

# THE CARDIOVASCULAR PERFUSION HANDBOOK

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## BLOOD CONSERVATION DURING ADULT CARDIOPULMONARY BYPASS

### BACKGROUND

Cardiac surgery and cardiopulmonary bypass have placed a tremendous demand on blood banking facilities (20-25%). Open heart surgery has historically been associated with a high rate of blood transfusion (45-55%). Efforts to decrease such a burden have allowed for a reduction in the blood units transfused per patient, during the last decade.

The well known risks associated with allogeneic blood transfusions have prompted the search for methods and techniques designed to further decrease the exposure of patients to allogeneic blood.

Religious belief and the right to choose have led some patients to refuse transfusion of allogenic blood or blood products under all circumstances.

### Factors reinforcing the avoidance of blood transfusion:

- *Transfusion-transmitted infections*
- *ABO incompatible transfusion reactions*
- *Transfusion-associated immunomodulation:*
  - *Increased infection risk*
  - *Dissemination of malignant cells*
- *Negative effects of the storage lesion*
- *Dwindling blood supplies*
- *Increasing cost of haemovigilance*
- *Improved patient outcomes*
- *Evidence of reduced overall costs*
- *Litigation*
- *Religious belief*
- *Motivation for more discriminating transfusion practice*
- *Health care team satisfaction*
- *Accommodates patient preference*
- *Higher standard of Ethical Care*

## **OBJECTIVES**

In today's multicultural healthcare system, patients who request alternatives to blood transfusion are not only moved by religious beliefs. Cardiac surgery with CPB can be performed without the administration of Allogeneic blood as a result of the employment of several combined strategies. A comprehensive blood conservation program designed to avoid blood transfusion must be a team group endeavor, and should include all phases of treatment, from the preoperative period to the post hospital discharge. A coordinated multidisciplinary approach is central to the success of any blood conservation program.

The increased risk of transfusion associated with open heart surgery is predominantly related to the coagulopathy and hemodilution that occur as a result of the use of CPB to perform the operations. Conservation of red cell mass and plasma proteins and prevention of coagulopathy are the most important objectives of a guideline/protocol designed to avoid blood transfusion.

General strategies developed to guide the prevention of blood transfusion are usually centered around a few ideas, such as:

- *Lowering the risks that are associated with bleeding*
- *Use of meticulous surgical techniques*
- *Reduce or reverse crystalloid administration*
- *Optimization of CPB circuit and prime*
- *Use of hemostatic agents*
- *Begin medical treatment well in advance of upcoming surgeries (Epo & Iron)*
- *Maintaining a high level of critical care awareness*

## **MINIMUM ACCEPTED HEMATOCRIT LEVELS**

Mortality risks related to hematocrit levels during cardiac surgery have been disclosed from large series of cases. Based on this body of experience, a minimum nadir hematocrit of 15% for normal risk patients (17% for high-risk patients) during bypass and 22% (24% for high-risk patients) postoperatively should allow for an adequate oxygen transport and delivery and should also reduce the risks of increased morbidity and mortality. Successful management of Jehovah's Witness patients has revealed a remarkable tolerance of severe acute normovolemic anemia. The tight adherence to a specific guideline will allow for the vast majority of cases to be performed with hematocrits above the minimum levels described. Most hospitals and blood bank facilities have established standards to the minimum accepted hematocrit on a surgical patient (transfusion triggers), and these values should be reevaluated and adopted by the cardiac surgical team in order to orient the efforts towards bloodless surgery and the highest standard of perfusion care.

## ***STRATEGIES TO AVOID BLOOD TRANSFUSIONS***

### **1. PRE-OPERATIVE STRATEGIES**

Check blood cell mass and blood coagulation. Correct anemia and investigate and treat any coagulation disorders.

**1.1. Anemia** type and etiology should be sought and corrected to the normal value or to the closest possible. A few drugs and nutritional supplements may be indicated, such as: **Iron** (ferrous sulphate), folic acid, vitamin B12 and **EPO** erythropoietin. Nutritional adjustments should help to normalize hematocrit and hemoglobin values.

**1.2. Coagulation disorders** if present should be investigated and treated whenever possible.

Vitamin K1 administration, discontinuance of platelet inhibitors or changing to a short acting reversible platelet inhibitor may be necessary.

The majority of patients will have normal hematocrits (hemoglobin levels) and blood coagulation. These patients can benefit from Erythropoietin EPO administration in order to enhance their red cell production.

