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A Multiscale Computational Framework to understand Vascular Adaptation

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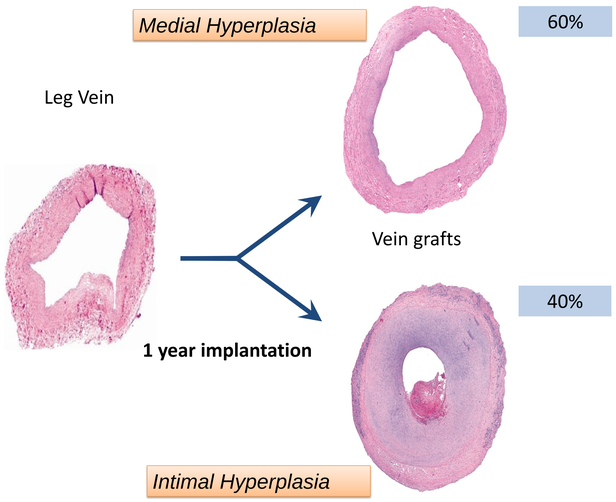
Caring for America's Veterans — Team VA — North Florida South Georgia Veterans Health System — with Ability, Skill and Will

Abstract: We have introduced a multiscale computational framework to analyze the vascular adaptation in human implantation as this fails after certain period of time in most of the cases. Our framework is agile, modular and facilitates the scope of analysing and testing different hypothesis associated with the vascular adaptation. A mathematical model has been defined to understand cellular activities of the vein graft associated with the environmental conditions (i.e. shear stress and tension) in a two dimensional space at first. Next, we have been applying statistical analysis (i.e. PRCC, eFAST) to find out the key parameters of the model responsible for this adaptation using high performance computing. Finally, these key parameters can be linked with gene regulatory system to produce special drug to control this adaptation.

Introduction: The initial radial symmetric vein graft deforms because of the shear stress and tension at the wall and ultimately fails to circulate blood.



Vein graft Phenotypes

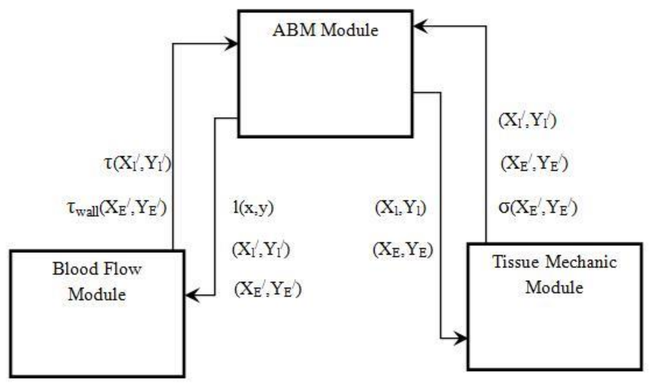
Our research goal is to understand why this vein graft shows different kinds of phenotypes by using a computational framework.

We can test and verify different hypotheses associated with this vein graft adaptation by using our computational framework.

This research will help to understand the reason behind this vein graft adaptation.

Framework: There are three modules in our framework. The agent based module (ABM) explains the cellular activities inside the vein graft associated with the probabilistic rules of cell apoptosis or mitosis.

The Blood flow module calculates the shear stress generated inside the lumen of the vein graft.

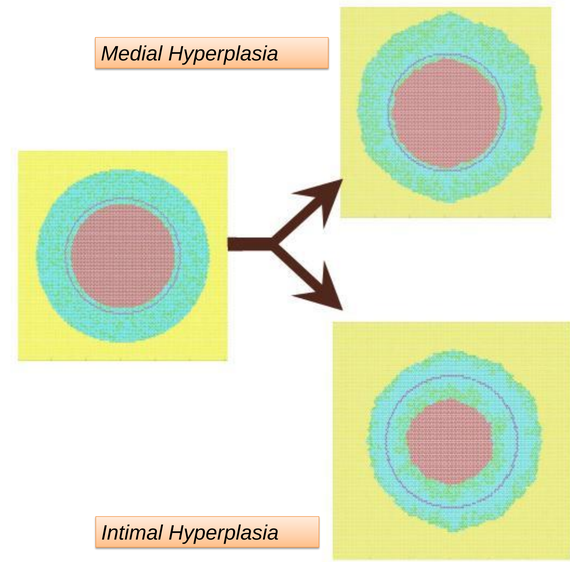


Computational Framework

The Tissue mechanic module calculates the tension generated by transmural pressure at the wall.

These three modules are coupled to calculate the probabilistic rules associated with the vein graft adaptation.

Results: We are running computer simulations to generate special patterns observed in the vein graft adaptation using the framework in the cluster machines.



Computer Generated Image

Conclusion: Our research goal is to specify the patterns associated with different parameters of the framework to understand the vein graft adaptation.

References:

1. M.Garbey, M.Rahman, S.Berceli, "A Multiscale Computational Framework to Understand Vascular Adaptation", Journal of Computational Science, 2014 (to be submitted).
2. M.Rahman, M.Garbey, S.Berceli, "Vein Graft Adaptation: Cross Validation between a Hybrid ABM-PDE model and a dynamical system", Journal of mechanobiology, 2014 (to be submitted).