Normalizing Blood for Blood Prime:

Reducing Hemodynamic Instability

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Background

Pediatric patients are at a higher risk for hemodynamic instability during renal replacement therapy (RRT) due to factors inherent in the underlying disease processes that make them candidates for this lifesaving therapy.

Further issues arise from the renal replacement therapy:

- **Bradykinin Release Syndrome: An inflammatory response resulting from the blood coming into contact with the filter: a potent vasodilator, increasing the permeability of postcapillary venules and it is spasmogenic for some smooth muscle and evokes pain.** Segen's Medical Dictionary. © 2012 Farlex
- **Hypotension: caused by fluid shifts during initiation and when fluid is removed too rapidly for the patient's condition, localized or generalized bleeding, and sepsis.**
- **Hypocalcemia: caused by the use of citrate as a blood preservative and when used as a regional anticoagulant for the renal replacement circuit.** May cause or increase hypotension.

Circulating Blood Volumes

Infant:	80 mL/kg	5 kg = 400 mL
Child:	75 mL/kg	10 kg = 750 mL
		20 kg = 1500 mL
Adult:	70 mL/kg	50 kg = 3500 mL

Extracorporeal Blood Volumes

Gambro Prismaflex® Filters

M60	93 mL
M100	52 mL
HF 1000	165 mL

WHY is this volume critical?

Smaller body proportions

An infant weighing 5 kg requires CRRT. The M60 filter is chosen. The extracorporeal volume is 93 mL and the infant's circulating volume is 400 mL. The blood volume which will be outside of the child's body is almost 25% the circulating volume or approximately 100 mL.

An adult weighing 50 kg would have a circulating volume of 3500 mL and the extracorporeal volume using a HF1000 filter would be 165 mL. The volume of blood outside the body is approximately 4%.

Why is Normalized Blood Important?

In pediatric medicine, the extracorporeal blood volume present in ECMO, apheresis and renal replacement therapies represents a challenge to maintaining hemodynamic stability. When these therapies require more than 10% of the patient's blood volume in the extracorporeal circuit, significant fluid shifts occur.

Blood and albumin primes have been utilized to minimize these fluid shifts.

However, it has been observed in the smallest and sickest patients, the physiologic state of banked or stored blood adversely affects hemodynamic stability due to the low pH and non-existent calcium.

Normalized blood has be found to further reduce the hemodynamic changes that can adversely affect the patient outcomes.

Physiological Differences in Banked or Stored Blood

Physiologic Blood Values		
Variable	Normal	Banked/Stored CPDA-1 (AABB, 18th Ed.)
pH	7.35-7.45	5.0-6.0
Potassium (mEq)	3.5-5.0	6.4
Ionized Calcium (mmol/L)	1.0-1.4	<0.2
Citrate	0	1840

CPDA-1: Citrate Phosphate Double-Dextrose
Potassium continues to rise as the stored blood ages; total extra-cellular K+ load is less than 0.5 mEq for fresh blood and 5-7 mEq at expiration. Adapted from AABB Technical Manual, 18th edition.

Blood Normalization

Blood Normalization is a process that reduces the physiologic differences between normal circulating blood and banked or stored blood.

History

2001 – First described by Dr. Patrick Brophy, University of Iowa Children's Hospital

2009 – Adapted by Dr. Peter Yorgin, Loma Linda University: Normalized Blood Educational Video YouTube.com

2014 – Implemented by Dr. Peter Yorgin, Rady Children's Hospital San Diego

Blood Normalization Protocol

Blood Normalization		
	Gambro Prismaflex® Filter Sizes	
Components	HF1000	M60
Packed Red Blood Cells	160 mL	55 mL
5% Albumin	110 mL	55 mL
Heparin	300 units	150 units
Sodium Bicarbonate	44 mEq	22 mEq
Calcium Gluconate	400 mg	200 mg

1. **Blood normalization is based on the circuit used and NOT the patient's weight**
2. **Prime circuit with normal saline, complete "prime test"**
3. **Ask blood bank to place the RRBCs in a 400 mL transfer bag**
4. **Add albumin, heparin, bicarbonate and calcium in the order listed**
5. **Gently agitate to thoroughly mix**
6. **Manual prime circuit with normalized blood**

Goals for Normalized Blood

pH 7.30 -7.50

Ionized Calcium 1.0-1.4

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