucose Concentration Measurement

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Introduction

Microdialysis is a technique useful for continuous glucose monitoring in diabetic patients based on the transfer of glucose through a microdialysis membrane from the interstitial fluid to a saline solution perfused into the microdialysis probe.

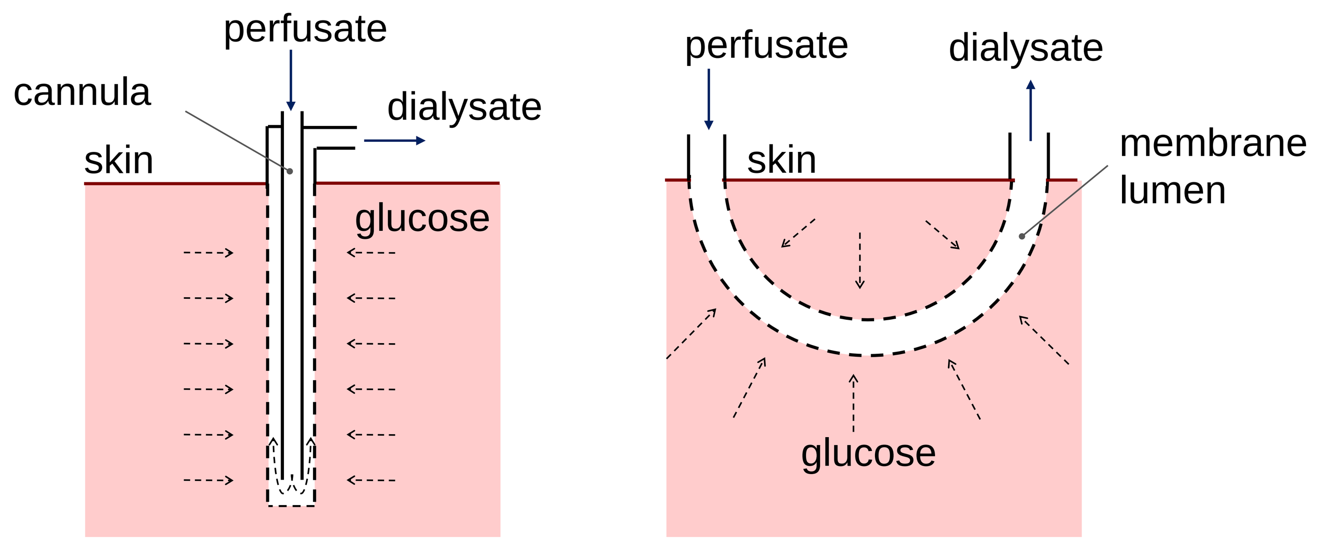


Figure 1. Studied configurations of microdialysis: I) hollow-fiber with inner cannula, II) hollow-fiber.

Aim

To develop a preliminary model for glucose transfer in two types of microdialysis probes: a hollow-fiber using an inner cannula and a single hollow-fiber.

The model was applied to study the influence of the perfusion rate and the response of the probe to changes in blood glucose concentration and in the resistance of the transport in the traumatized layer (caused by the reaction of the organism against the probe).

Modeling

- Geometry:
  - → Axial-symmetry assuming that the interaction between the probe and the surrounding tissues only reaches a short distance.

