A COMPUTATIONAL MODEL OF THE INTERACTION BETWEEN CONTINUA AND NETWORKS: APPLICATION TO MICROCIRCULATION AND UREMY

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Introduction

The key role of microcirculation in haemodialysis is already known, since it is directly involved in the removal of toxins from the tissues. Recently, microcirculation alterations were pointed out in uremic patients.
We model the interaction of a network with the surrounding continua in order to describe the local phenomena involved in tissues and microcirculation vasculature in both healthy subjects and uremic patients.

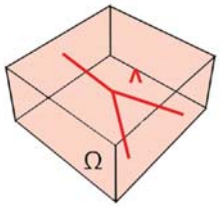
Healthy subject *Patient on dialysis*

adapted from: Yeh et al. (2017)

Model

The finite element model - implemented using the open source software GetFEM++ (getfem.org) - has the unique ability of combining the following features:

- realistic vasculature
- coupled capillary and interstitial flow
- haematocrit dependent flow properties (*Fåhræus-Lindqvist effect)*
- prediction of red blood cells (RBCs) distribution along the vasculature (*simulating plasma skimming effect)*
- non-linear description of the lymphatic drainage.



Schematic view of a vessel network (Λ) and the surrounding tissue (Ω).

Ω: Porous media
(Darcy's law)

Λ: Cylindrical conducts
(Poiseuille's law)

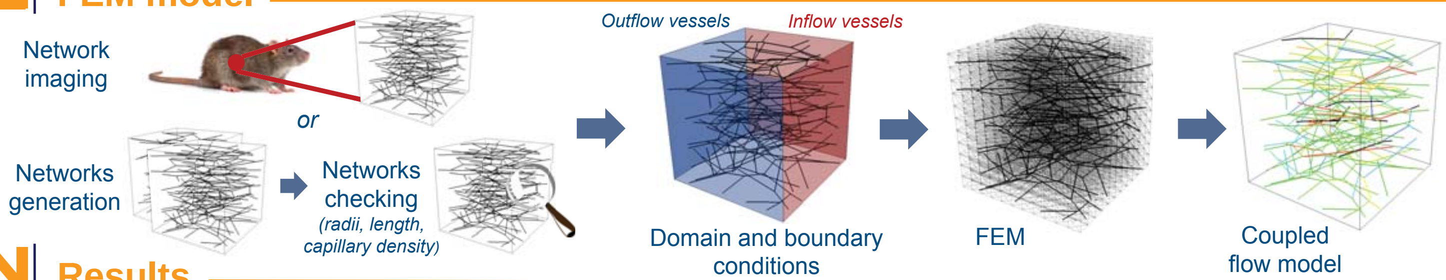
Lymphatic drainage
(non-linear function of fluid pressure)

Leakage across capillary wall
(Starling's equation)

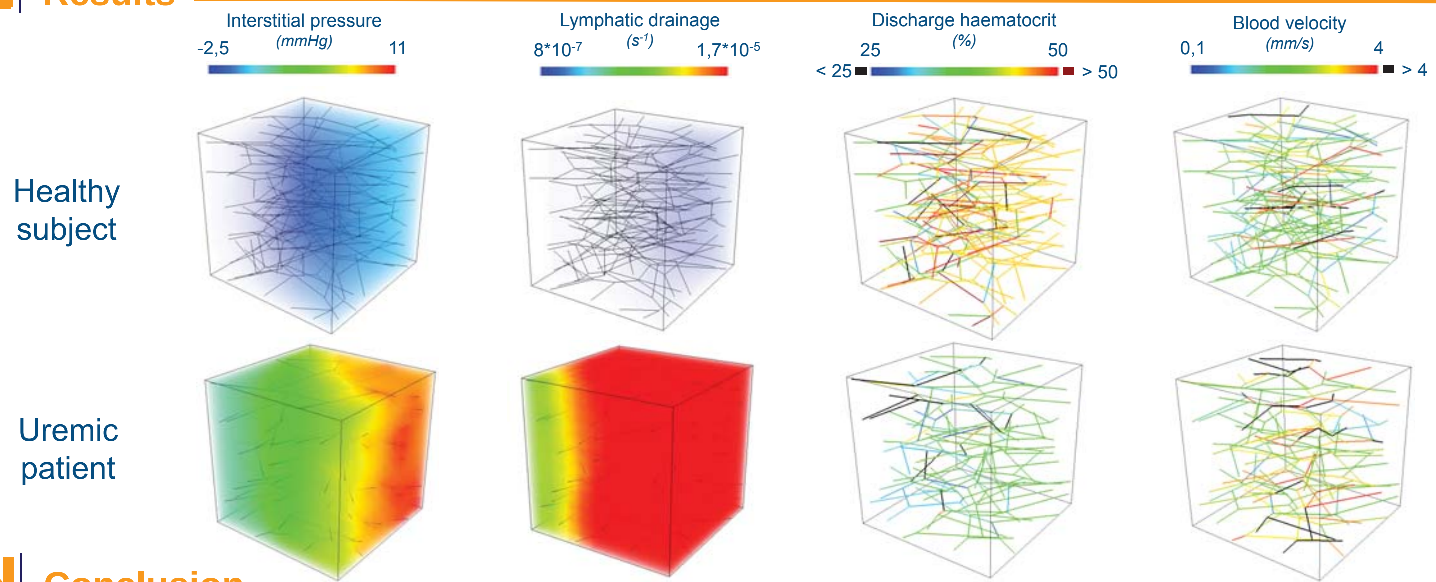
Parameters changed:

Case	Discharge haematocrit (%)	Capillary hydraulic conductivity (m^2 s kg^{-1})	Oncotic pressure gradient (mmHg)	Capillary wall reflection coefficient (-)	Capillary density S/V (m^{-1})
Healthy subject	45	1 x 10^{-12}	25	0,95	7000
Uremic patient	35	8.80 x 10^{-12}	19	0,75	4900

FEM model



Results



Conclusion

The model showed good agreement with the literature data available in terms of mean interstitial pressure (Ebah et al). After this preliminary comparison against experimental data, we analysed variations concerning the other variables using parameters referred to healthy subject and uremic patient. The model can be applied to deeper studies the alterations induced by uremy in the microcirculation.

References

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