Micromechanical Force Measurements for Biomedical Applications

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The advancement of cardiovascular science is structured on a feedback basis, where statistical findings and observations gathered within the clinical environment are probed by biological models. While there have been numerous examinations of in vivo (in living) and model flow systems to characterise phenomena associated with occlusion development, the role that surface free energy plays in these transient systems is relatively unknown. This may be a critical paradigm for pharmaceutical agent design from an adsorption basis, whose role is to prevent the onset of blockage. Arterial shear flow profiles may promote the sloughing of particles (emboli) from the surface of stabilising thrombi (clotted blood), displacing these within the vasculature, and increasing the risk of occlusion-related physiological complications. Thromboemboli may collide in situ to form metastable aggregates, increasing vessel occlusion likelihood, although this has not been previously documented. A micromechanical force (MMF) apparatus was applied to study porcine clotted blood particle cohesion in modified continuous phases, where the technique has previously outlined how interfacial free energy dictates cohesive and adhesive properties of solids in multiphase fluid systems. This study introduces a conceptual model to illustrate the MMF applicability, supported by cohesive force measurements as a function of physio-chemical parameters to derive insight as to the governing mechanism of particle cohesion. The measurement is based on visual observation of inter-particle pull-offs: Hooke's Law is applied to calculate separation force. Native blood components and pharmaceutical agents (alteplase, tranexamic acid, and aspirin) reduced the baseline measurement by an order of magnitude, which is hypothesized to be a result of surfactant adsorption. These results provide new insight to better inform the potential mechanisms of macroscopic thromboemboli aggregation in the vascular system – data of which can be directly applied to computational simulations to predict particle fate, better informing models for the mechanistic development of embolic occlusions.