Donor, component, and recipient factors in the efficacy of RBC transfusion

Nareg Roubinian, MD, MPH
Blood Systems Research Institute
Kaiser Permanente Division of Research

Kaiser Permanente Northern California

- >4 million patients cared for at 21 hospitals and 56 clinics
  - Integrated health care delivery system linked by a common EHR
- Kaiser Permanente Northern California Division of Research
  - Longitudinal outpatient and hospital-based registries (>10 years)
  - Automated risk adjustment for adult & neonatal patients (COPS2/LAPS2)
- Development of a linked donor-component-recipient database
  - > 1 million blood components, > 500,000 patients, > 1.1 million hospitalizations between 2008-2017
  - ~1/2 of blood components are supplied by BSRI allowing analysis to examine blood donor and component factors on recipient outcomes

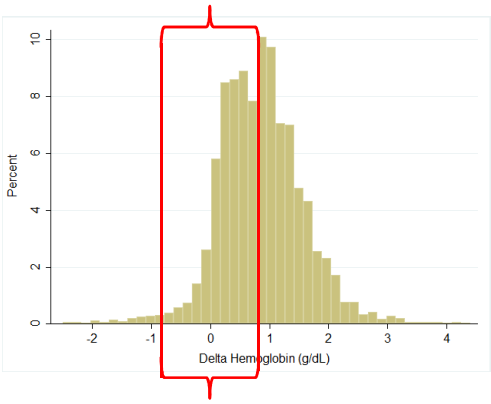
Blood Donor Factors & Efficacy of RBC Tx?

- Sex, Age, BMI, Race
- Donation frequency
- Hb level

Donor Factors

- Osmotic hemolysis
- Donor genetic polymorphisms

? Poor RBC Tx response*



* Exclude patient bleeding, hemolysis

Methods: Donor-comp-recipient linkage

- Linkage using blood donor and component data with hospitalized transfusion recipients who received a single RBC unit between 2008 and 2016
- Donor factors included: sex, age, body mass index (TBD blood type, race, ethnicity, donation frequency, parity)
- Component factors included: collection method, RBC solution, gamma irradiation, and storage age
- Recipient factors included: sex, age, body mass index, pre-transfusion Hb, and indication for TX (TBD comorbidities, severity of illness)

Results: Donor-recipient linkage

- We linked blood donor and component data for 42,726 single RBC unit transfusions administered to 21,701 unique transfusion recipients.
  - Median donor age was 47 years (IQR: 29-58) and 57% of transfused RBC units were from male donors
  - All RBC units were leukoreduced; median storage age of RBC units prior to transfusion was 18 days (IQR 8-25)
  - 11% of RBC units were irradiated
  - Median recipient age was 73 years (IQR: 62-82), and 45% were male.
    - Recipient hemoglobin levels drawn 18 hrs pre- or post- transfusion

Results: Donor-recipient linkage

- Recipients of RBC's from male & female donors had similar pre-TX hemoglobin levels (8.2 g/dL; p=0.94)
- Recipients of male donor RBC units had higher post-transfusion Hb levels (9.3 vs 9.2 g/dL) and larger increments in Hb (1.1 vs. 1.0 g/dL) compared to those of female RBC units (both p=<0.001)
  - Hb value of donor units: Male – 15 g/dL, Female 13.6 g/dL

Donor age & body mass index

Donor Age by Quartile				
	16-29	30-47	48-59	60+
Pre-TX Hb	8.2	8.2	8.2	8.1
Post-TX Hb	9.2	9.2	9.2	9.2
Delta Hb	1.0	1.0	1.0	1.0
% Delta -1 g/dL	52%	52%	52%	53%

Donor Body Mass Index by Quartile				
	13-25	25-28	28-32	32+
Pre-TX Hb	7.8	7.8	7.8	7.8
Post-TX Hb	8.9	8.8	8.9	8.9
Delta Hb	1.0	1.0	1.0	1.0
% Delta -1 g/dL	55%	53%	55%	55%

