A NOVEL APPROACH TO REDUCE RED BLOOD CELL UNIT EXPOSURES TO PEDIATRIC PATIENTS UNDERGOING HEART SURGERY

BLAKE DENISON C.C.P.
Pediatric Perfusionist, Dell Medical School at the University of Texas

Exposure to blood products

- The adminstration of blood products is associated with risks of transfusion associated circulatory overload (TACO), transfusion related acute lung injury, hemolytic transfusion reaction, infectious complications and immunomodulation.[1]
- As the amount of blood transfused increases there is a direct correlation with a prolonged ICU stay.
- Transfusion can also lead to allosensitization in which patients develop panel-reactive antibodies (PRAs). High levels of PRAs can lead to a longer time on the transplant list, and they are associated with an increased risk of death in the first year after orthotopic heart transplant.[2]
- Post transplant patients with PRAs >50% have a 17% higher mortality at 1 year after transplantation.

Prime

<8 kg pts.	• Fresh PRBC and FFP
8 to 15 kg pts.	• Fresh PRBC, FFP or 25% Albumin • Changes with each patient
>15 kg pts.	• Bloodless? Crystalloid and 25% Albumin • If CPB hemodilution is <25%

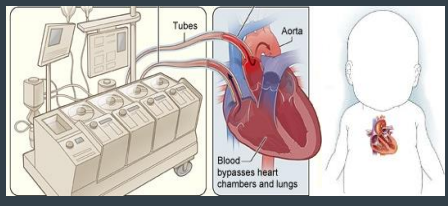
Check prime parameters pre-bypass

Cardiopulmonary Bypass Circuits

Weight	Art: Venous	Oxygenator	Prime Volume
0-7 kg	3/16" : ¼"	Capiox RX05	300 mL
7-24 kg	¼" : 3/8"	Capiox RX15	600 mL
24-35 kg	3/8" : 3/8"	Capiox RX15	800 mL
35-45 kg	3/8" : 3/8"	Capiox RX25	900 mL
> 45 kg	3/8" : ½"	Capiox RX25	1200 mL

CPB Prime Volume 600 mL

7 kg Patient Blood Volume 595 mL ⟷ 25 kg Patient Blood Volume 1875 mL



Hematocrit and Factors

- We believe that the transition on and off bypass should be as smooth as possible.
- A post dilutional hematocrit in the low to mid 30s is our clinically acceptable range on bypass however it not uncommon to push it to the into 40's if necessary.
- The hematocrit will be increased if extreme bleeding or post operative cyanosis is expected.
- Plasma is generously given to aide in hemostasis.

Considerations

- It is difficult to avoid transfusion in pediatric cardiac surgery patients due to the patient's small blood volume in comparison to the volume of the CPB circuit, and multiple strategies for blood conservation in pediatric cardiac surgery have been implemented.
- These strategies include miniaturization of the CPB circuit, vacuum-assisted drainage, cell salvage, ultrafiltration,[3] point of care testing (thromboelastometry or thromboelastography), transfusion algorithms, factor concentrate usage, and restrictive transfusion practices.[4,5]

What options do you have when these considerations are relatively fixed?

Ask for larger units of blood.

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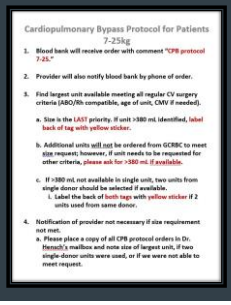
New Protocol

- The idea of purposefully sending larger units of blood was proposed to the blood bank.
- They evaluated the request and determined its feasibility.
- Blood ordering guidelines were amended by the nurse practitioners.
- The new blood ordering guidelines were reinforced by the circulating nurse prior to surgery when applicable.
- The large units were marked with a sticker for identification



Cardiopulmonary Bypass Protocol for Patients 7-25kg

1. Blood bank will receive order with comment "CPB protocol 7-25."
2. Provider will also notify blood bank by phone of order.
3. Find largest unit available meeting all regular CV surgery criteria (ABO/Rh compatible, age of unit, CMV if needed).
   a. Size is the LAST priority. If unit >380 mL identified, label back of tag with yellow sticker.
   b. Additional units will not be ordered from GCRBC to meet size request; however, if unit needs to be requested for other criteria, please ask for >380 mL if available.
   c. If >380 mL not available in single unit, two units from single donor should be selected if available.
      i. Label the back of both tags with yellow sticker if 2 units used from same donor.
4. Notification of provider not necessary if size requirement not met.
   a. Please place a copy of all CPB protocol orders in Dr. Hensch's mailbox and note size of largest unit, if two single-donor units were used, or if we were not able to meet request.

