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An Experimental Study of Thrombocyte Reactions in Response to Biomaterial Surfaces and Varying Shear Stress

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Extended Abstract
Objective
Thrombotic complications are among the leading causes for morbidity and mortality in patients who depend on artificial organs. Foreign materials in contact with blood lead to an activation of platelets. As a consequence thrombus growth on the surface takes place. Therefore it is important to evaluate the thrombogenic properties of blood-contacting surfaces. Goal of this study is to experimentally measure platelet activation and adhesion, thrombus formation and thrombus growth under the influence of well-defined shear rates for cylindrical gap flow and for flow in a rectangular chamber.

The function and role of the adhesive proteins fibrinogen and von Willebrand factor are also studied. Different materials including polystyrene, polyurethane as well as collagen-coated surfaces are tested.

Materials and Methods
Experiments with citrated human whole blood from voluntary male donors are performed in a rectangular flow chamber as well as in a Taylor-Couette system for laminar circumferential flow and Taylor vortex flow using different biomaterials. The activation and drop of single platelets, adhesion and aggregation are measured by means of differential blood count, analysis of scanning electron microscopic photographs, and flow cytometry, respectively. In order to determine the amount of fibrinogen which is bound by the platelets flow cytometry is again used and von Willebrand factor is visualized by means of fluorescence microscopy.

Results and Discussion
Regions and flow conditions with a high potential for thrombus growth could be identified. The experiments clearly show the influence of the material and flow conditions. Polystyrene surfaces were found to cause less blood trauma than other tested materials.

A clear pattern of platelet adhesion could be observed and lets assume that a binding mechanism change occurs at a shear rate of 1000 1/s as could be shown by Schneider et al. (1986). Visualization of the underlying protein adsorption patterns confirms that von Willebrand factor undergoes a conformational change from a spherical to a linearly stretched state and confirms the hypothesis that platelet binding behavior depends on whether blood is subjected to low or high shear stress.

Conclusion
At low shear rates the observed platelet behavior coincides with works published by authors such as Hubbell and McIntire. At the transition to shear rates above 1000 1/s it could be shown that a significant change in platelet behavior occurs. In the future, this knowledge may be important in order to predict platelet reactions. It was also shown that there is a strong difference between platelet behavior in the venous circulation and slowly perfused devices such as oxygenators in contrast to the arterial

circulation and the blood flow through high shear producing devices such as rotary blood pumps.

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