Interval Changes in ROTEM Values During Cardiopulmonary Bypass

Christopher F. Tirotta, MD, MBA • Richard G. Lagueruela, MD • Danielle Madril, MD • Daria Salyakina, PhD, MS, CBA
Weize Wang, MPH, MA • Thomas Taylor, BS • Jorge Ojito, CCP • Hyunsoo Lim, CCP • Robert Hannan, MD • Redmond Burke, MD
The Heart Program at Nicklaus Children's Hospital, Miami, FL

Nicklaus Children's Hospital Heart Program

FIU Herbert Wertheim College of Medicine, Florida International University

Background

The ROTEM (Tem International GmbH, Munich, Germany) is an enhanced modification of thromboelastography (TEG) (Haemonetics Corp., Braintree, MA), first described in 1948. Both are point-of care (POC) coagulation monitoring instruments that test the visoelastic properties of whole blood. Use of the ROTEM has been shown to reduce the need and amount of transfused blood products in pediatric cardiac surgery patients. Tirotta et al. demonstrated that administering human fibrinogen concentrate (HFC) at a dose of 70 mg/kg to neonates and infants undergoing cardiac surgery reduced the need for fresh frozen plasma (FFP) and cryoprecipitate.

The purpose of this study is to quantify the changes that occur to the ROTEM values with cardiopulmonary bypass (CPB), and with distinct transfusion interventions during the course of the operation.

Methods

After receiving IRB exempt status from the Research Institute of Nicklaus Children's Hospital, we retrospectively reviewed 171 pediatric patients undergoing cardiac surgery requiring CPB; this incorporated the time period from June 1, 2015 to August 31, 2017. All the cases were done by the same anesthesiologist and surgeon. ROTEM assays were done at baseline prior to the start of surgery, on CPB prior to the administration of plateletpheresis, on CPB after plateletpheresis (25 cc/kg), off CPB immediately after the administration human fibrinogen concentrate (HFC) (55 mg/kg); there were also ROTEMs done in the post CPB period after the administration of further component therapy, if needed after the HFC administration. Through regression analysis we adjusted for the variation in blood products received by different patients.

Results

Results from GEE and Beta regression models suggested significant changes in HEPTEM CT after all four interventions, HEPTEM MCF after three out of the four interventions, FIBTEM MCF after three out of the four interventions, and in HEPTEM after all four interventions, adjusting for age groups and continuous values of the actual interventions (Table 1, Figure 1). Patients' fibrinogen levels decreased by 162.1 mg/dL (95% CI: -187.7 to -136.5) after CPB, but increased by 69.8 mg/dL (95% CI: 58.3 to 81.2) and 73.1 mg/dL (95% CI: 43.1 to 103.1) after receiving plateletpheresis and then HFC respectively. We also sub-analyzed the data for the various age groups: for patients 90 days or less (Table 2), patients from 90 days to two years (Table 3) and then for patients greater than two (Table 4).

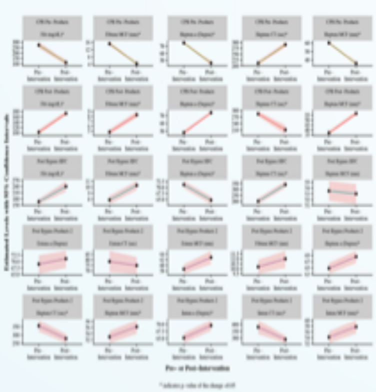

Table 1.
Results from GEE and Generalized Linear Mixed Model for each of the ROTEM values and fibrinogen levels

Outcome	Intervention	N	Estimates: Pre-Intervention (95% CI)	Post-Intervention (95% CI)	Change from Pre- to Post-Intervention (95% CI)	p
Heptem CT (sec)	CPB Pre-products	266	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	206	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	219	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	189	[illegible]	[illegible]	[illegible]	[illegible]
Heptem MCF (mm)	CPB Pre-products	266	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	205	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	217	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	188	[illegible]	[illegible]	[illegible]	[illegible]
Fibtem MCF (mm)	CPB Pre-products	255	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	196	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	219	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	190	[illegible]	[illegible]	[illegible]	[illegible]
Heptem α (º)	CPB Pre-products	265	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	204	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	217	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	188	[illegible]	[illegible]	[illegible]	[illegible]
Intem CT (sec)	Post bypass products 2	183	[illegible]	[illegible]	[illegible]	[illegible]
Intem MCF (mm)	Post bypass products 2	181	[illegible]	[illegible]	[illegible]	[illegible]
Intem α (º)	Post bypass products 2	180	[illegible]	[illegible]	[illegible]	[illegible]
Extem CT (sec)	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Extem MCF (mm)	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Extem α (º)	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fib (mg/dL)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note. N was number of observations used for each model. All the models were controlled for the continuous values of the corresponding interventions and age groups. Generalized linear mixed model using beta distribution was applied to predict α (º), while generalized estimation equation was used for other outcomes. Estimates were predicted marginal means.

Table 2.
Results from GEE and Generalized Linear Mixed Model for each of the ROTEM values and fibrinogen levels for in patients aged 90 days or younger

Outcome	Intervention	N	Estimates: Pre-Intervention (95% CI)	Post-Intervention (95% CI)	Change from Pre- to Post-Intervention (95% CI)	p
Heptem CT (sec)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heptem MCF (mm)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fibtem MCF (mm)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heptem α (º)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fib (mg/dL)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note. N was number of observations used for each model. All the models were controlled for the continuous values of the corresponding interventions. Generalized linear mixed model using beta distribution was applied to predict α (º), while generalized estimation equation was used for other outcomes. Estimates were predicted marginal means.

Table 3.
Results from GEE and Generalized Linear Mixed Model for each of the ROTEM values and fibrinogen levels in patients older than 90 days and younger or equal to 2 years old

Outcome	Intervention	N	Estimates: Pre-Intervention (95% CI)	Post-Intervention (95% CI)	Change from Pre- to Post-Intervention (95% CI)	p
Heptem CT (sec)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heptem MCF (mm)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fibtem MCF (mm)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heptem α (º)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fib (mg/dL)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note. N was number of observations used for each model. All the models were controlled for the continuous values of the corresponding interventions. Generalized linear mixed model using beta distribution was applied to predict α (º), while generalized estimation equation was used for other outcomes. Estimates were predicted marginal means.

Table 4.
Results from GEE and Generalized Linear Mixed Model for each of the ROTEM values in patients aged older than 2 years

Outcome	Intervention	N	Estimates: Pre-Intervention (95% CI)	Post-Intervention (95% CI)	Change from Pre- to Post-Intervention (95% CI)	p
Heptem CT (sec)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heptem MCF (mm)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fibtem MCF (mm)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CPB Post-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass HFC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heptem α (º)	CPB Pre-products	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Post bypass products 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note. N was number of observations used for each model. All the models were controlled for the continuous values of the corresponding interventions. Generalized linear mixed model using beta distribution was applied to predict α (º), while generalized estimation equation was used for other outcomes. Estimates were predicted marginal means.

Conclusions

CPB induced profound pertubations in ROTEM values. Administration of plateletpheresis and then HFC significantly improved these values by quantifiable amounts.

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