

## More about...

4. Page TC, Light WR, McKay CB, Hellums JD. Oxygen transport by erythrocyte/hemoglobin solution mixtures in an *in vitro* capillary as a model of hemoglobin-based oxygen carrier performance. *Microvasc Res* 1998; 55: 54-64.
5. Standl T, Horn P, Wilhelm S, et al. Bovine haemoglobin is more potent than autologous red blood cells in restoring muscular tissue oxygenation after profound isovolaemic haemodilution in dogs. *Can J Anaesth* 1996; 43(7): 714-723.
6. Standl TG, Reeker W, Redmann G, Kochs E, Werner C, Schulte am Esch J. Haemodynamic changes and skeletal muscle oxygen tension during complete blood exchange with ultrapurified polymerized bovine haemoglobin. *Intensive Care Med* 1997; 23: 865-872.
7. Levien LJ. South Africa: clinical experience with Hemopure. *ISBT Science Series (Vox Sanguinis)* 2006; 1: 167-173.
8. George I, Geng-Hua Y, Schulman AR, et al. A polymerised bovine haemoglobin oxygen carrier preserves regional myocardial function and reduces infarct size after acute myocardial ischemia. *Am J Physiol Heart Circ Physiol* 2006; 291: H1126-H1137.

## Cell-salvage techniques – a practical approach

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Blood is an expensive and increasingly scarce commodity. Moreover, the transfusion of homologous blood carries the risk of major transfusion reactions and transmission of infective agents such as the hepatitis and HI viruses. Therefore, there is a worldwide resistance to homologous blood transfusion, and a policy of bloodless surgery is becoming increasingly popular.

For the past 13 years efforts have been made to limit the use of blood transfusion in the open-heart unit at Greenacres Hospital, Port Elizabeth. This article gives an overview of the techniques used to salvage and transfuse red blood cells during cardiac surgery. This policy results in the haematocrit being at an optimal level during cardiopulmonary bypass surgery, allowing the majority of patients to return to the ICU without having received a transfusion of homologous blood. Cell saving has emerged as an indispensable part of our strategy. An added bonus of cell saving is that inflammatory mediators are removed during the cell-saving process, reducing the systemic inflammatory response associated with conventional cardiopulmonary bypass surgery.

Briefly, the techniques we follow are:

1. Minimising blood loss during surgery.
2. Intraoperative cell salvage with the Electra 5 cell saver.
3. Postoperative cell salvage in the ICU when indicated (blood loss more than 500 ml in the first 2 hours postoperatively).

### Minimising blood loss during surgery

This is the most important factor in conserving autologous blood. In our experience excessive blood loss during the procedure often goes unnoticed, collecting in open pleural spaces.

Sources include bleeding from unsecured side branches of the internal mammary artery, the internal mammary bed, the internal periosteum of the sternum, the arteries around the xiphisternum, the leg after vein harvesting and cannulation sites. We take particular care to ascertain that all these areas are dry, and make liberal use of cautery and the argon laser technique.

### Intraoperative cell salvage

A custom-designed sucker facilitates heparin being delivered to the operation site so that shed blood (which is immediately sucked away) is mixed with anticoagulant. Haemolysis is minimised by setting the vacuum at the lowest effective level. The blood/anticoagulant mixture carried into the sterile reservoir is filtered to remove large clots and debris. The blood must be anticoagulated to prevent clotting and secondary fibrinolysis.

Great care is taken to administer the correct amount of anticoagulant. A ratio of 1:5, and not more than 1:10, of anticoagulant to collected blood is recommended. Most collection reservoirs have filters in the 40 - 150 µm range.

Blood and anticoagulant are then drawn from the collection container and centrifuged. The red cells are separated from waste products and suspended in a sterile, isotonic saline solution. Waste products include white cells, platelets, plasma, anticoagulant, fats and free plasma haemoglobin. These products are collected in a bag and discarded. Packed red cells that have been separated from the waste products are collected separately. Then the washed red cells are reinfused into the circulation using a 40 µm leucocyte filter.

### Postoperative cell salvage

When there is excessive bleeding into the underwater drainage bottles immediately after the operation the cell-saving machine is transferred, together with the patient, to the ICU, allowing blood from the bottles to be processed. Normal saline (not plain water) is placed in the underwater drainage bottles. Blood can be collected and washed up to 6 hours postoperatively.

Before 2001 only conventional cardiopulmonary bypass procedures were done in our unit. The cell saver was used to recover red cells not recovered by the cardiotomy sucker. Cells were recovered from e.g. blood-soaked surgical swabs and very low haematocrit blood (in pleural spaces) judged unsuitable for direct return to the heart-lung machine because of haemodilution. However, most shed blood was still returned to the heart-lung machine via the cardiotomy sucker. Blood from the cardiotomy sucker contains elevated inflammatory markers and is an independent source of inflammatory mediators.

In 2001, with this in mind, we changed from the conventional cardiopulmonary bypass procedure to the mini bypass closed circuit. This method allows a low priming volume. Tip-to-tip coated tubing and the use of a centrifugal pump minimise blood damage. Using this method all the shed blood, including that removed by the cardiotomy sucker, is returned to the cell saver. Washed and suspended red cells are then returned to the open heart circuit.

Using the mini circuit, combined with the cell saver, the following observations were made:

- The haematocrit remained constantly high during cardiopulmonary bypass. During the procedure it was noted that the haematocrit dropped 4 - 5%. However, at the end of the procedure, with washed red blood cells having been reinfused, the haematocrit had usually returned to the preoperative value.
- The need for homologous blood transfusion diminished considerably. Currently, only 7% of patients require blood transfusion postoperatively.

#### Further reading:

- Allen SJ, McBride WT, McMurray TJ, et al. *Ann Thorac Surg* 2007; 83(2): 578-585.
- Djaiani G, Fedorko L, Borger MA, et al. *Circulation* 2007; 116: 1888-1895.
- Jessen M. Invited commentary. *Ann Thorac Surg* 2007; 83: 1766-1767.
- Van den Goor JM, Nieuwland R, van Oeveren W, et al. *J Thorac Cardiovasc Surg* 2007; 134: 798-799.