A multiphase model for fluid dynamics in damaged tissue

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Abstract:

Tissues are clusters of similar cells that cooperate to perform specific functions within the human body, their internal mechanisms still being intensively researched. Tissues are formed by a mixture of cells, liquid in which chemical substances are dissolved, and an extracellular matrix made of polymer threads that keep the cells bound together. When tissues are damaged due to mechanical or chemical causes, they react by sending a fluid flow to the part involved. Leaving aside this healing role, the uncontrolled concentration of fluid in the involved tissue has an impact on its function and, consequently on human health.
Tissues can be represented as a mixture [3,4] with three fluid components [2] consisting of a biomass phase (cells and polymeric matrix), which is split into two components - alive and dead cells, with volumetric fractions $\phi_{\rm a}(\mathbf{x}, t)$ and $\phi_{\rm d}(\mathbf{x}, t)$ respectively, and a fluid component, $\phi_{\rm f}(\mathbf{x}, t)$, that carries nutrients, waste, and toxicants.

The mixture [1] is governed by the mass and linear momentum balance laws coupled with advection-reaction-diffusion equations for the concentrations of nutrients $ c_{\rm n}(\mathbf{x},t)$ and toxicants $c_{\rm p}(\mathbf{x},t)$.
In our paper we develop and simulate a model, by using a the open acces freeFEM platform [5] that solves systems of partial differential equations through finite element methods. In particular, the action of toxicants and the fluid infiltration caused by toxicants' damage on the tissue are investigated.

References

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