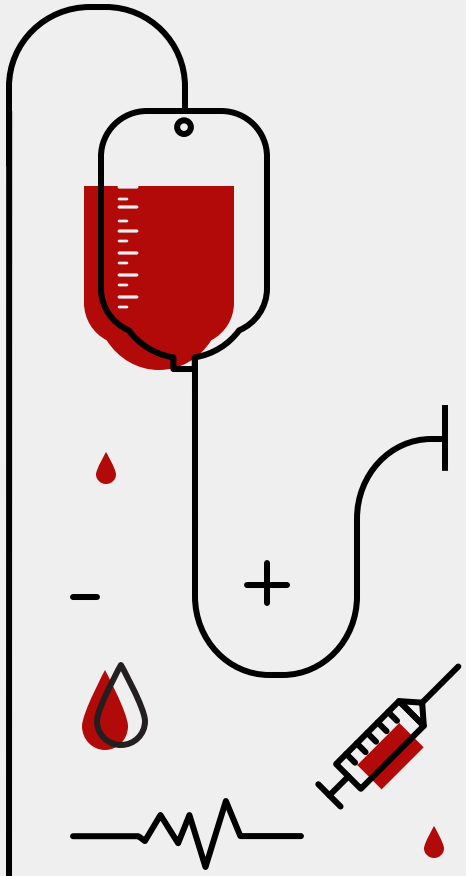

Viscoelastic Assay: “Point of Care” Perioperative Blood Management

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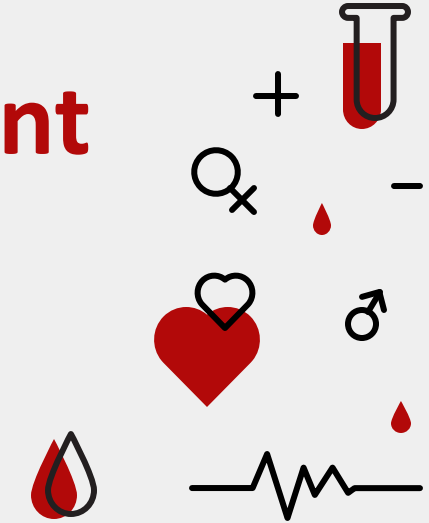


Objectives

- Apply concepts and theories of evidence based practice related to risks and benefits of blood transfusion
- Synthesize principles of viscoelastic assay and the coagulation system
- Integrate knowledge of ”point of care” viscoelastic assay and transfusion strategies into clinical practice

Point of Care Coagulation Testing POCCT

- Provides clinicians with the ability to rapidly evaluate the coagulation status of a patient in real time (negating the need for transport to a lab) and meaningful data is obtained within 10 minutes.
- Increasing interest in a variety of clinical settings including trauma, cardiac, vascular, obstetrics, liver disease, transplant, burns, orthopedics, and monitoring the effects of anticoagulants.

Viscoelastic Hemostasis Assay

- Materials' tendency to behave in both a viscous and elastic manner.
- Blood responds to shear stress with permanent deformation (viscous).
- Blood becomes increasingly elastic, resisting shear stress to return to its original shape following deformation.
- Shear modulus – viscous unclotted state to elastic clotted state.

Blood Health

Blood is an organ, therefore blood transfusion is a blood transplant.

Blood transplant is the first line of treatment

Transfusion Triggers

- Hemoglobin/Hematocrit 10/30
- Blood loss of ≥ 15% of circulating blood volume
- Clinical presentation
- Improve oxygen delivery
- Platelet count < 50,000
- Active bleeding
- Coagulation profiles

Risk v. Benefits

Troublesome Events

- Alloimmunization [Platelets – Leukocytes – RBCs]
- Human Leukocyte Antigens [HLA] [Granulocyte – Platelet – RBC specific]
- Allergic reactions
- Febrile reactions
- Allogenic Blood Transfusion [TRALI – TACO – TAS – HTR – TTI]
- Intravascular hemolysis
- Coagulopathy
- Renal impairment and Failure
- Death

Transfusion-Associated Fatalities by Complication FY15-19

Complication	FY15 No.	FY15 %	FY16 No.	FY16 %	FY17 No.	FY17 %	FY18 No.	FY18 %	FY19 No.	FY19 %	Total No.	Total %
Anaphylaxis	2	5%	5	12%	3	8%	2	6%	2	5%	**14**	**7%**
Contamination	5	14%	5	12%	7	19%	7	23%	1	2%	**25**	**13%**
HTR (ABO)	2	5%	4	9%	1	3%	2	6%	4	9%	**13**	**7%**
HTR (Non-ABO)	4	11%	1	2%	6	16%	4	13%	11	25%	**26**	**14%**
Hypotensive Reaction	1	3%	1	2%	0	0%	0	0%	0	0%	**2**	**1%**
TACO	11	30%	19	44%	11	30%	12	39%	12	27%	**65**	**34%**
TRALI**	12	32%	8	19%	9	24%	4	13%	12	27%	**45**	**23%**
Transfusion Reaction, Type Not Determined	0	0%	0	0%	0	0%	0	0%	2	5%	**2**	**1%**

