Thromboelastometry and Thromboelastography in the Management of Hemorrhagic Shock

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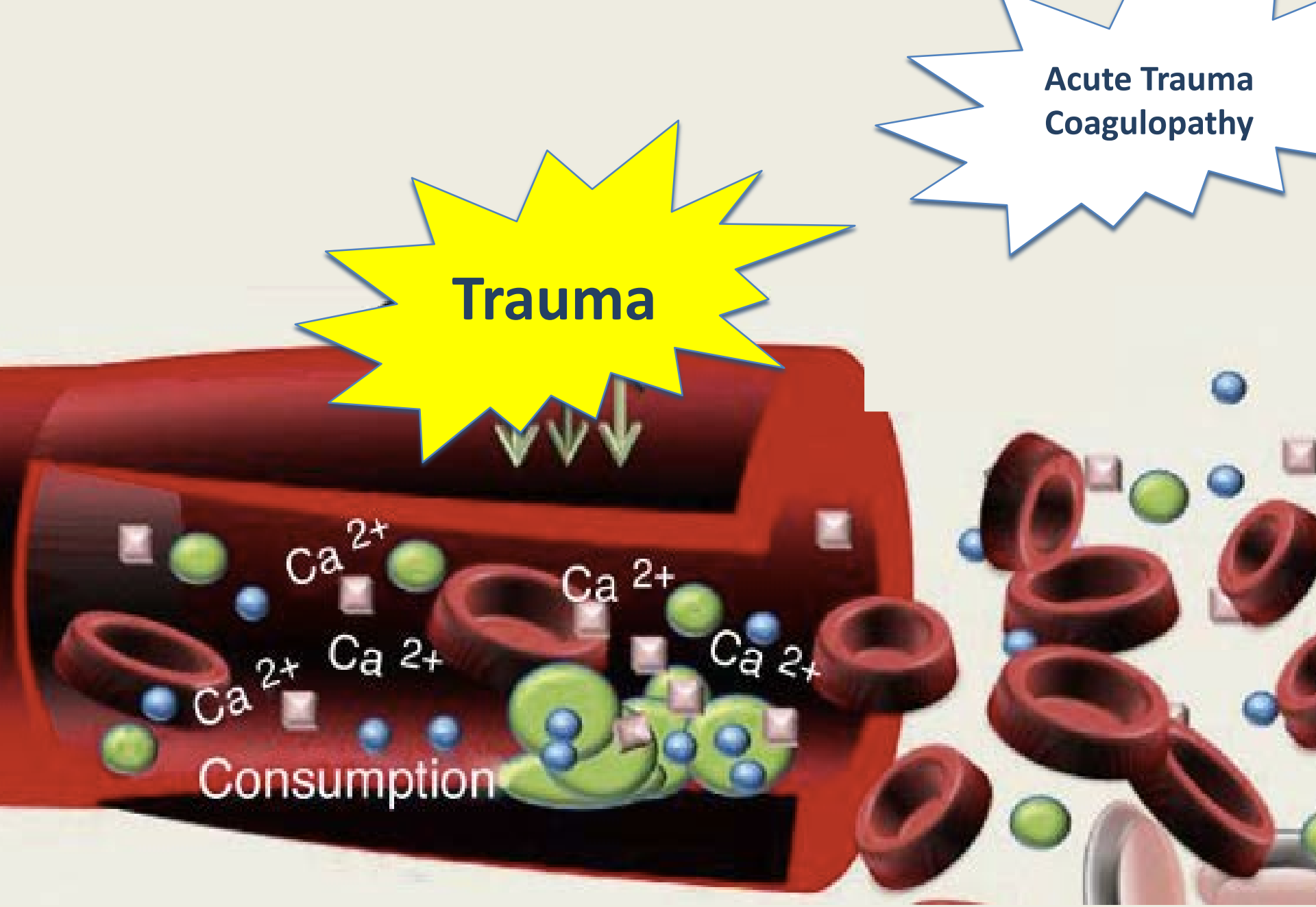
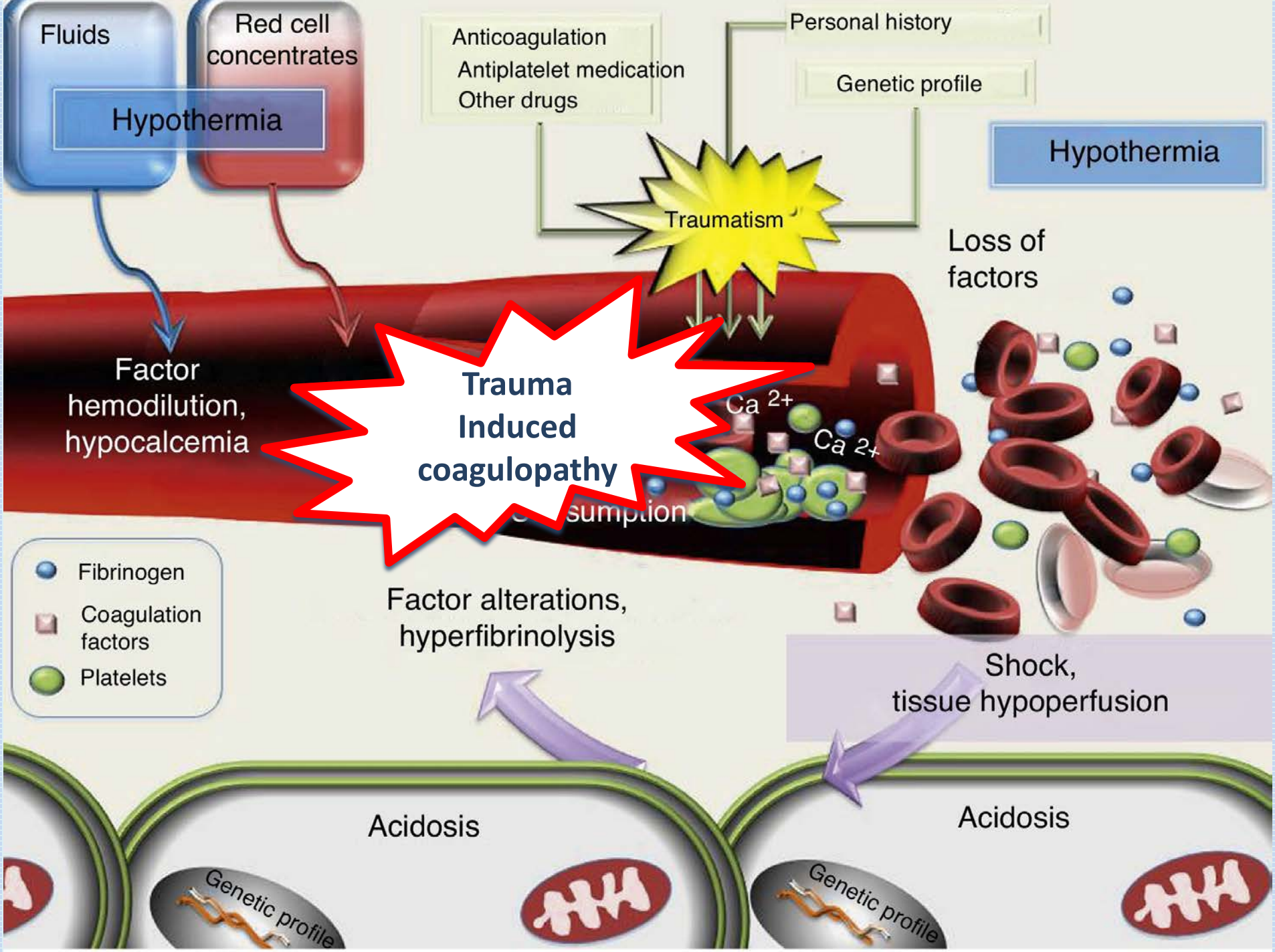