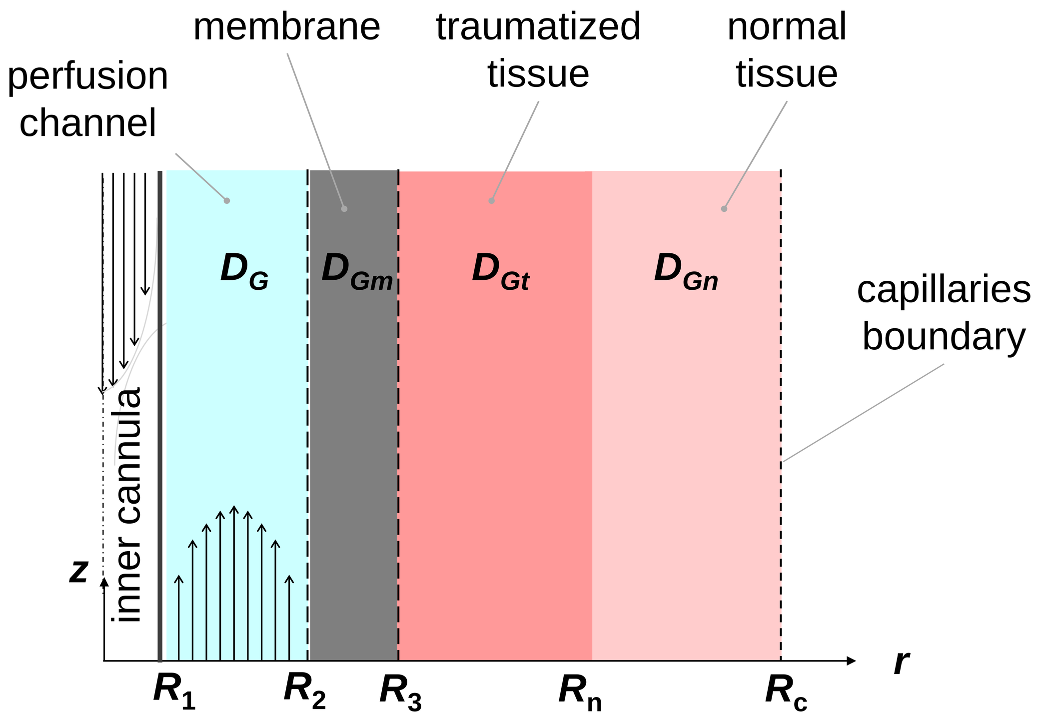


Figure 2. Scheme of the layers included in the model

- Transport of diluted species model:
  - → With convection in the perfusion channel: $U_z(r)$
  - → An effective diffusion coefficient is used instead of the convection in the normal tissue
- Boundary conditions for glucose concentration:
  - → partitioning coefficients relates membrane concentrations and concentration in the domains in contact with the membrane.
  - → same concentration at both sides of the boundary between normal tissue and traumatized tissue
  - → Concentration at the capillaries boundary depends on glucose concentration in blood
- Mesh:
  - → Mapped meshing for a finer estimation in the *r*-coordinate
  - → Geometric sequence distributions in the perfusion channel domain near to the membrane boundary
- Solver:
  - → Direct stationary solver: PARDISO
  - → BDF method used to solve the time dependent problem

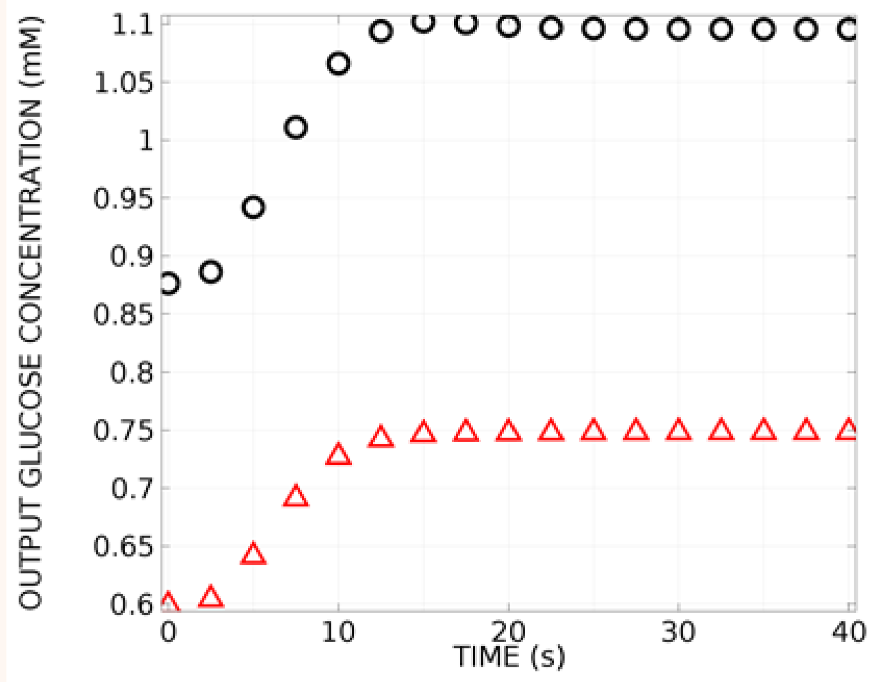
Conclusions

→ The model can be used to better understand the behavior of a microdialysis probe under different conditions like changes in the operating variables or in the resistance to transport as a consequence of the inflammatory evolution.

→ However, in the present development of the model, some biological parameters are uncertain and they must be fitted from experimental data.