US Department of Health and Human Services 2019

Practice Guidelines for Perioperative Blood Management

- ASA Guidelines – Target setting: Perioperative
- Recommendations:
  - A restrictive RBC transfusion strategy (usually Hb <8 g/dL or Hct <25%) may be safely used to reduce transfusion administration.
  - Determination of whether Hb between 6 – 10 g/dL justifies RBC transfusion should be based on potential or actual ongoing bleeding (rate and magnitude), intravascular volume status, signs of organ ischemia, and adequacy of cardiopulmonary reserve.
  - RBCs should be administered unit-by-unit, when possible, with interval reevaluation.

Anesthesiology 2015

What about the rest?

- Plethora of studies suggesting transfusion of perioperative RBCs is known to increase postoperative morbidity and mortality.
- Patient Blood Management Programs

- Little is known about whether transfusion of platelets and/or fresh frozen plasma are associated with perioperative morbidity and mortality.
- Key Point – they work.

Platelets

- Multiple or single donors
- One unit increases platelet count 5000-10,000 cells/mL^3
- Clinical uses
    - Platelet count < 50,000
    - Known platelet dysfunction (Thromboelastometry)
- Loose ability to aggregate when refrigerated
- Room temperature
    - Bacterial growth
        - Sepsis

Fresh Frozen Plasma

- Clinical uses
  - PT > 1.5 times normal (18) - PTT > 1.5 times normal (55-60)
  - Coagulation factor assay of < 25% activity (Thromboelastometry)
  - Urgent reversal of warfarin therapy
  - Antithrombin deficiency (requiring heparin)
  - Massive blood transfusions
- Contains
  - Fibrinogen – Albumin – Proteins S & C – Antithrombin - TFI

Cryoprecipitate

- Fibrinogen and Factor (VIII)
    - Each unit yields 100 – 250 mg of fibrinogen – 80 – 100 units of factor VIII – 50 – 60 mg of fibronectin
- Clinical uses
    - Treatment of hemophilia A
    - Von Willebrand's disease
    - Massive transfusion with fibrinogen concentrates
    - Consumption coagulopathy

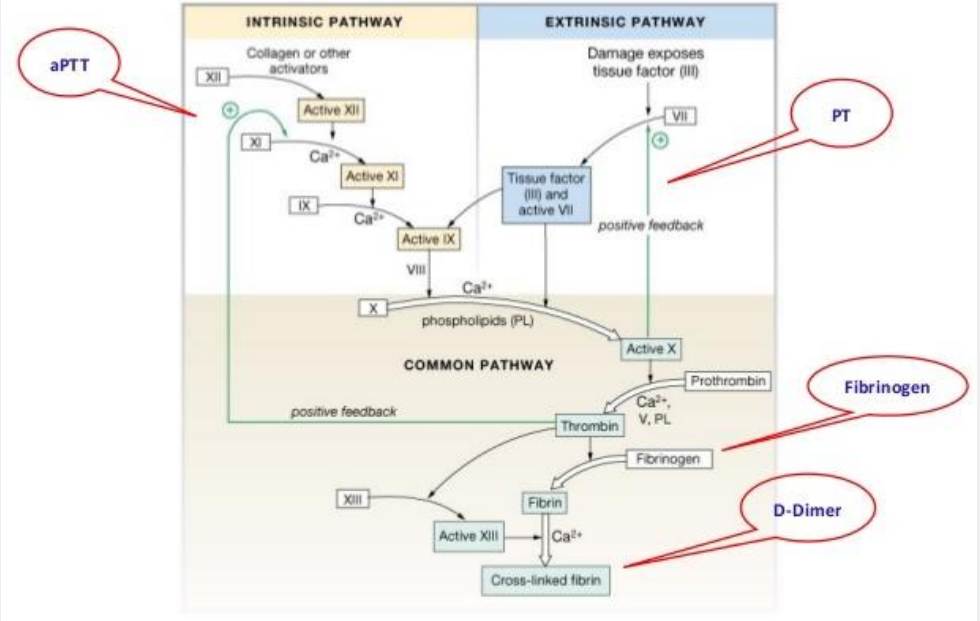
Conventional Test of Coagulation

Test of coagulation

- Platelets – number not function
- Clotting studies – PT/APTT/INR
- Fibrinogen levels

