ADVANCES IN HEMATOLOGY

Current Developments in the Management of Hematologic Disorders

Section Editor: Craig M. Kessler, MD

The Effects of Storage Duration on Erythrocytes

Steven M. Frank, MD
Associate Professor
Director, Perioperative Blood Management Services
Department of Anesthesiology/Critical Care Medicine
Johns Hopkins Medical Institutions
Baltimore, Maryland

H&O How long are red blood cells typically stored?

SF Currently in the United States, the storage duration is set by the US Food and Drug Administration (FDA) at 42 days or 6 weeks. This duration was selected based on the percent of red cells that are still viable 24 hours after transfusion, which is 75%. The quality and function of the cells, however, remains controversial since a variety of detrimental changes occur during storage.

H&O What types of changes occur in red blood cells under standard blood banking conditions?

SF The most rapid change is the loss of nitric oxide, which occurs within hours after storage. Nitric oxide is a vasodilator, so it helps the red cells deliver oxygen to ischemic tissues. There is a loss of 2,3-diphosphoglyceric acid (2,3-DPG), an allosteric effector that helps the hemoglobin unload oxygen to the tissues. Loss of 2,3-DPG makes it more difficult for the red cells to deliver

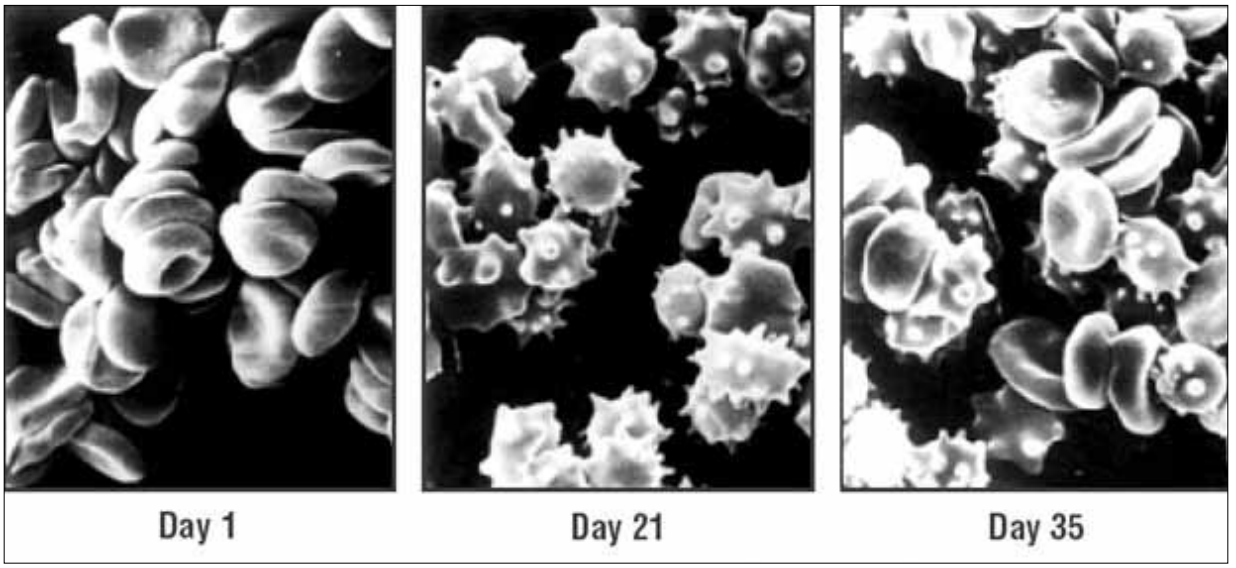

Figure 1. Images from a scanning electron micrograph of stored red blood cells on day 1, day 21, and day 35 (magnification of 4.4 x 103).

Reprinted with permission from Hovav T et al. Alteration of red cell aggregability and shape during blood storage. *Transfusion.* 1999;39:277-281.

oxygen. There are also changes to the cell membranes during storage (Figure 1).

H&O Could you please describe your recent study on the effects of storage duration on erythrocytes?

In our recent study, we assessed changes to the stiffness of the red cell membrane, which we referred to as *deformability*. We examined 16 patients before and after transfusion to evaluate the effects of storage duration and determine whether changes in deformability are reversible after transfusion. We found that the cell membrane became stiffened after 3 weeks of storage. A novel discovery in our study was that after transfusion, the red cells did not regain the normal membrane properties. The loss of deformability was permanent and did not reverse after transfusion.

H&O Why is deformability of the membrane important?

SF The capillaries in our body are the same diameter, or even smaller, than the red cell itself. In order for red cells to travel through small capillary beds, they must change their shape and squeeze through the small capillaries. If the membranes become stiffened and they lose deformability, it is harder for the cell to travel through capillary beds.

H&O Is there any other research in this area?

SF There are 2 large, multicentered randomized trials under way, which will be completed in approximately a year. One is a US study called the RECESS (Red Cell Storage Duration Study) trial, and the other is a Canadian study called the ABLE (Age of Blood Evaluation) trial. These trials are randomizing patients to receive fresher or older red cells and examining overall outcomes such as heart attack, stroke, death, and renal failure. Until the results of these trials are available, there will not be a real answer regarding how the age of red cells affects overall outcomes. Our study is one more piece of the puzzle showing that during storage, red cells lose the natural properties that allow them to deliver oxygen normally.

Suggested Readings

Frank SM, Abazyan B, Ono M, et al. Decreased erythrocyte deformability after transfusion and the effects of erythrocyte storage duration. *Anesth Analg*. 2013;116:975-981.

ClinicalTrials.gov. Red Cell Storage Duration Study (RECESS). http://clinicaltrials.gov/show/NCT00991341. Identifier: NCT00991341.

Lacroix J, Hébert P, Fergusson D, et al. The Age of Blood Evaluation (ABLE) randomized controlled trial: study design. *Transfus Med Rev*. 2011;25:197-205.