Flow-driven vascular network organization in a chorioallantoic membrane model

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Introduction

Adding vascular network to engineered tissues is an important step for the clinical application of these tissues. Recent studies have shown that vascular cells can display plasticity with respect to local cues, meaning that the organization is influenced by the environment and not just by genetics [1, 2]. Since it is clear that vascular cells are programmed to respond to hydrodynamic signals, and by considering the challenging nature of internal fluid flow control within vessels, we hypothesize that fluid flow shear stress on the outside of a vascular network can also guide vascular organization. As a natural highly vascularized model, the chick embryo and its chorioallantoic membrane (CAM) is applied in this project.

Methods

An artificial cubic eggshell is designed in a way that allows oxygen passage into the chick embryo as well as high observability. A patterned membrane fabricated by microfabrication techniques is used in one of the walls of the artificial cubic eggshell to exert external fluid shear stress on CAM. The shear stress profile in the designed pattern is modeled using COMSOL Multiphysics software tool. The spreading vascular network is visualized using optical color imaging and the degree of vasculature revealed by the vessels-occupied area are calculated by using ImageJ software.

Results

The results of this project show how external fluid flow shear stress affects vascular development and organization. When the hypothesis holds true, the results of this project will provide us with an extra tool to control vascular organization in engineered tissues.

Discussion and Conclusions

If the external fluid flow shear stresses could control vascular organization, the blood vessels can be designed and reorganized without disturbing blood flow within the vascular network. This method can open new horizons in developing a functional vascular network within engineered tissues, which is a key challenge in tissue engineering.

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References

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