PUBLISHABLE SUMMARY OF THE PROJECT

PEOPLE MARIE CURIE ACTIONS

Incoming International Fellowships (IIF)

Call: FP7-PEOPLE-2011-IIF

Project No: 301214

Project Acronym: MICROPULSATILE

Project Full Name: Pulsatile Viscous and Viscoelastic Microfluidics

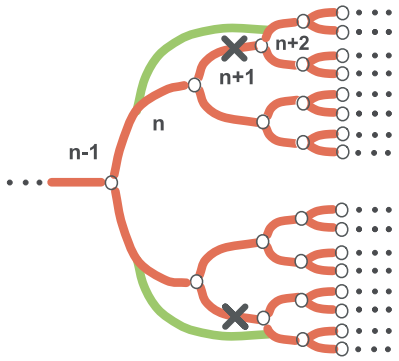
Project coordinator name: Prof. Ignacio Pagonabarraga

Project incoming international researcher: Professor Eugenia Corvera Poiré

The project has enhanced our theoretical understanding on how periodic forcing affects the viscoelastic flow in one and two fluid phases and set the grounds to apply such understanding to problems of biological, medical and technological importance. The project is divided into two main lines. Line 1 concerns the study of blood flow to a tissue with the purpose of developing a methodology capable of relating the visual characteristics of a vessel vasculature transporting blood, with the flow that goes through it. Line 2 concerns the study of pulsatile interfaces between two fluids in devices at the microscale.

Summary description of the project objectives.

Line 1. Establishment of the relation between the visual characteristics of a vasculature irrigating a tissue with the flow that goes through it. In particular, to determine the effect that bypasses (anastomotic vessels), obstructions and selective vessel suppression have on flow, depending on the anatomical place where they occur. Such an understanding provides insight into the circumstances under which, suppression or addition of vessels, will enhance or reduce flow towards a healthy tissue or towards a tumour.
Line 2. To develop fundamental knowledge regarding the effect that a pulsatile pressure gradient has on microfluidic interfaces.



Main results:

We have worked with realistic vascular network models that are in good agreement with a large part of mammalian vasculatures. We have found that the local structure of the vessel network plays a crucial role, controlling how network bypasses increase the flow towards the tissue that the vessel network irrigates. This implies that whenever there is an underlying tree-like network in an *in-vivo* vasculature, our model is able to interpret the anastomotic effect. The study of anastomosis is particularly relevant around cancer tumours.

We have also identified anatomical sites in a network that are critical for its overall capacity to supply blood to a tissue after obstructions. We demonstrate that relatively small obstructions in such critical sites are able to cause a much larger decrease on flow than larger obstructions

placed in non-critical sites. The locality of our results imply that whenever there is a tissue irrigated by a tree-like *in-vivo* vasculature, we can interpret how important obstructions are for the irrigation of a tissue.

We have studied how intrinsic redundancy can save lives. Built-in (or intrinsic) redundancy constitutes a fundamental and intrinsic aspect of healthy vasculatures, like some found in the brain and the heart. We explain how intrinsic redundancy in blood vasculatures, effectively protects organs by guaranteeing flow in the presence of large occlusions and by avoiding the flow shortages that small obstructions would cause in the absence of redundancy. Our analysis offers a plausible reason of why nature has selected intrinsic redundancy rather than evolving thicker vessels to assure blood supply for tissue irrigation at key places of the organism.

We have also proposed a novel, linear one-dimensional (1-D) dynamical theory of blood flow in networks of flexible vessels for which a full analytical solution exists. Using our model we have calculated the blood flow in the human common carotid artery, upper thoracic aorta and aortic bifurcation. Our results show a good agreement between pressure, flow and area waveforms calculated by our analytical approach and those computed using existing 1-D and three-dimensional (3-D) numerical schemes. Our analytical solution captures the main features of pulse waveforms in large arteries and networks. It enables the understanding of mechanisms by identifying and separating the precise role of each cardiovascular parameter involved in the system.

We have studied theoretically, numerically and currently are studying experimentally, the dynamics of fluid-fluid interfaces in micro devices subject to periodic forcing. We find that the competition between wetting and driving gives rise to very interesting regimes for the dynamics of the interface. Our studies have potential impact in the design of lab-on-a-chip devices.

Built-in redundancy might be a desirable feature in man-made microfluidic devices. Accordingly, in parallel with the study of anastomosis in blood vasculatures, we have explained how intrinsic redundancy in microfluidic networks, effectively protects devices, by guaranteeing water flow in the presence of occlusions. Our analysis provides guidance in the design of microfluidic devices for which careful tailoring of built-in redundancy can prevent failure by blockage of particles or bubbles.

This research has led to fundamental as well as applied knowledge that could be relevant to medical doctors, biomechanical engineers, experimental physicists and engineers working in microfluidics.

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