

# Red Cell Salvage: Current Status

## WHITE PAPER

### Background

Intraoperative Red Cell Salvage (RCS) was introduced in the early 1980s and rapidly gained clinical acceptance. Early RCS was done without cell washing, but washed RCS became the standard of care in cardiac surgery and other procedures as its advantage in removing contaminants such as lipids, vasoactive substances, and inflammatory mediators became widely appreciated. RCS gained popularity because it did not carry the risk of transfusion-transmitted diseases, notably HIV and hepatitis B and C and decreased demand for allogeneic blood. While both of these benefits are still true today, the increased safety profile of allogeneic transfusion as well as the presence of stable blood inventories have diminished their importance. Nevertheless, strong clinical and economic reasons remain to use RCS. This white paper addresses these issues.

### Risks of allogeneic transfusion and the rise of patient blood management

Outcomes are worse when patients are transfused with allogeneic RBC. Survival was significantly reduced for patients exposed to 1 or 2 units of RBC during hospitalization for cardiac surgery (coronary artery bypass and/or valve surgery) compared to patients who were not transfused.<sup>(1)</sup> Using 11,885 patient pairs matched for 55 risk factors, Ferraris et al. found that surgical patients who received 1 unit of intraoperative allogeneic RBC had significantly higher mortality, more wound infections and a higher rate of pulmonary, renal and cardiac complications, as well as longer length of stay.<sup>(2)</sup> Adverse clinical outcomes including serious perioperative infections, post-injury multiple organ failure and increases in intensive care unit time have been widely reported in recipients of allogeneic blood. Significantly, these complications are worsened in a step-wise, dose-response manner.<sup>(3)</sup> While the cause(s) of the adverse outcomes have not been clearly elucidated, the blood storage lesion and subsequent immune suppression are probably important contributors.

Over the last 5 years the concept of patient blood management (PBM) has gained traction. The principles of PBM consist of the 4 “rights:” 1) right product; 2) right dose; 3) right time and 4) right patient. Underpinning this philosophy is a multidisciplinary approach which matches the selection of appropriate technology to the needs of the patients. Intraoperative and perioperative RCS play a key role in PBM.

# Red Cell Salvage: Current Status

## Risks of allogeneic transfusion are avoided by the use of red cell salvage

In a study of transfusion and infection after cardiac surgery involving nearly 25,000 patients, investigators found that allogeneic, but not autologous, transfusion increased the odds of in-hospital infection 2-fold.<sup>(4)</sup> The Mayo Clinic has the world's largest RCS programs and Winters and colleagues found that recipients of autologous RBC in surgery had a significant long-term survival advantage (83% 10-year survival for RCS-only versus 34% allogeneic-only).<sup>(5)</sup> Other life-threatening complications of transfusion, including transfusion-related acute lung injury (TRALI), should be decreased by elimination of allogeneic transfusions. TRALI has been observed in 2.4% of cardiac surgery patients in a Dutch nested, case-control study.<sup>(6)</sup> Vlaar et al. found that the risk factors for TRALI were total amount of blood products, number of red cells stored more than 12 days and total amount of plasma transfused. While many studies involving cell salvage address cardiac surgery, washed cell salvage confers an advantage in other surgical procedures, including the reduction of postoperative infection in patients having primary arthroplasty.<sup>(7)</sup> In four randomized, controlled studies patient outcomes were improved with the use of cell salvage or preoperative autologous donation.<sup>(8)</sup>