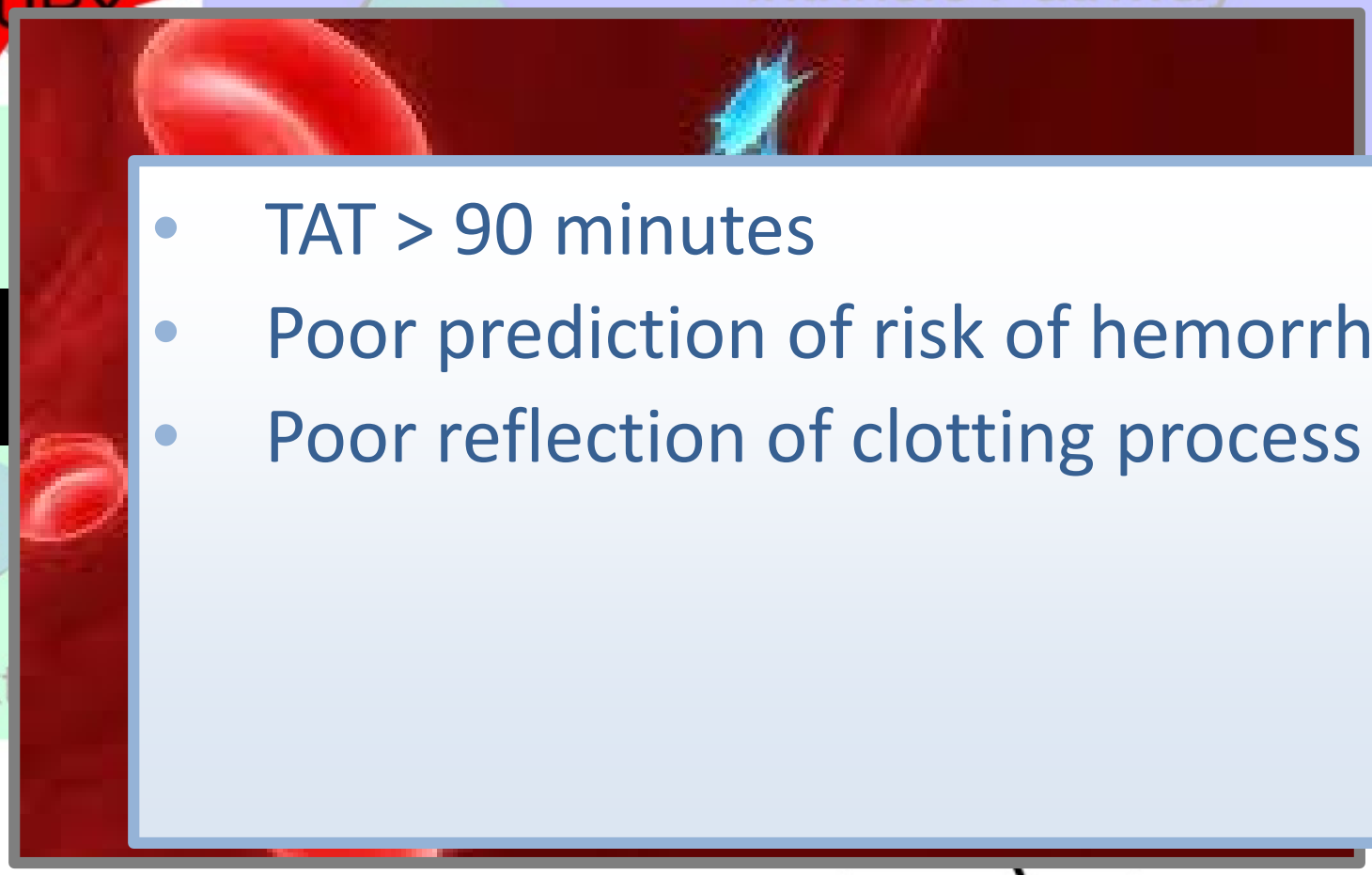
Clinical Head, Critical Care, Steve Biko Academic Hospital & Kalafong Hospital


