Microfluidic Blood Sorting For Improved Blood Quality Over Prolonged Storage

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Prolonged blood storage raises concerns of compromised blood quality and rapid red blood cell (RBC) clearance post transfusion. In this work, we report significant changes in RBC deformability and osmotic fragility over storage period. A novel microfluidic RBC sorter was introduced to mechanically enrich bad RBC subpopulations, which has potential implication of improving clinical outcome post blood transfusion.

Introduction: Blood storage lesion is known to introduce additional risk relating to blood transfusion.[1] Increased RBC hemolysis[1] as well as retention in spleen[2] are believed to be two key mechanisms for the rapid RBC clearance post transfusion. In this work, we employed a novel microfluidic platform to assess changes in RBC deformability over prolonged storage period. Additionally, a high throughput blood sorting technique was applied to remove less deformable RBCs, mechanically purifying the old stored blood. Besides deformability characterization, RBC osmotic fragility was also measured as an important indicator of *in vivo* hemolysis.

Materials and Methods: Packed RBCs were purchased from blood bank and stored at 4°C up to 40 days. The microfluidic device used to characterize RBC deformability was previously described[2] with critical feature size of 3 µm x 5.3 µm (gap width and depth). The high throughput blood sorting device consisted of a long straight channel of 20 µm x 10 µm x 2 cm, connecting to the center and side outlets.[3] Osmotic fragility was quantified by the percentage of hemolysis using Pink Test assay.[4]

Results and Discussion: RBS deformability (or velocity) and osmotic fragility were monitored for up to 40 days. Significant stiffening was observed for all 3 healthy blood donors (color coded black, blue and red) after 20 days of storage period (Figure 1A), whereas gradual increase in osmotic fragility was noted throughout the storage time (color coded gray, purple, pink for different blood donors). For blood stored more than 4 weeks, the microfluidic sorting device was applied for blood enrichment. It was found that the side outlet was able to collect significantly stiffer and more fragile RBC subpopulations ($p < 0.05$).

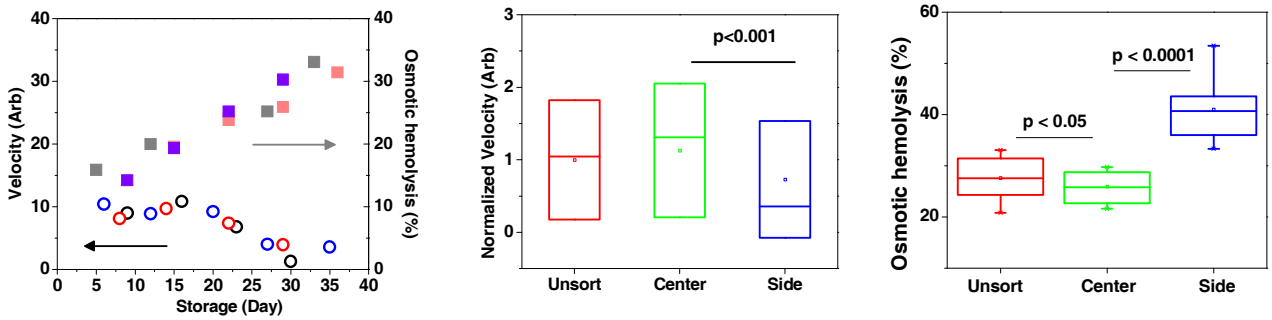

Figure 1 Time dependent changes in RBC deformability (velocity) and osmotic fragility (A). After sorting, significant subpopulation enrichment was observed in side channel in terms of deformability (B) and fragility (C).

Conclusions: Deteriorations in RBC deformability and fragility were observed over the course of blood storage. The microfluidic deformability sorter has demonstrated great potentials for improving blood quality over prolonged storage time. The system has promising implications in extending blood shelf life and reducing transfusion related risk.

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References:

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