Test of fibrinolysis

- Degradation products

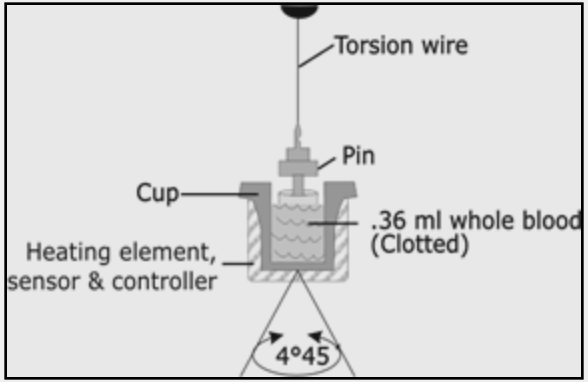


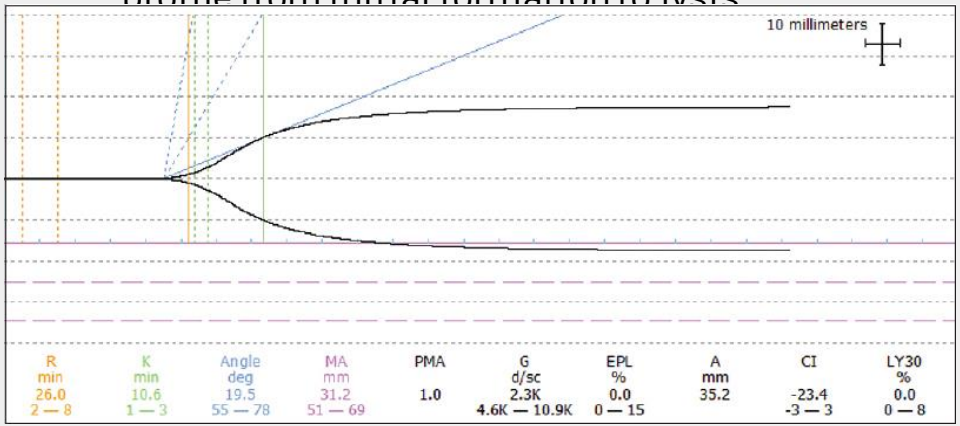
Viscoelastic Functional Description

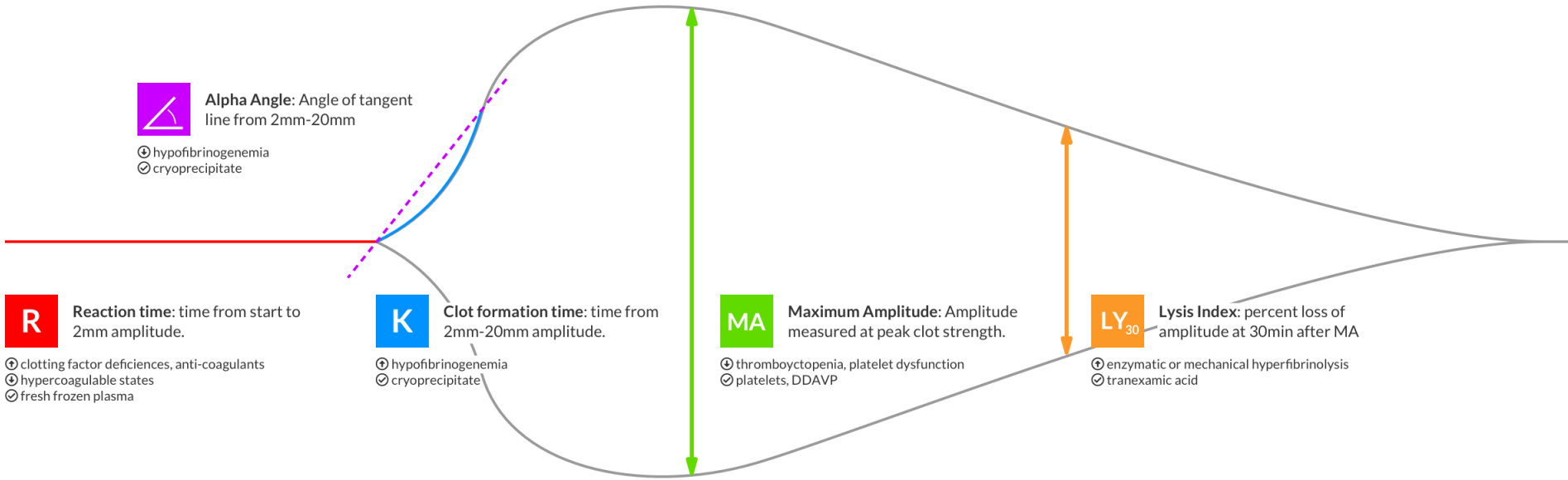
- Developed in 1948 by Professor Hartert.
- Monitors the thrombodynamic properties of blood as it is reduced to clot under a low shear environment.
- Determination of kinetics of clot formation and growth as well as the strength and stability of the formed clot.
- Ultimately providing ”point of care” information about the ability of the clot to perform the work of hemostasis.
- Kinetics determine the adequacy of quantitative factors available for clot initiation, formation, stability and degeneration.