Acute Trauma Coagulopathy
Trauma
Ca 2+
Ca 2+
Ca 2+
Ca 2+
Ca 2+
Consumption


Fluids
Red cell concentrates
Hypothermia
Anticoagulation
Antiplatelet medication
Other drugs
Personal history
Genetic profile
Hypothermia
Traumatism
Loss of factors
Factor hemodilution, hypocalcemia
Trauma Induced coagulopathy
Ca 2+
Ca 2+
sumption
Fibrinogen
Coagulation factors
Platelets
Factor alterations, hyperfibrinolysis
Shock, tissue hypoperfusion
Acidosis
Acidosis
Genetic profile
Genetic profile

Coagulation: Standard laboratory tests (SLTs)



- TAT > 90 minutes
- Poor prediction of risk of hemorrhage
- Poor reflection of clotting process

Thromboelastography
TEG®

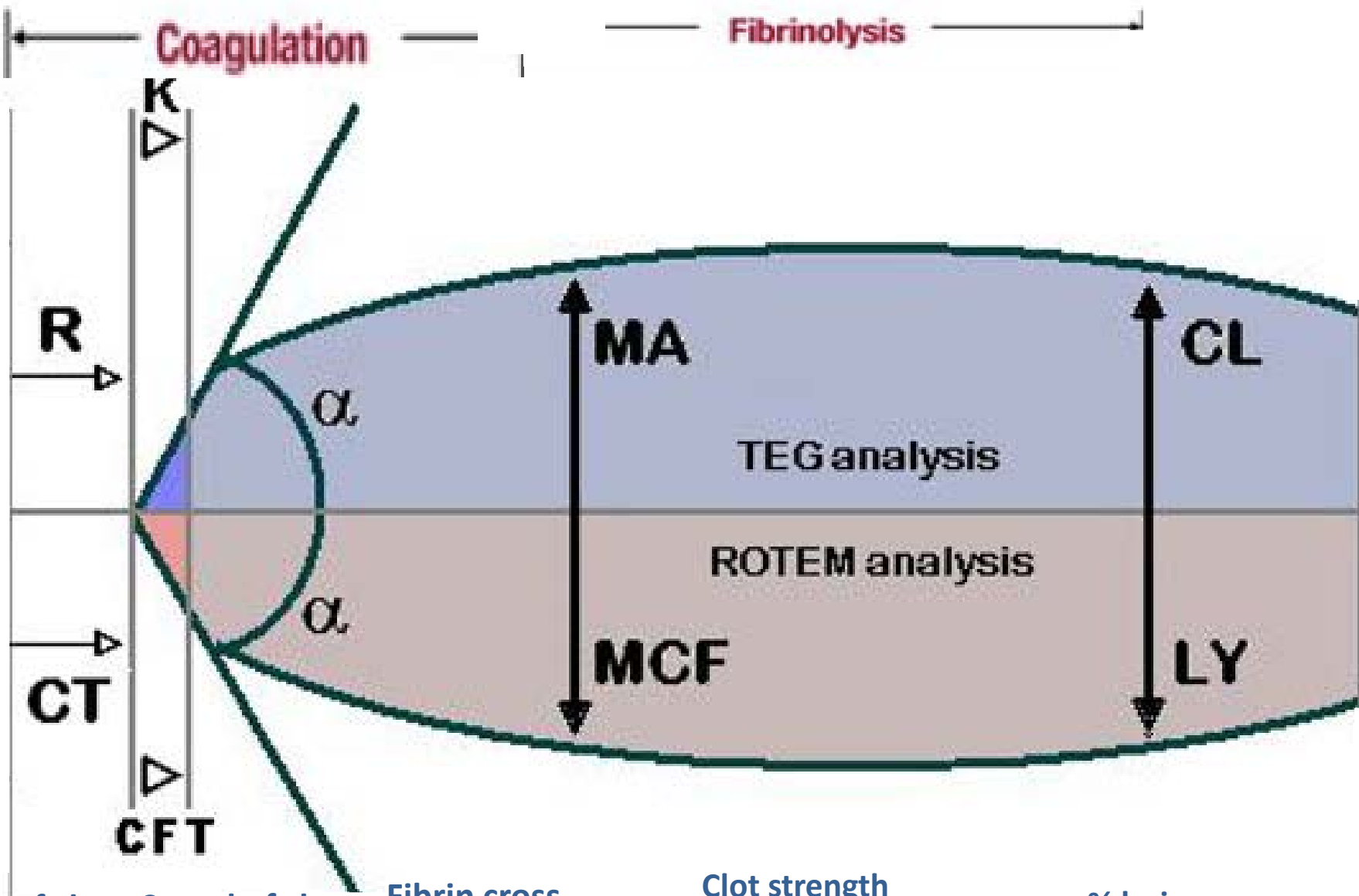
Clot initiation → Formation → Strength → Stability

