The Risk of Anemia in Cardiac Surgical Patients - Nathaen S. Weitzel, MD

Objectives: At the conclusion of this lecture, the participant should be able to:
1. Outline the risks of anemia in cardiac surgical patients.
2. Discuss whether anemia is an independent risk factor for cardiac surgery.
3. Consider when and why to transfuse in cardiac surgical patients.
4. Discuss whether transfusion changes the risk profile and improves the outcome of the anemic patient.
5. Discuss how to mitigate the risk of anemia in cardiac surgical patients.

Anemia continues to be a hot topic in the perioperative arena as is evident by the vast number of publications available on this topic. This syllabus will outline the topics of discussion and highlight some key references to supplement the lecture presentation.

Transfusion medicine has long sought to define the actual risks of anemia to patients and through this, to provide a solid guideline for clinicians about when it is appropriate to transfuse patients. The underlying concept is oxygen delivery, how this affects the various organ beds, and thus how it affects patient outcomes. Cardiac surgery and cardiopulmonary bypass tend to stress the hemostatic system to a greater degree than most areas of surgery, and thus serves as a very interesting topic regarding blood transfusion and transfusion medicine.

Anemia is defined by the World Health Organization as hemoglobin levels less than 13 mg / dL in men and 12 g / dL in women. If you apply this definition to cardiac surgery, pre-operative anemia can reach beyond 50% of patients [1-3]. Anemia has long been associated with decreased outcomes with multiple observational trials totaling more than 20,000 patients demonstrating this [1]. The trouble is that oxygen delivery and demands can vary significantly from patient to patient, thus making an absolute transfusion trigger nebulous. Some of the key known effects of pre-operative anemia includes:

- Increased mortality
- Increased ICU stay
- Increased transfusion rates
- Prolonged ventilation
- Renal insufficiency
- Stroke
- Delirium

Clearly if the solution were as simple as transfusions for anemic patients, we would have nothing to talk about. The fact is that blood transfusions, especially packed red blood cell (PRBC) transfusions have been consistently shown in multiple studies of various designs to be independently associated with all of the above outcomes, most importantly mortality! [4-8]. There is some conflicting evidence to suggest that outcomes following cardiac surgery are worsened by the bleeding itself and that transfusion may be a marker, yet this remains open for debate [9].

Cardiopulmonary bypass creates a scenario that primes the patient for intraoperative anemia. Factors that account for this include various pump priming practices and pre-bypass fluid management resulting in variable hemodilution; pre-operative anemia as discussed above, surgery for low BMI patients, intraoperative bleeding complications, and any coagulopathy from
CPB. Discussion of transfusion triggers is a lengthy one with multiple studies looking at this, however the discussion tends to begin with a landmark trial by Hebert et al published in the NEJM in 1999[10]. This RCT demonstrated an improvement in outcomes using a restrictive approach (7-9 g/dl) vs liberal approach (10g/dl). Whether this ICU population is applicable to the cardiac world has been questioned, yet the current STS / SCA guidelines suggest that transfusions should be used below 6 g/dl but not above 10 g/dl [11]. The concept of Critical Oxygen Delivery has been discussed and researched in various studies as an attempt to determine specific measurable markers more specific than simply the Hct / Hb values, that may determine the need for transfusion. Critical Oxygen delivery (DO2_crit) has been defined as the necessary degree of oxygen delivery to prevent organ dysfunction and shock [12-14].

Key Equations for calculating these values are:
- CaO2 = (1.34 x Hgb x SaO2) + (.003 x O2PaO2)
- DO2 (mL/min/m²) = CaO2 x CI. CI is either Cardiac Index or bypass pump flow = 10 x pump flow (L/min/m²) x CaO2.
- VCO2 (mL/min/m²) = etCO2 (mmHg) x Ve (L/min) x 1000 / 760 x body surface area (m²)

Ranucci and colleagues have demonstrated significant results looking for nadir DO2_crit values as well as DO2 / VCO2 ratios. They, among others, have identified a critical value for DO2_crit of 272 ml/min/m², below which incidence of acute kidney injury increases serving as a marker for systemic organ damage[12]. It has been demonstrated that Hg values below 4 g/dL places patients at or below this critical value and thus likely represents the lowest denominator for survival[14]. VCO2 values also represent a potentially interesting value serving as a marker for anaerobic metabolism and increased CO2 production. It is not clear at this time how to appropriately apply these measured values in the standard cardiac patient to assist in determining a true transfusion threshold. It does seem clear, however, that the microcirculation is a key vessel bed that has high variability in terms of blood flow, and that this is the actual determinant of oxygen delivery, beyond what we can easily calculate. Further studies into the measurements of DO2_crit and VCO2 values may assist the clinician in individualizing the need for transfusions during bypass.

In conclusion, anemia is associated with decreased outcomes in cardiac surgical patients whether this is a pre-operative, intra-operative or post-operative event. It seems that blood transfusions, while life saving for patients with hemorrhagic injuries at risk of losing significant amounts of blood, may also be associated with decreased outcomes for those patients not currently below the critical oxygen delivery values. It remains to be discovered how best to apply this knowledge, but a discussion of the specific details surrounding these points will aid in overall understanding of this problem.

References.


