GHOST CELLS AS A TWO-PHASE BLOOD ANALOG FLUID — VISUALIZATION OF MECHANICAL HEMOLYSIS

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Background:

In designing mechanical circulatory support systems, minimizing hemolysis and thrombosis is crucial. Traditional methods for assessing hemolysis in in-vitro blood experiments are time-consuming and provide only quantitative data. Therefore, we are working on the Fluorescent Hemolysis Detection to locally resolve hemolysis within a mechanical circulatory support system.

Methods:

Fluorescent Hemolysis Detection involves a two-phase blood analog fluid made from ghost cells, erythrocytes devoid of hemoglobin and loaded with calcium ions targeted by an extracellular calcium-indicator (Cal590 potassium salt, AAT Bioquest). Upon hemolysis, calcium and indicator bind to each other and thereby exhibit an increased fluorescence signal under laser excitement.

Mechanical hemolysis is induced with high shear stresses in the FDA pump, running at an operational point of 3500 RPM and a volume flow of 2.5 L min^{-1}, inducing a pressure difference of 350 mmHg. A laser sheet at 532 nm excites the fluorescent indicator in the pump, and the fluorescent signal is captured optically using a high-speed camera (Flowsense EO, Dantec Dynamics). Additionally, samples undergo analysis for blood count, free plasma hemoglobin, and fluorescent signal. The pump is also operated with blood to compare the hemolysis with ghost cells.

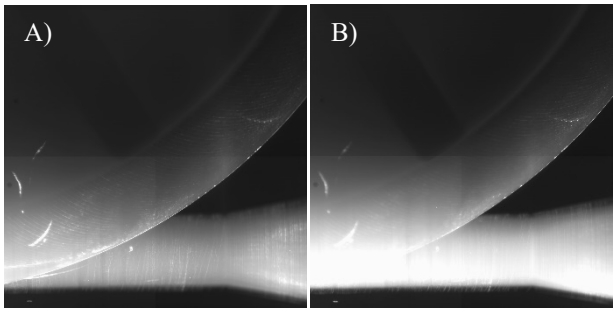

Figure 1: Fluorescent Hemolysis Detection shown in the outlet area of the FDA Pump: A) start of runtime, B) after 13 minutes at 3500 RPM, 2.5 L min- and 350 mmHg pressure drop.

Results:

The free plasma hemoglobin exhibits an increase over time for both ghost cells and blood. The normalized hemolysis index for ghost cells surpassed that of blood. Moreover, the fluorescent signal of the ghost cells fluid obtained by the camera (Figure 1) increased by 21 % in mean brightness over the pump's operational duration.

Conclusion:

Our study highlights the hemolysis differences between ghost cells and blood, demonstrating the visibility of increased hemolysis in the FDA pump, which is made visible with the Fluorescent Hemolysis Detection.
Further data analysis will determine if locally resolved hemolysis detection is possible.

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