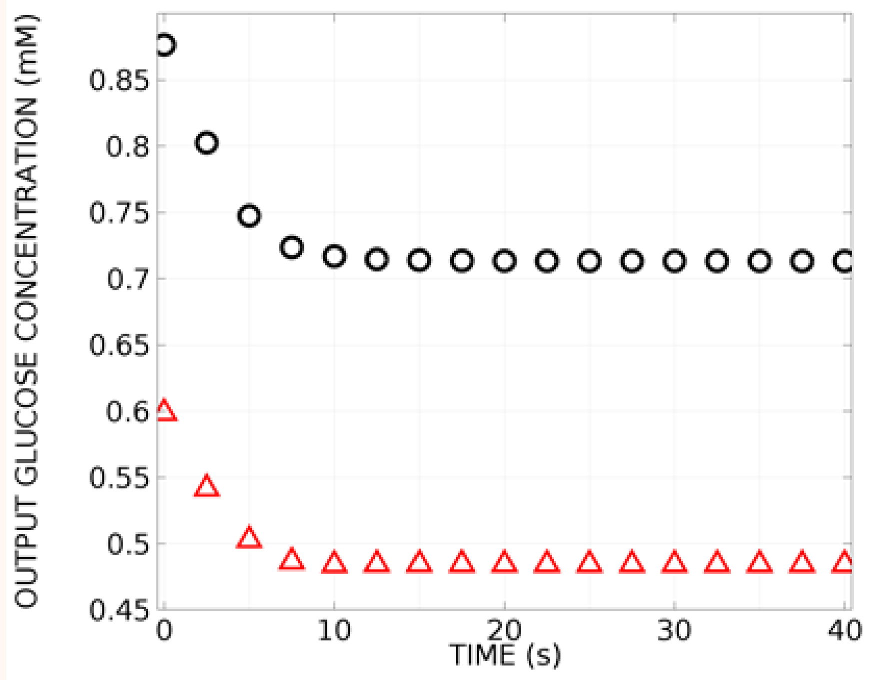
Results

→ For the same perfusion flow, the glucose recovery for the hollow-fiber with cannula configuration (**O**) is greater than that of the single hollow-fiber (**Δ**) in spite of both systems having the same channel section



→ The response of both systems stabilizes in less than 20 s against changes of 25% in the blood glucose concentration

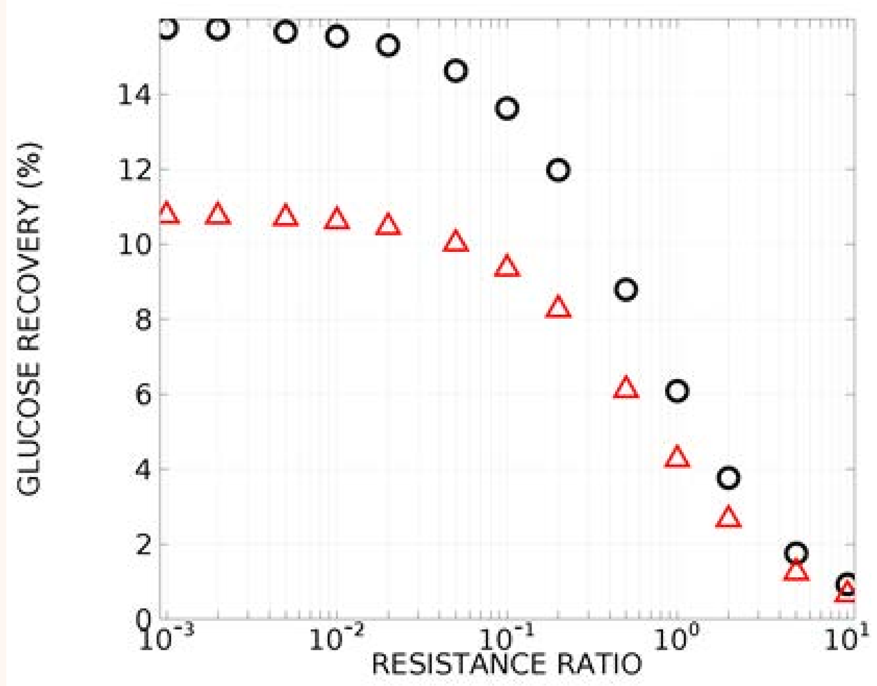
Figure 3. Output glucose concentration after an increment of 25% in blood glucose concentration.



→ The responses of both systems become stable in less than 20 s.

→ The effect of changes in the perfusion flow must be taken into account to correct the glucose measure.

Figure 4. Output glucose concentration after a step change in the perfusion rate from 120 to 150 µL/h.



→ The measured valued is significantly affected when the transport resistance of the traumatized layer becomes 5% greater than that of the membrane,.

Figure 5. Glucose recovery versus the ratio of the traumatized layer resistance to the membrane resistance.

Acknowledgements

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For further information

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