

Isovolemic Hemodilution

Anesthetic Pearls: Anesthetic Implications and Management of Isovolemic Hemodilution

Isovolemic Hemodilution: Removal of blood from patient and replacement with non-hemoglobin fluid and then later reinfusion of withdrawn blood.

- Moderate hemodilution: Hct reduced to - 28%
- Extreme hemodilution: Hct < 20%
- Most recommend a minimum safe Hct of approximately 20%

Advantages:

1. Reduce blood transfusion requirements during surgery
2. Avoidance of blood transfusion complications (infections and immunosuppression)
3. Improved tissue perfusion due to decreased viscosity (improves rheology of blood)
4. Preservation of platelet function, coagulation factors, and 2,3 DPG levels
5. May be used in patients with infections or malignancy (not used with cell-saver)
6. Less expensive than autologous blood donation through blood bank

Technique:

1. Performed in OR before or after induction; in awake or anesthetized patients
2. Crystalloid or colloids are infused as whole blood is withdrawn
 - a. Crystalloid replacement at 3x the volume of blood removed
 - b. Colloids replacement with equal volume of blood removed (? better intravascular retention)
3. Modified Hgb-based oxygen carrying solutions and fluorocarbon-based oxygen carrier solutions are not yet commercially available
4. Blood withdrawn from central / peripheral vein or radial artery
5. Blood collected in standard blood bags containing anticoagulant (usually CPD)
6. Amount of blood withdrawn = $EBV \times Hct (initial) - Hct (allowable Hct) / Hct (average)$
7. Serial Hct should be done throughout blood removal

Physiology:

- A. Decreased Hgb concentration leads to a decrease in arterial oxygen content
- B. Compensatory mechanisms: increase in cardiac output to maintain O_2 delivery by:
 - a) Decreased blood viscosity (increase in venous return, decrease SVR, reduced afterload) - most significant between Hct of 45 and 30%
 - b) Increased sympathetic stimulation
 - c) Increase in stroke volume (more in adults)
 - d) Increase in heart rate (only children)
 - e) Hemodilution leads to redistribution of blood flow to heart / brain and increased in tissue oxygen extraction

Coronary Physiology:

Normal Coronary Anatomy:

- Increased coronary and myocardial blood flow due to decreased in viscous resistance and coronary vasodilation.
- Myocardial O_2 consumption is maintained or slightly increased.
- Redistribution of blood flow away from subendocardium during extreme hemodilution.

Coronary Artery Disease:

- Hemodilution to Hct of 25% is well tolerated for single-vessel disease & good LV function, but with multi-vessel disease, little is known tolerance of moderate hemodilution.
- Increase in trans-stenotic coronary flow due to decreased blood viscosity and increase in myocardial O_2 extraction.
- Global diastolic LV function is not as well preserved during progressive hemodilution patients with decreased LV function thereby leading to limited response to hemodilution and may ultimately have decreased cardiac output.

Patient Selection:

- A. Overall health status should be carefully evaluated rather than chronologic age
- B. Have been used in the elderly and pediatrics (in children, O_2 extraction ratio is increased to compensate)
- C. Any patient expected to lose more than 25% of EBV (not efficacious if only a small volume is withdrawn)
- D. Jehovah's witness patients may agree if maintained in closed circuit with continuous flow
- E. Surgery requiring aortic cross-clamping (improved hemodynamic tolerance, less transfusion requirements)

Contraindications:

1. Not appropriate if Hgb < 11 g/dl
2. Decreased renal function
3. Restrictive or obstructive pulmonary disease
4. Pre-existing coagulopathy
5. Hepatic disease
6. Disorders associated with reduction in coags and impaired platelets
7. Carotid or vertebral artery disease

Complications:

- A. Myocardial ischemia (increased CO and myocardial O_2 consumption while blood supplying myocardium is reduced leading to hypovolemia and tachycardia)
- B. Cerebral hypoxia
- C. Peripheral edema (especially when crystalloid is used)