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One unit

	2016		Post Intervention	
Patient Weight	14.05	kg	12.98	kg
Patient HCT Pre Bypass	36.89	%	36.15	%
Average PRBC unit	332.90	mL	404.51	mL
PRBC added to Prime	281.72	mL	331.45	mL
Prime HCT	19.85	%	25.22	%
Total PRBC Vol Used	333.96	mL	398.78	mL
First HCT on Bypass	28.69	%	30.69	%
Last HCT on Bypass	31.59	%	34.80	%

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Two units

	2016		Post Intervention	
Patient Weight	11.86	kg	10.44	kg
Patient HCT Pre Bypass	36.33	%	34.38	%
Average PRBC unit	313.62	mL	389.55	mL
PRBC added to Prime	317.66	mL	337.79	mL
Prime HCT	22.65	%	23.97	%
Total PRBC Vol Used	571.65	mL	657.39	mL
First HCT on Bypass	29.00	%	29.15	%
Last HCT on Bypass	37.22	%	38.45	%

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3 or more units

	2016		Post Intervention	
Patient Weight	12.13	kg	13.57	kg
Patient HCT Pre Bypass	35.95	%	38.83	%
Average PRBC unit	313.46	mL	389.69	mL
PRBC added to Prime	339.92	mL	20.44	mL
Prime HCT	23.51	%	20.44	%
Total PRBC Vol Used	836.05	mL	966.00	mL
First HCT on Bypass	29.03	%	29.78	%
Last HCT on Bypass	40.69	%	42.33	%

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Overall Comparison

	2016 228 Patients	Post Intervention 90 Patients
Average Patient Weight	12.81	12.12 kg
Average Unit	321 mL	398 mL (24% Larger)
Multiple Units in Prime	10.1%	0%
Hematocrit Prime	21%	24.3%
Hematocrit on Pump	28.88%	30.04%
Hematocrit off Pump	35.49%	36.87%
1 Unit RBC	n=94 41%	n=49 54%
2 Unit RBC	n=95 42%	n=32 36%
3+ Unit RBC	n=39 17%	n=9 10%

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Precautions

PRBC unit Potassium	11.85	mmol/L
PRBC Unit HCT	55.91	%
PRBC Unit Glucose	700.94	mg/dL

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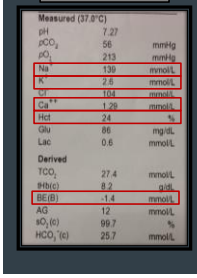
Prime

Patients Blood Gas



The pump is primed with .45% NaCl (sodium 77 mmol/L and pH 5.0).

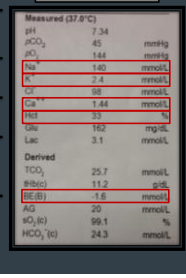
PRBC and FFP are added as the crystalloid is chased out.

By hemoconcentrating the circuit we can increase the hematocrit.

Washing the prime with different crystalloid solutions we can influence the electrolytes.

We add Sodium Bicarbonate, Calcium and Heparin to the circuit.

Pump Blood Gas



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Conclusion

- We were able to receive units of blood over 380 mL over 70% of the time when requested.
- The new blood ordering protocol has substantially decreased the amount of patients who received multiple units of RBC.
- The significantly larger units helped achieve a more clinically favorable hematocrit during cardiopulmonary bypass.
- The development and implementation of this protocol by a multidisciplinary team resulted in a decrease in the number of RBC exposures in pediatric patients undergoing cardiac surgery with the use of cardiopulmonary bypass. The use of this protocol and other blood conservation strategies can help to minimize transfusion-associated morbidity and allosensitization.

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References

- References:
- 1. Goobie SM and Haas T. Perioperative bleeding management in pediatric patients. Curr Opin Anesthesiol 2016;29:352-358.
- 2. Mahle WT, Tresler MA, Edens RE, et al. Allosensitization and outcomes in pediatric heart transplantation. J Heart Lung Transplant 2011;30:1221-7.
- 3. Durandy Y. Perfusionist strategies for blood conservation in pediatric cardiac surgery. World J Cardiol 2010; 2:27-33.
- 4. Cholette JM, Faraoni D, Goobie SM, et al. Patient blood management in pediatric cardiac surgery: a review. Anesth Analg 2017 Oct 5. doi:10.1213/ANE.0000000000002504.
- 5. Singh SP. Strategies for blood conservation in pediatric cardiac surgery. AnnCard Anesth 2016; 19:705-16