## Allogeneic blood requirements are reduced with red cell salvage

Technological improvements such as the introduction of minimally invasive surgery as well as the acceptance of normovolemic anemia (lowering the “transfusion trigger”), have contributed to a reduction in allogeneic blood transfusions. Is there still a role for cell salvage? In a prospective, randomized controlled study in neonates and infants undergoing open heart surgery, the RCS group had significantly fewer RBC and coagulant product transfusions in the first 48 hours after surgery.<sup>(9)</sup> In a cohort study of low-to-moderate risk cardiac surgery, the use of cell salvage resulted in a significant reduction in postoperative allogeneic RBC transfusions as well as earlier discharge from the intensive care unit after surgery.<sup>(10)</sup> Additionally, the cell salvage group had a lower incidence of myocardial infarction. When miniaturized cardiopulmonary bypass circuits are used, cell salvage significantly reduced intraoperative RBC requirements (9% vs. 48%).<sup>(11)</sup>

## Salvaged RBC are functionally superior to allogeneic RBC

Refrigerated storage of blood results in a “storage lesion,” characterized by rheologic changes, metabolic derangements, changes in oxygen affinity and delivery, oxidative injury to lipids and proteins, RBC shape change, loss of membrane and reduced RBC lifespan.<sup>(12)</sup> These changes become more pronounced with longer storage. Salvaged RBCs are “fresher” and therefore

# Red Cell Salvage: Current Status

should perform better than stored RBCs. In a recent study from Johns Hopkins Hospital, Salafia et al. demonstrated that RBC deformability and aggregation are minimally affected by coronary pulmonary bypass with RCS, but are negatively affected by the addition of stored allogeneic blood.<sup>(13)</sup> Given that structure and function of RBC affect oxygen delivery, these findings favor the use of RCS.

## Economics

Cost-effectiveness is impacted by many factors, not the least of which is the “cost” of transfusion. Many studies have shown the cost of acquiring blood is only 20-33% of the total cost of delivery of the blood to the patient.<sup>(14)</sup> Such analyses generally do not take into account the complications of allogeneic transfusion that can be avoided by using RCS. While most authorities believe that cost-effectiveness is readily achieved when the equivalent of two RBC units are salvaged, in the opinion of some blood management experts, if the full costs are considered, cell salvage is cost-effective when the equivalent of one unit of RBC is recovered.<sup>(15)</sup>

## Summary

Intraoperative red cell salvage has been shown to reduce the risks of allogenic transfusion: Its utilization reduces the need for allogeneic RBC transfusion. The RBC are functionally superior to stored RBC. When utilized appropriately, the economics are favorable.

M. A. Popovsky, M.D.

Chief Medical Officer

December 2013

# Red Cell Salvage: Current Status

## References

1. Surgenor S, Kramer R, Olmstead, et al. Anesthesia and Analgesia. 2009;108:1741-46.
2. Ferraris V, et al. Arch. Surg. 2012;147:49-55.
3. Leal-Noval SR, Marquez-Vacaro JA, Garcia-Curiel A, et al. Crit Care Med. 2000;28:935-40.
4. Rogers M, Blumberg N, Saint S, et al. BMC Medicine. 2009;7:37:1-9.
5. Winters J, Moore B, et al. Transfusion. 2004;44:4A.
6. Vlaar AP, Hofstra JJ, Determann RM, et al. Blood. 2011;117:4218-25.
7. Innerhofer P, Klinger A, Klimmer C, et al. Transfusion. 2005;45:103-10.
8. Vanderlinde E, Heal JM, Blumberg N. BMJ. 2002;324:772-775.
9. Cholette J, Powers K, Alfieris, et al. Ped Crit Care Med. 2013;14:1-10.
10. Vonk B, Meesters M, Garnier R, et al. Transfusion. 2013;53:2782-89.
11. Silva L, Andres A, Senger R, et al. Rev Bras Cir Cardiovasc. 2013;28:183-9.
12. Solomon S, Wang, D, Sun J, et al. Blood. 2013;121;1663-1672.
13. Salaria O, Barodka V, Hogue C, et al. Anesthesia and Analgesia (In press).
14. Shander A, Hofmann A, Ozawa S, et al. Transfusion. 2010;50: 753-65.
15. Waters J, Dyga R, Waters JF, et al. Transfusion. 2011;51:2126-32.

