Age-Separated RBCs Show Changes in Oxygen Carrying Capacity and Rigidity during Hypothermic Storage

O.O. Mykhailova1, W. Li1,2, J.P. Acker1,2
1Centre for Innovation, Canadian Blood Services, Edmonton, Alberta, Canada
2Department of Laboratory Medicine and Pathology, University of Alberta, Edmonton, Alberta, Canada

Red cell concentrates (RCCs) received from healthy blood donors contain an age spectrum of cells (from 0 to 120 days old) that can vary depending on donor’s age and sex. Older cells may contribute to the red blood cells (RBCs) storage lesion to a greater extent than younger cells. Due to progressive loss of cell membrane and water with age, older RBCs become smaller than younger RBCs and their intracellular hemoglobin concentration is higher, resulting in changes in RBC characteristics such as oxygen carrying capacity, osmotic fragility, rigidity, and others.

RCCs from three healthy donors were separated with Percoll density gradients into less dense (young) and dense (old) RBCs and stored for 42 days at 4°C. In vitro quality was assessed weekly to monitor changes in RBC indices, hemolysis, oxygen saturation, osmotic fragility, deformability, rigidity and phosphatidylserine externalization (Annexin V). Repeated measures analysis of variance (ANOVA) was used to determine the influence of storage duration. Significant difference was defined as p < 0.05.

Young RBCs after Percoll separation showed significantly higher mean corpuscular volume (MCV) and lower mean corpuscular hemoglobin concentration (MCHC) compared to both control cells (parent RCCs) and old RBCs (p < 0.001) throughout the 42-day storage. Old RBCs had a significantly faster increase in MCV and decrease of MCHC comparatively (p < 0.001).

Analysis of the storage effect showed significantly reduced oxygen carrying capacity in old RBCs compared to the control (p = 0.002) and young RBCs (p < 0.001) throughout storage, but the rate of changes were the same for both subpopulations.

Deformability, osmotic fragility and phosphatidylserine externalization of young and old RBCs did not differ from the control cells, while the rate of the change in rigidity and osmotic fragility were significantly higher in both RBC subpopulations. Young RBCs showed lower rigidity than control (p = 0.003) and old ones (p = 0.0014), but a higher rate of change for both rigidity (p = 0.003) and osmotic fragility (p < 0.001).

Hemolysis in the old RBC subpopulation was significantly higher (p = 0.048) and increased rapidly (p = 0.009) in comparison with the young cells during storage. However, both the separated RBC subpopulations had a higher percent of hemolysis compared to control cells during the storage (p < 0.001).

Therefore, the differences in the quality parameters of the young and old RBC subpopulations during 42 days of storage suggest increased contribution to the storage lesion in blood samples containing a higher ratio of old RBCs.