Mathematical modelling of early stages vasculogenesis & cell-matrix interactions.

Chiara Villa [1]

[1]) School of Mathematics and Statistics, University of St Andrews, UK.

The formation of new vascular networks is essential for tissue development and regeneration in addition to playing a key role in pathological settings such as ischemia and tumour development. Experimental findings in the past two decades have led to the identification of a new mechanism of neovascularisation - cluster-based vasculogenesis - which occurs in a variety of hypoxic settings in vivo. The first part of this talk will focus on the early stages of cluster-based vasculogenesis during which endothelial progenitor cell (EPC) cluster formation is mediated by the action of extracellular matrix (ECM)-degrading enzymes and EPC proliferation. I will present a mathematical model comprising a system of partial differential equations including non-local dynamics, which sheds light on the mechanisms responsible for cluster formation and cluster size. The numerical results, which qualitatively compare with data from in vitro experiments, provide further insights on the underlying dynamics indicating promising, fruitful future modelling and experimental research perspectives. The second part of this talk will focus on mechanical and mechanochemical models of pattern formation in biological tissues, which are particularly suited to study the late stages of vasculogenesis as they include a force-balance equation describing the mechanical equilibrium of the cell-ECM system. In particular, this is usually defined using the Kelvin-Voigt model of linear viscoelasticity to represent the stress-strain relation of the ECM. However, depending on the type of biological tissue considered other constitutive models of linear viscoelasticity may be better suited. I will present a mechanical model of pattern formation within which the pattern formation potential of different stress-strain constitutive equations for the ECM is assessed. The key results of the study support the idea that fluid-like constitutive models (e.g. Maxwell materials) have a pattern formation potential much higher than solid-like models (e.g. Kelvin-Voigt materials), highlighting the importance of empirical work to justify modelling assumptions and suggesting possible implications on pattern formation in different tissues or pathological processes.