Does Blood Save Lives?

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OBJECTIVES

The objective of this session is for the participant to recognize the association between red cell transfusion and adverse outcomes in patients with cardiovascular disease undergoing cardiac surgery. In addition, the participant will become aware of structural and functional changes in red cell products with increasing storage duration and implications of these changes on patient outcome.

While life saving, red cell transfusion has been associated with increased morbidity, higher in-hospital mortality and reduced long-term survival in patients undergoing surgery. A higher prevalence of cardiac, neurologic and pulmonary morbidities have been reported for patients transfused in the perioperative period. Transfusion of RBC has also been attributed to more infectious complications such as pneumonia, septicemia and bacteremia and deep and superficial wound infections compared to those not receiving a red cell transfusion. A recent investigation of patients undergoing elective major vascular surgery noted that perioperative transfusion in patients who were not anemic and who were clinically stable were at significant risk for myocardial infarction and death. An investigation examining the role of transfusion in perioperative lung injury reported more pulmonary complications in patients transfused red cells and fresh frozen plasma. Pulmonary complications included respiratory distress, longer intubation times, and reintubation for pulmonary reasons. Interestingly, a majority of patients both transfused and not transfused had lung injury following cardiopulmonary bypass manifested by a PaO2/FiO2 ratio less than 300. Differentiation of transfusion associated circulatory overload, and transfusion related lung injury is particularly problematic in this patient population. Excess morbidity associated with transfusion often translates to longer intensive care unit and hospital length of stay.

There are a number of structural and functional changes that occur with red cell storage that may in part be related to a number of adverse outcomes associated with transfusion. Following donation blood is routinely stored for up to 42 days. The influence of prolonged storage on impairment of oxygen delivery and clinical outcomes is controversial. An analysis of changes occurring during red cell storage suggests that storage induced defects in RBC units could be related to transfusion associated adverse outcomes. The authors noted RBC deformability gradually decreased with increasing storage duration in addition to decreases in 2, 3 DPG, and increases in potassium, lactate, and free hemoglobin with increasing duration of storage. Reynolds et al reported that loss of nitric oxide bioactivity with routine blood storage adversely impacted red blood cell hypoxic vasodilatory activity with associated impairment in blood flow. Interestingly, they reported that repletion of nitric oxide bioactivity could restore red blood cell vasodilatory activity and improve tissue blood flow. A recent laboratory investigation by Sweeney et al commented on a mechanism whereby stored red blood cells could contribute to excess thrombotic complications. In their investigation red cell storage age had a significant impact on thrombin generation. The authors noted that some stored red blood cells released microvesicles which expressed phosphatidylserine and were capable of facilitating thrombin generation. Relevy and colleagues suggested the potential risk with transfusion may be related to impaired red blood cell rheology. The authors examined the effect of cold storage on RBC adherence and deformability noting that red blood cell flow properties were affected by cold storage. Cold storage increased the number of adherent red blood cells and strength of their interaction with endothelial cells. A marked decrease in RBC deformability was reported as early as 2 weeks into the storage period. In a laboratory investigation Rigamonti et al demonstrated that red cell storage limits the ability of red blood cells to deliver oxygen to brain tissue. They noted fresh blood demonstrated greater increases in regional cerebral blood flow and tissue oxygen tension compared to stored blood.

There are a number of clinical investigations that report an increase risk for adverse outcomes associated with storage duration. In cardiac surgery, administration of red cells older than 14 days storage duration was associated with reduced survival and an increase in complications following surgery. In trauma patients, Zallen et al reported a risk adjusted increase in multisystem organ failure with increasing number of RBC transfused and with red cell units of older storage duration, beyond 14 and 21 days storage. Leal-Noval et al examined transfusion on cerebral oxygenation in patients with traumatic brain injury. Younger blood stored less than 19 days storage duration was associated with improved cerebral oxygenation versus older blood. In a separate investigation Leal-Noval S et al suggested storage duration longer than 28 days may be a risk factor for nosocomial pneumonia. Of note, there are investigations that do not find an association between prolonged red cell storage and adverse outcomes.
While transfusion is necessary for some patients, it has a strong reported association with adverse morbid outcomes. Whether morbidity is due intrinsic properties of allogenic red cells or to the biochemical and mechanical properties that occur with increasing storage duration is unsettled. Furthermore, the optimal hematocrit to initiate a transfusion in an individual patient is unknown in part because of our inability to measure tissue oxygenation at the bedside.

REFERENCES