

Model predictions of deformation, embolization and permeability of partially obstructive blood clots under variable shear flow

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Abstract

© 2017 The Author(s) Published by the Royal Society. All rights reserved. Thromboembolism, one of the leading causes of morbidity and mortality worldwide, is characterized by formation of obstructive intravascular clots (thrombi) and their mechanical breakage (embolization). A novel two-dimensional multi-phase computational model is introduced that describes active interactions between the main components of the clot, including platelets and fibrin, to study the impact of various physiologically relevant blood shear flow conditions on deformation and embolization of a partially obstructive clot with variable permeability. Simulations provide new insights into mechanisms underlying clot stability and embolization that cannot be studied experimentally at this time. In particular, model simulations, calibrated using experimental intravital imaging of an established arteriolar clot, show that flow-induced changes in size, shape and internal structure of the clot are largely determined by two shear-dependent mechanisms: Reversible attachment of platelets to the exterior of the clot and removal of large clot pieces. Model simulations predict that blood clots with higher permeability are more prone to embolization with enhanced disintegration under increasing shear rate. In contrast, less permeable clots are more resistant to rupture due to shear rate dependent clot stiffening originating from enhanced platelet adhesion and aggregation. These results can be used in future to predict risk of thromboembolism based on the data about composition, permeability and deformability of a clot under specific local haemodynamic conditions.

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Keywords

Blood shear, Multi-phase model, Multi-scale, Thromboembolism, Thrombosis

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