

Fresh whole blood transfusions for life-threatening haemorrhage

For patients with life-threatening haemorrhage, restoration of circulating volume is essential and blood transfusion is inevitable. The ability to separate and store red blood cells, fresh frozen plasma, platelets and cryoprecipitate revolutionized the management of blood loss. Before this, blood donors were relied on to come to hospital for each emergency. This was unpopular, unreliable and impractical. Current military practice permits the use of warm fresh whole blood, donated by on-site military personnel, for casualties with life-threatening injuries when stored products are unavailable or if the response to haemostatic resuscitation with blood products is poor (Spinella, 2008). Indications for fresh whole blood transfusions in civilians include massive haemorrhage, burns, cardiac surgery, neonatal exchange transfusion and traumatic brain injury (Repine et al, 2006). This article looks at the advantages and disadvantages of fresh whole blood transfusions.

Advantages of whole blood transfusion

Increasing data, mainly from the military, suggest that fresh whole blood transfusions are at least as safe as red blood cells and have particular use in rapid restoration of blood circulating volume, treatment of hypothermia and early management of coagulopathy (Repine et al, 2006; Spinella, 2008). Indeed, the dilutional coagulopathy seen with significant transfusions of red blood cells may not even arise. Hughes et al (2007) showed that whole blood could be kept at 19°C for up to 72 hours without significant loss of platelet function. Clotting factor function is 86% in one unit of fresh whole blood compared to 65% in a unit of whole blood reconstituted from stored blood products (Spinella, 2008). In paediatric cardiac surgery, priming the bypass circuit with whole blood rather than packed

cells led to an overall reduction in the number of exposures to blood products, with one exposure per whole blood prime compared to three exposures with packed red blood cells (Valley et al, 2007).

Fresh blood is typically kept at room temperature for 24 hours before being discarded, whereas packed red blood cells can be stored for 35–42 days although only relatively rarer blood groups (e.g. O rhesus negative) tend to be kept for more than 28 days (Ho et al, 2003). Storing red blood cells causes significant changes in their structure and function, with eventual loss of biconcave structure, increased formation of spiculated echinocytes and depletion of 2,3-diphosphoglycerate, reducing the oxygen-carrying capacity of haemoglobin.

The incidence of alloimmunisation and inflammatory response has been reduced by pre-storage leukoreduction of red blood cells but stored blood remains a source of inflammatory mediators, including interleukin-8, tumour necrosis factor and bradykinin. These may contribute to systemic inflammatory responses seen after massive transfusions of red blood cells (Ho et al, 2003). A study of complications after cardiac surgery found a significantly increased risk of postoperative complications, longer hospital stay and reduced short- and long-term survival when red cells that had been stored for more than 2 weeks were transfused, compared to red blood cells stored for less than 2 weeks (Koch et al, 2008).

Disadvantages of whole blood transfusions

Obtaining a reliable supply of fresh whole blood in the emergency setting, especially when resources are already stretched, would pose a significant challenge. As with red blood cell transfusions, fresh whole blood is subject to ABO and rhesus incompatibility reactions. While fortunately rare, when these do occur they may be catastrophic. The risk of acute lung injury and transmission of infectious diseases appears similar to that with transfusion of packed red blood cells. There is also the risk of microchimerism (persistence of >1% allograft cells in the

donor), which may be associated with autoimmune diseases such as systemic lupus erythematosus and graft *vs* host disease.

The need for prospective randomized controlled trials of transfusion of fresh whole blood *vs* blood components is limited by patients with life-threatening haemorrhage needing to receive both packed cells and whole blood transfusions in the emergency setting.

Conclusions

Prolonged storage of blood is detrimental. The military use fresh whole blood for life-threatening injuries, allowing simultaneous and rapid restoration of circulating blood volume and its constituents while reducing the total number of exposures to blood products. However, the logistics of obtaining a reliable, consistent supply of fresh whole blood restricts its use in civilian medicine. Further studies are needed to see if there are clear benefits of fresh whole blood over red blood cells in patients whose blood loss can be predicted, such as in cardiac surgery. Only then could we consider introducing a system to allow transfusion of fresh whole blood for patients with life-threatening haemorrhage. **BJHM**

- Ho J, Sibbald W, Chin-Lee I (2003) Effects of storage on efficacy of red cell transfusion: when is it not safe? *Crit Care Med* **31**(12): S687–96
- Hughes J, Macdonald V, Hess J (2007) Warm storage of whole blood for 72 hours. *Transfusion* **47**(11): 2050–6
- Koch C, Liang L, Sessler D, Figueroa P, Hoeltge G, Mihaljevic T (2008) Duration of red-cell storage and complications after cardiac surgery. *N Engl J Med* **358**: 1229–39
- Repine T, Perkins J, Kanvar D, Blackburne L (2006) The use of fresh whole blood in massive transfusion. *J Trauma* **60**(6): S59–69
- Spinella P (2008) Warm fresh whole blood transfusion for severe haemorrhage: US military and potential civilian applications. *Crit Care Med* **36**(7): S340–5
- Valley M, Buckley K, Hayes K, Fortuna R, Geiss D, Holt D (2007) Are there benefits to a fresh whole blood versus packed red cell cardiopulmonary bypass prime on outcomes in neonatal and paediatric cardiac surgery? *J Extra Corporeal Technol* **37**(3): 168–76

Anaesthetic and critical care dilemmas are coordinated by Dr John Orr and Dr Annie Hunningher, Research Fellows at the Centre for Anaesthesia, UCL, London. Ideas for future dilemmas can be sent to Rebecca Linssen bjhm@markallengroup.com

Dr Rachel Blackshaw is Specialist Registrar in Anaesthesia, Anaesthetic Department, South Devon Healthcare NHS Foundation Trust, Torquay, Devon TQ2 7AA