

Laboratory of Biorheology and Medical Ultrasonics, Montreal, Canada
Research project : Ultrasonic characterization of erythrocyte aggregation

Under normal physiological conditions, red blood cells (RBCs) form reversible aggregates in low flow that usually take the form of rouleaux or complex tridimensional structures. When the flow rate is increased, the shearing forces disaggregate rouleaux and RBCs return to their individual state. However, many diseases involving circulatory disorders induce pathophysiological hyper-aggregating conditions that provoke an increase in bulk blood viscosity. Such hemorheological disorders have been observed in diseases such as deep venous thrombosis, diabetes and atherosclerosis. RBC aggregation has been shown to be of prognostic value in the aggravation of these diseases. In current clinical practice, all available techniques allowing the characterization of RBC aggregation require the withdrawal of blood and the analysis in a laboratory instrument.



Photomicrography under static condition of a diluted blood sample of a normal subject. The figure shows rouleaux of a few red blood cells (magnification 375X).

The main limitation with these techniques is that they do not allow a direct local measurement of the level of aggregation but rather give a global systemic 'aggregability' index. Furthermore, the blood samples have to be anti-coagulated and manipulated outside the body, which could potentially modify the process of aggregation.

This limitation is very constraining when one considers that the complications associated with these pathologies are generally localized in precise sites of the body: as examples lower limbs for thrombosis; feet for diabetes; bifurcations and recirculation zones for atherosclerosis. The ultrasonic characterization of RBC aggregation is a very promising tool to determine the level of aggregation *in vivo* and *in situ*. The ultrasonic waves scattered by blood can be analyzed to reveal the size and structural state of blood. Such a characterization tool should provide new insights into the understanding of the implication of RBC aggregation in the development of these diseases.

Research efforts in this field at the LBUM are targeted toward three main axes:

- Development of realistic mechanical and stochastic models that describe the effect of RBC aggregation on the scattered ultrasonic signal as a function of frequency and spatial organization of the erythrocytes;
- Experimental ultrasonic characterization of RBC aggregation in well defined and controlled flow environments leading to reliable parametric indices of aggregation; the effect of the anisotropy of RBC aggregates and of the flow pulsatility is investigated;
- Clinical characterization of RBC aggregation in humans and animal models, focusing on diseases with known circulatory related disorders such as deep venous thrombosis, diabetes, beta-thalassemia and sickle cell anemia.