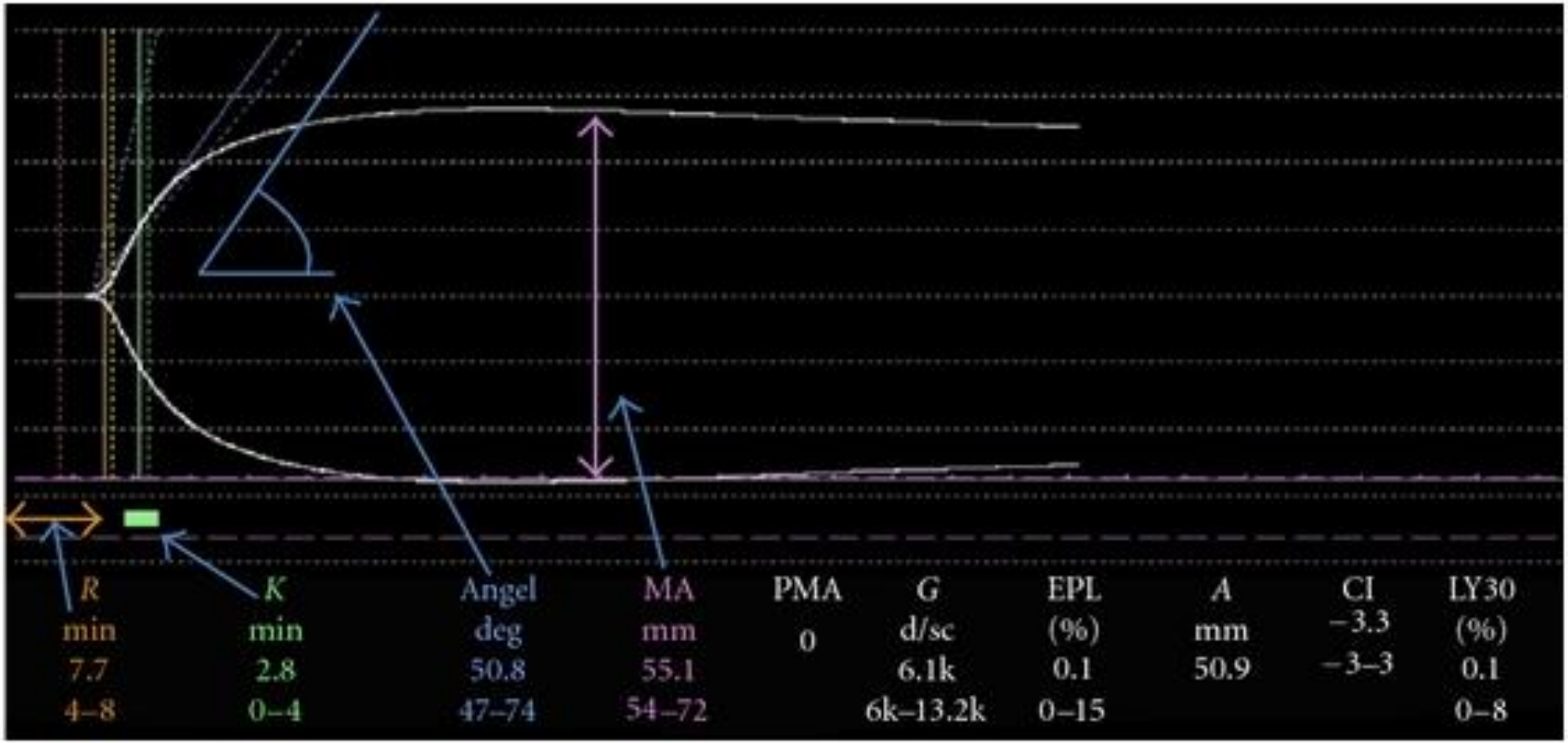
TEG

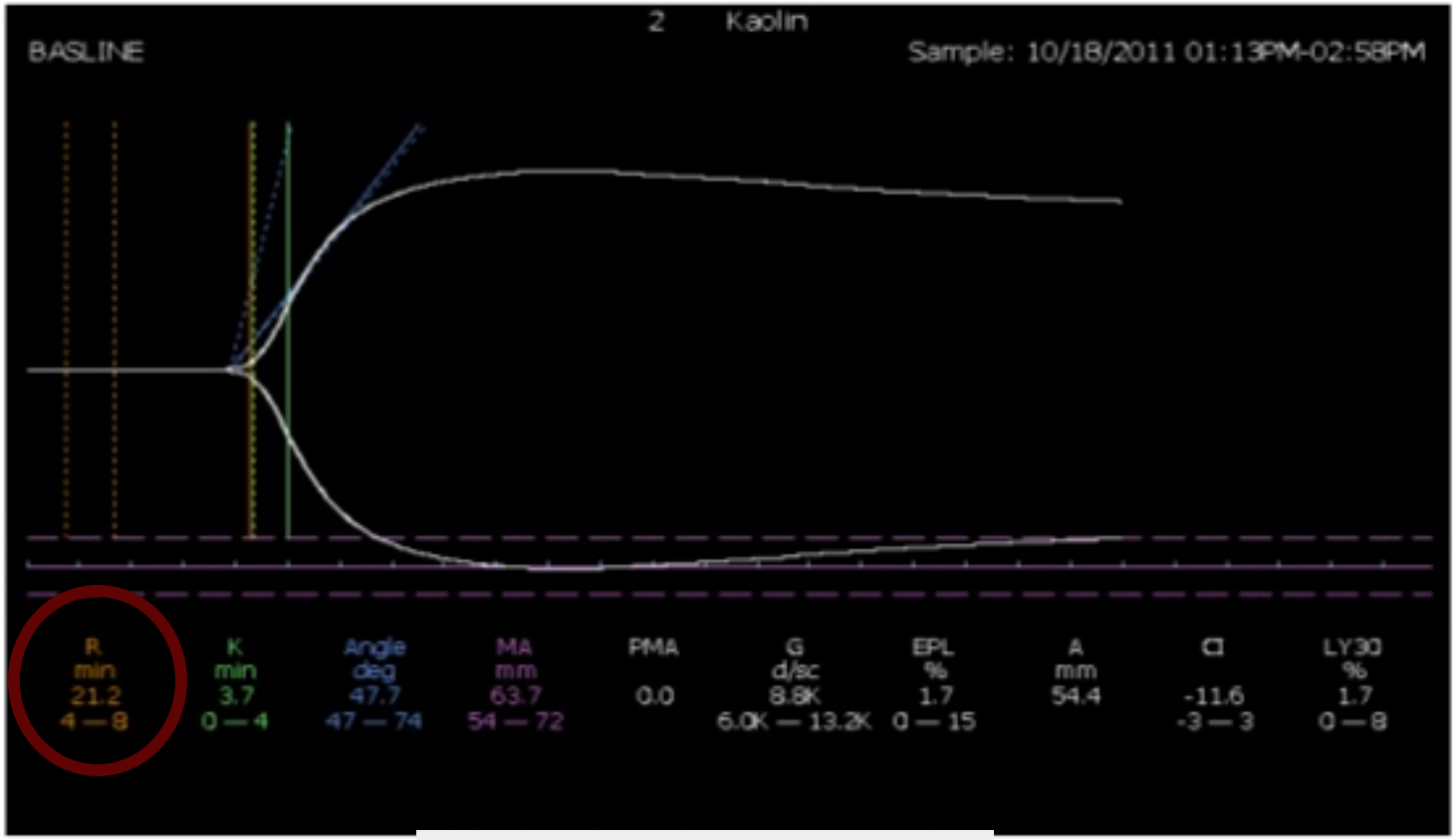
- Cup oscillates
- Pin attached to torsion wire
- Clot binds pin to cup
- Pin motion is function of clot strength
- System generates a hemostasis profile from initial formation to lysis






Alpha Angle: Angle of tangent line from 2mm-20mm
hypofibrinogenemia
cryoprecipitate
R
Reaction time: time from start to 2mm amplitude.
clotting factor deficiences, anti-coagulants
hypercoagulable states
fresh frozen plasma
K
Clot formation time: time from 2mm-20mm amplitude.
hypofibrinogenemia
cryoprecipitate
MA
Maximum Amplitude: Amplitude measured at peak clot strength.
thromboyctopenia, platelet dysfunction
platelets, DDAVP
LY30
Lysis Index: percent loss of amplitude at 30min after MA
enzymatic or mechanical hyperfibrinolysis
tranexamic acid


R
min
7.7
4–8
K
min
2.8
0–4
Angel
deg
50.8
47–74
MA
mm
55.1
54–72
PMA
0
G
d/sc
6.1k
6k–13.2k
EPL
(%)
0.1
0–15
A
mm
50.9
CI
−3.3
−3–3
LY30
(%)
0.1
0–8