Whole blood vs. apheresis derived RBC's

Change in Hb per unit for whole blood derived RBC			
Donor Sex	Pre-TX Hb	Post-TX Hb	Delta Hb
Female	7.9 ± 1.3	8.9 ± 1.5	1.0 ± 1.1
Male	7.9 ± 1.4	9.1 ± 1.5	1.2 ± 1.2
Change in Hb per unit for apheresis derived RBC			
Donor Sex	Pre-TX Hb	Post-TX Hb	Delta Hb
Female	7.8 ± 1.1	8.7 ± 1.2	0.9 ± 0.9
Male	7.8 ± 1.1	8.7 ± 1.2	0.9 ± 1.0

Gamma irradiation & RBC storage age

Red Blood Cell Storage Age (Days)				
	1-19	20-26	27-32	33-42
Un-irradiated				
Pre-TX Hb	7.8	7.9	7.9	7.9
Post-TX Hb	8.8	8.8	8.9	8.8
Delta Hb	1.0	1.0	1.0	1.0
Irradiated				
Pre-TX Hb	7.7	7.8	7.8	7.7
Post-TX Hb	8.5	8.7	8.6	8.6
Delta Hb	0.9	0.9	0.9	0.9

Recipient Gender and Body Mass Index

Change in Hb per RBC unit transfused by sex		
Recipient Gender	Male Donor	Female Donor
Female	1.2 (0.6-1.7)	1.1 (0.6-1.6)
Male	0.9 (0.4-1.4)	0.8 (0.3-1.3)

Change in Hb per RBC unit transfused by Recipient BMI				
Recipient Sex	Underweight	Normal	Overweight	Obese
Female	1.5 (1-2)	1.2 (0.7-1.8)	1.1 (0.6-1.6)	0.9 (0.5-1.3)
Male	1.2 (0.7-1.6)	0.9 (0.5-1.4)	0.8 (0.3-1.2)	0.7 (0.2-1.1)

Combinations of donor-component-recipient factors and delta hemoglobin

	Male Blood Donor		Female Blood Donor	
	Unirradiated	Irradiated	Unirradiated	Irradiated
Female Recipient				
Pre-TX Hb	7.9	7.9	7.8	7.8
Post-TX Hb	9.1	9.0	8.8	8.7
Delta Hb	1.2	1.1	1.1	1.0
Male Recipient				
Pre-TX Hb	7.9	7.9	7.8	7.7
Post-TX Hb	8.8	8.8	8.6	8.4
Delta Hb	1.0	0.9	0.9	0.8

Multivariable Risk Model for 1 g/dL rise in Hb levels			
Characteristic	**Odds Ratio**	**95% CI**	**P-value**
Female recipient (vs. male)	2.0	1.9-2.1	<0.001
Male donor (vs. female)	1.2	1.1-1.3	<0.001
Recipient age*	1.2	1.1-1.2	<0.001
Gamma irradiation	0.8	0.7-0.9	<0.001
Recipient body mass index*	0.7	0.7-0.8	<0.001
Pre-TX hemoglobin level*	0.7	0.7-0.8	<0.001
Donor age*	1.0	0.9-1.0	0.94
RBC storage age*	1.0	1.0	0.55

* Risk factor by quartile

Multivariable risk model & post-transfusion intervals			
Characteristic	**Post-TX OR**	**24-Hr OR**	**48-Hr OR**
Female recipient (vs. male)	2.0	1.6	1.4
Male donor (vs. female)	1.2	1.2	1.2
Recipient age*	1.2	1.1	1.1
Gamma irradiation	0.8	0.7	0.6
Recipient body mass index*	0.7	0.7	0.8
Pre-TX hemoglobin level*	0.7	0.6	0.6
Donor age*	1.0	1.0	1.0
RBC storage age*	1.0	1.0	1.0

* Risk factor by quartile

Conclusions

- Donor, component, and recipient factors are significant predictors in the change in hemoglobin levels for RBC TX after multivariable analysis
- Donor age and BMI as well as RBC storage age were not significant factors in hemoglobin increments – alone or in multivariable models
- Multivariable modeling can allow assessment of donor genetic polymorphisms associated with hemolysis on hemoglobin increments
- Additional analyses examining the role of these and donor genetic characteristics on hemolytic parameters as well as other measures of RBC efficacy (e.g., oxygen delivery) are needed

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