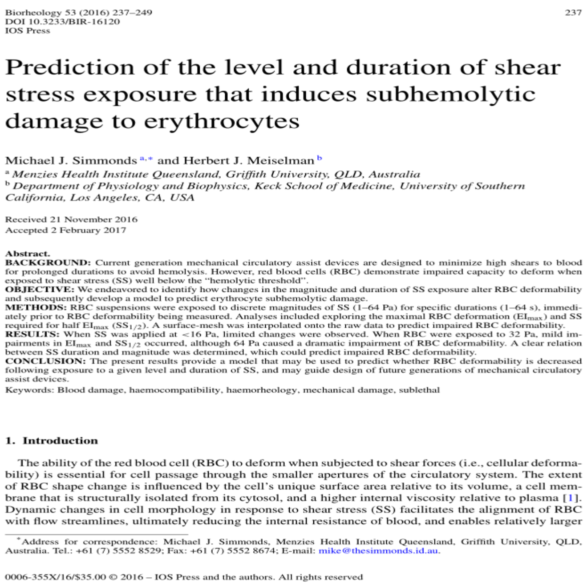
An Introduction To Biorheology



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Prediction of the level and duration of shear stress exposure that induces subhemolytic damage to erythrocytes

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Abstract.
BACKGROUND: Current generation mechanical circulatory assist devices are designed to minimize high shears to blood for prolonged durations to avoid hemolysis. However, red blood cells (RBC) demonstrate impaired capacity to deform when exposed to shear stress (SS) well below the "hemolytic threshold".
OBJECTIVE: We endeavored to identify how changes in the magnitude and duration of SS exposure alter RBC deformability and subsequently develop a model to predict erythrocyte subhemolytic damage.
METHODS: RBC suspensions were exposed to discrete magnitudes of SS (1–64 Pa) for specific durations (1–64 s), immediately prior to RBC deformability being measured. Analyses included exploring the maximal RBC deformation (EI_{max}) and SS required for half EI_{max} ($SS_{1/2}$). A surface-mesh was interpolated onto the raw data to predict impaired RBC deformability.
RESULTS: When SS was applied at <16 Pa, limited changes were observed. When RBC were exposed to 32 Pa, mild impairments in EI_{max} and $SS_{1/2}$ occurred, although 64 Pa caused a dramatic impairment of RBC deformability. A clear relation between SS duration and magnitude was determined, which could predict impaired RBC deformability.
CONCLUSION: The present results provide a model that may be used to predict whether RBC deformability is decreased following exposure to a given level and duration of SS, and may guide design of future generations of mechanical circulatory assist devices.

Keywords: Blood damage, haemocompatibility, haemorheology, mechanical damage, sublethal

1. Introduction

The ability of the red blood cell (RBC) to deform when subjected to shear forces (i.e., cellular deformability) is essential for cell passage through the smaller apertures of the circulatory system. The extent of RBC shape change is influenced by the cell's unique surface area relative to its volume, a cell membrane that is structurally isolated from its cytosol, and a higher internal viscosity relative to plasma [1]. Dynamic changes in cell morphology in response to shear stress (SS) facilitates the alignment of RBC with flow streamlines, ultimately reducing the internal resistance of blood, and enables relatively larger

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