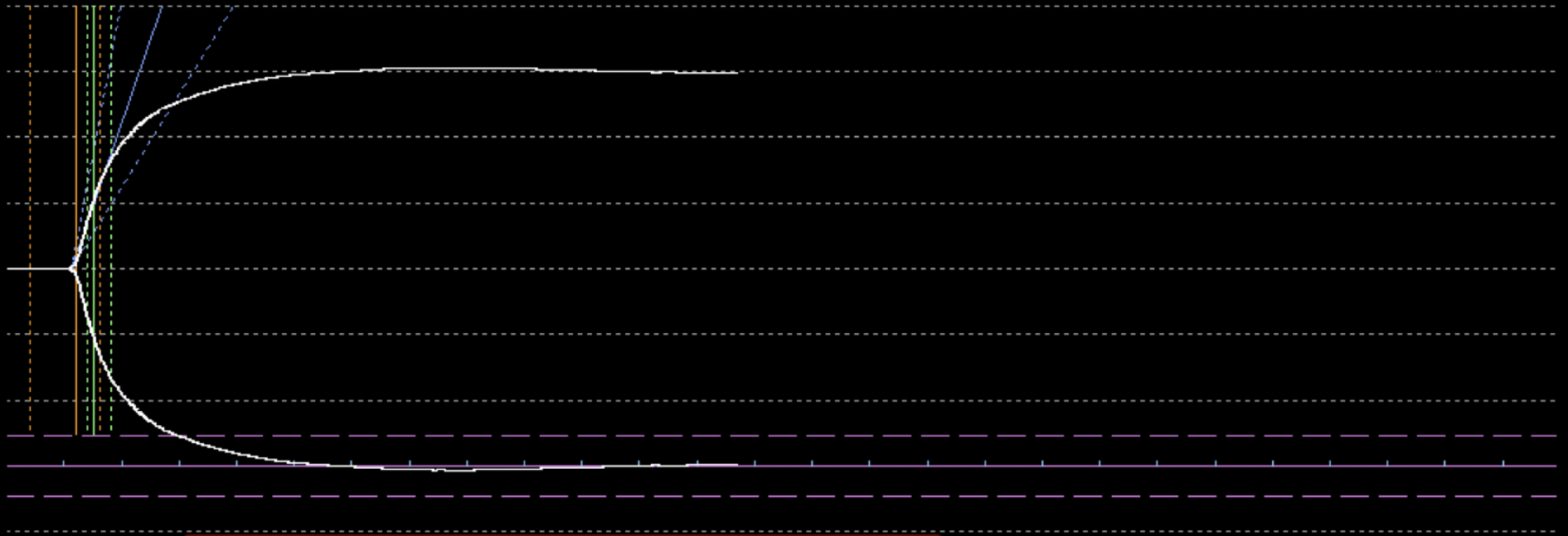


Heparin effect

1

Kaolin with heparinase

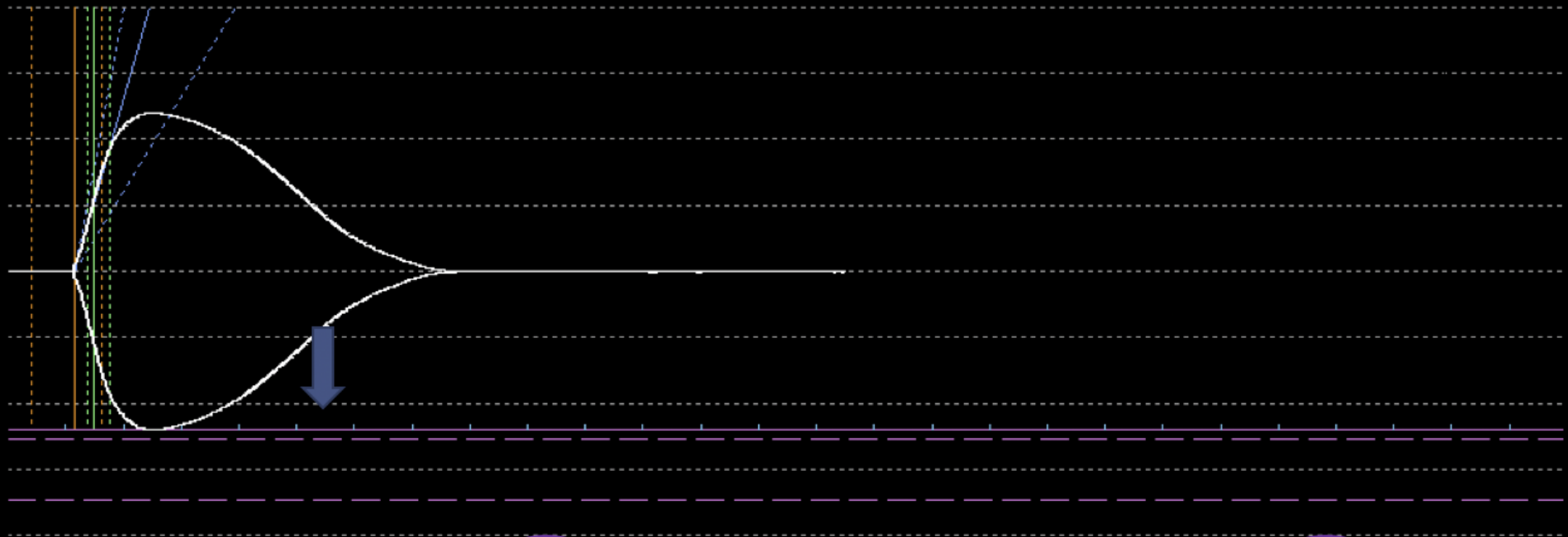
Post - protamine



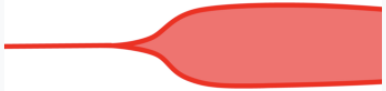
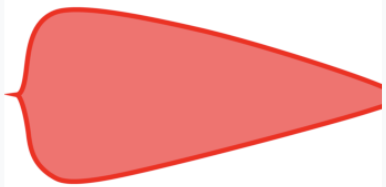
R	K	Angle	MA	G	LY30	CI	PMA	EPL	A
min	min	deg	mm	d/sc	%			%	mm
6.0	1.5	68.6	59.9	7.5	0.0	0.3	*0*	0.0	59.4
2 — 8	1 — 3	55 — 78	51 — 69	4.6 — 10.9	0 — 8	-3 — 3		0 — 15	

Baseline

Sample:



R	K	Angle	MA	G	LY30	CI	PMA	EPL	A
min	min	deg	mm	d/sc	%			%	mm
5.8	1.6	71.9	47.9	4.6	59.9	-0.8	*0*	59.9	0.2
2 — 8	1 — 3	55 — 78	51 — 69	4.6 — 10.9	0 — 8	-3 — 3		0 — 15	

Condition	Appearance	Main treatment
Normal		
Hemodilution or clotting factor deficiency		Fresh frozen plasma
Fibrinogen deficiency		Cryoprecipitate
Low or dysfunctional platelets		Platelets
Thrombosis		Anticoagulant
Primary fibrinolysis		Antifibrinolytics or tranexamic acid
Secondary fibrinolysis		Treating disseminated intravascular coagulation

Massive Transfusion Protocols

- Rely on abnormal values of conventional coagulation assays as triggers for transfusion of plasma, cryoprecipitate and platelets
- 1:1:1 resuscitation – Military data have demonstrated that patients receiving a higher ratio of FFP and platelets to PRBC were associated with a higher survival
- Goal directed treatment with blood products guided by TEG allows for “precision” in treatment
- Several studies have reported that TEG guided resuscitation reduces overall transfusion requirements and improves mortality
- Reduction in blood product use is desirable for patient safety and because blood products are a scarce and expensive resource

TEG and the Trauma Patient

- Factors contributing to coagulopathy
  - Blood loss
  - Hemodilution
  - Consumption of platelets
  - Hypothermic platelet dysfunction
  - Reduction in enzyme activity
  - Acidosis-induced reduction in coagulation factor activity
  - Unopposed fibrinolysis