### **2. INTRA-OPERATIVE STRATEGIES**

The main blood conservation goals during the intraoperative period of cardiac surgery are to minimize the blood loss, and preserve both red cell mass and coagulation factors. These can be attained with a meticulously conducted surgical technique and haemovigilance with and during cardiopulmonary bypass.

**2.1. Acute normovolemic hemodilution (ANH).** Blood is collected from patients immediately after anesthetic induction and before starting the operation. After collecting the first blood bag, removed volume is replaced by crystalloids and colloids infusion, guided by the collected volume and by changes in heart rate and mean arterial pressure. Two to three units of autologous blood can be collected from an adult patient without significant side effects. During surgery the blood remains in the operating room, ready for use. This technique allows for the autotransfusion of blood rich in functioning red blood cells and platelets, and containing intact all clotting factors after CPB.

**2.2. Administer an antifibrinolytic** agent to minimize perioperative and postoperative blood loss. Aprotinin or Tranexamic acid have been reported as equally effective to reduce blood loss by an average of 50-60%.

**2.3. Surgical technique.** A crucial factor in "bloodless surgery" is the meticulous nature of hemostasis required during surgical dissection and procedure. Technical aids help facilitate this, such as electrocautery, argon beam coagulator, microwave coagulation scalpels, and topical hemostatic agents, according to the surgeon experience and preferences. Blood loss from surgical field can be minimal with a carefully performed surgical exposure, even during reoperations.

**2.4. CPB circuit.** Perfusion team should adjust the customized cardiopulmonary bypass circuit normally used in order to minimize hemodilution via circuit priming volume. The CPB circuit can be tailored to accommodate a prime of 1,000-1,400 ml of crystalloids.

**2.5. Autologous priming (RAP).** The use of autologous priming to replace most of crystalloids from the circuit will contribute to reduce the degree of hemodilution and maintain adequate oxygen transport during cardiopulmonary bypass.

**2.6. Ultrafiltration (Hemoconcentration).** Ultrafiltration should be considered as an excellent complement to remove the excess water administered during autologous blood collection, but is also effective in removing platelet inhibitors (Reo-pro, Integrilin Aggrestat, Plavix,). Either conventional or modified ultrafiltration can be employed with good results. With an ultrafilter in the circuit, at the end of operation the hematocrit can be on the 32--36% range.

**2.7. Surgical hemostasis.** After weaning from bypass, meticulous hemostasis is secured. Pump residual blood can be administered as necessary to adjust the hemodynamic function and volume requirements. Diuretics should be liberally used to eliminate the excess of water and monitored for the removal of K<sup>+</sup> and Mg<sup>+</sup>.

**2.8. Anticoagulation.** Heparin administration and its effect on clotting time should be criteriously monitored during the procedure. Protamine should be cautiously administered in a dose sufficient to neutralize the heparin effect. Heparin neutralization should be monitored by the ACT return to baseline.

**2.9. Intraoperative blood cell salvage.** Whenever available, intraoperative blood salvage may be performed by the use of a cell washer. Otherwise all blood aspirated from the surgical field returns to the circuit. Blood remaining in the circuit at the end of bypass can be immediately reinfused to the patient to adjust for hemodynamics and volume requirements or it can be transferred in blood bags for a slower venous administration. Alternatively it may be collected and concentrated by ultrafiltration or cell washing.

Autologous blood collected at the start of the procedure (ANH) is administered as necessary to replace immediate losses and to increase post perfusion hematocrit.

More recently another easy and inexpensive technique to save, concentrate and return the blood to a patient is the **Hemobag**. All Perfusate remaining in the circuit can be collected, hemoconcentrated with an ultrafilter and reinfused to the patient, quickly and easily thus helping to avoid the use of allogeneic blood product transfusions.

### **3. POST-OPERATIVE STRATEGIES**

Criteria postoperative monitoring is an important adjunct of the blood conservation protocol. Residual blood from the pump system and autologous blood are administered in order to replace blood losses and to increase the hematocrit.

Shed mediastinal blood can be processed either in a cell saver for subsequent red cell infusion or it can just be returned to circulation by venous administration.

After leaving the ICU, patients with a low hematocrit can be subjected to the same regimen recommended to treat preoperative anemia, as described in the topic pre-operative strategies with micro sampling playing an important role.

An experienced team can conduct practically all of their adult patients through cardiac surgical operations without the transfusion of a single unit of blood or blood product.

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