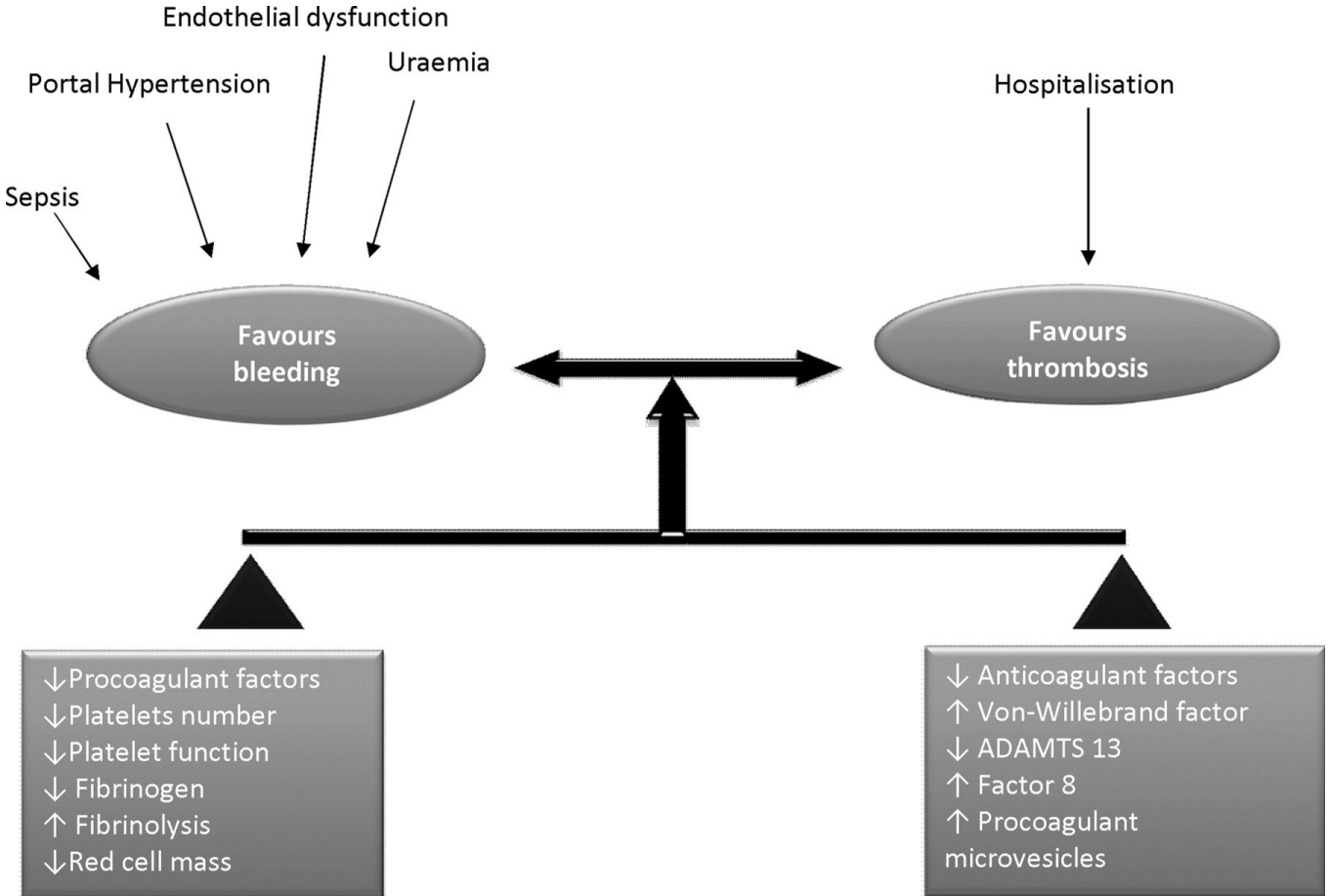
Obstetrics

- Procoagulant state with elevated clotting factor and fibrinogen concentrations.
- Thrombocytopenia complicates 10% of pregnancies. Decisions related to regional anesthesia have been based on platelet count. VHA will provide more information on platelet function.
- Obstetric hemorrhage
    - Blood loss may be difficult to quantify
    - Physiologic changes in pregnancy
    - VHA indicating hypofibrinogenemia.

Postoperative Bleeding in the Cardiac/Vascular Patient

- Preoperative Factors
  - Anticoagulants - Pre-existing clotting factor and/or platelet abnormalities
- Intraoperative Factors
  - Decreased platelet count – Heparin effect – Alien contact – Inflammatory response
- Postoperative factors
  - Reversal of heparin – non-functioning platelets – Fibrinolysis

TEG in the patient with Cirrhosis



TEG/ROTEM and Liver Transplant

- Eldeen et al. (2016) N = 828 undergoing LT 2008 – 2013 – The MA on preoperative TEG was significantly higher in patients diagnosed with Early Hepatic Artery Thrombosis
- Lawson et al. (2017)N = 28 who received MT in LT – A low MA and low angle had the highest predictability of MT during LT
- Abuelkasem et al. (2016) Among 296 possible measurement points from 376 consecutive LT recipients, 250 underwent final analysis: Tissue factor triggered ROTEM was more sensitive in identifying hyperfibrinolysis
- DePietri et al. (2016) N = 386 LT – ROTEM (to evaluate fibrinogen functional thromboelastography) added to TEG reduced the number of transfusion in patients undergoing LT

Practice Considerations

- Patients who have been on oral anticoagulants for a prolonged period of time and who need emergent surgery, the use of TEG can reveal the patient's likelihood of surgical bleeding.
- Use of TEG in a postoperative bleeding patient can easily indicate whether the issue is due to a surgical problem or coagulopathy.
- Postoperative hypercoagulability plays an important role in predisposing patients to VTE after certain surgical procedures (hip arthroplasty). TEG can examine the coagulation status and the patient may benefit from more optimal anticoagulation.
- Guide the management of COVID-19 critically ill patients.
- TEG provides global assessment of hemostatic function to monitor potential coagulopathies during pregnancy (gestational hypertension, diabetes, preeclampsia).
- TEG blood product management for Trauma induced coagulopathy.

Summary

- Promote anemia education and awareness
- Blood/blood product transfusion is equivalent to organ donation
- Benefits of PRBC transfusion are theoretical while the risks are fact.
- Transfusion of allogeneic blood/blood products represents a major risk for immunosuppression and adverse outcome.
- Accept lower transfusion thresholds
- Patient Blood Management

Summary

- Conventional coagulation assays alone are inadequate
- Viscoelastic testing – Thromboelastography (TEG) and Thromboelastometry (ROTEM) provides point of care dynamic measurement of coagulation and fibrinolysis
- Viscoelastic Assay measures global clot formation – it identifies the contribution of platelets and fibrinolysis to hemostasis
- It is designed to provide useful information amidst the cauldron of factors contributing to post-surgical bleeding in cardiac and vascular patients, decreased utilization of blood and blood products in the trauma surgical patient.
- Preoperative TEG/ROTEM provides information re: risk of HAT and hyperfibrinolysis in LT patients
- Appropriate use of viscoelastic testing can result in cost savings and decreased patient exposure to blood and blood product therapy with its

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