1948: Helmet Hartert

1990: CPB

Liver Tranplant

Thromboelastometry
ROTEM®



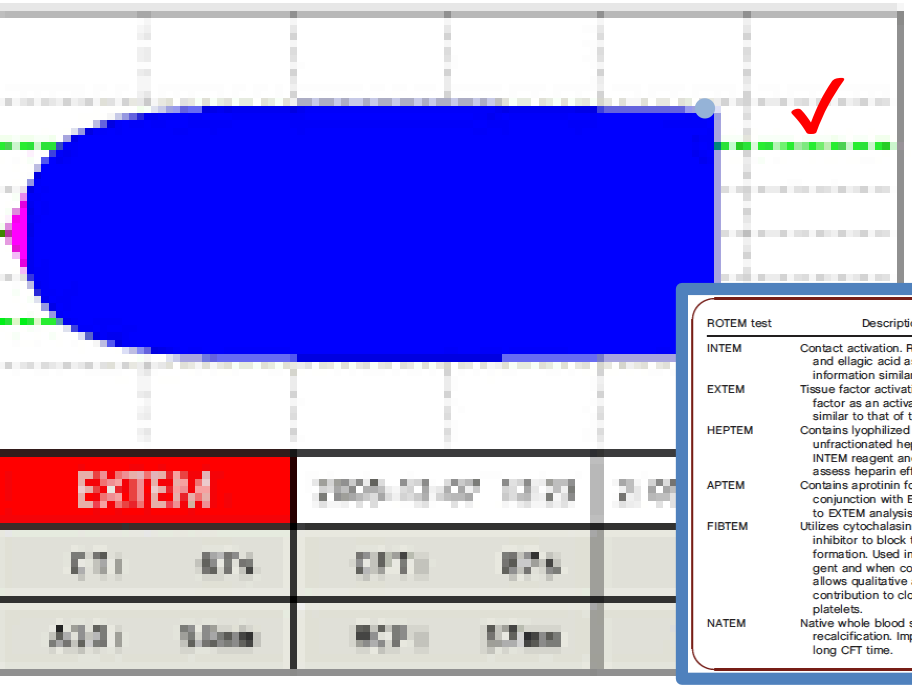
Start of clot Forming
5-10 min
Clotting Factors

Speed of clot formation
1-3 min
Fibrinogen
Platelets

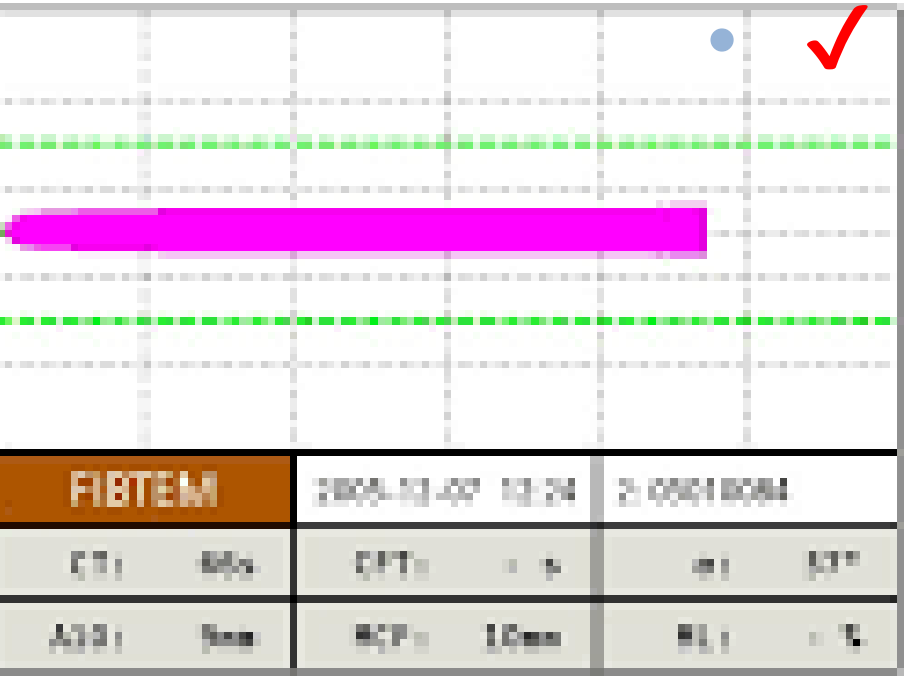
Fibrin cross linking
55^0-72^0
Fibrinogen
Platelet

Clot strength
50-70mm
Platelet functior
Fibrinogen (20%,

- % lysis
<5%



ROTEM test	Description and interpretation
INTEM	Contact activation. Reagent contains phospholipid and ellagic acid as activators and provides information similar to that of the APTT.
EXTEM	Tissue factor activation. Reagent contains tissue factor as an activator and provides information similar to that of the PT.
HEPTEM	Contains lyophilized heparinase for neutralizing unfractionated heparin; used in conjunction with INTEM reagent and compared to ITEM analysis to assess heparin effect.
APTEM	Contains aprotinin for inhibiting fibrinolysis; used in conjunction with EXTEM reagent and compared to EXTEM analysis to assess fibrinolysis.
FIBTEM	Utilizes cytochalasin D, an actin polymerization inhibitor to block the platelet contribution to clot formation. Used in conjunction with EXTEM reagent and when compared to EXTEM analysis allows qualitative analysis of the fibrinogen contribution to clot strength independent of platelets.
NATEM	Native whole blood sample analyzed following only recalcification. Impractical for clinical use given long CFT time.

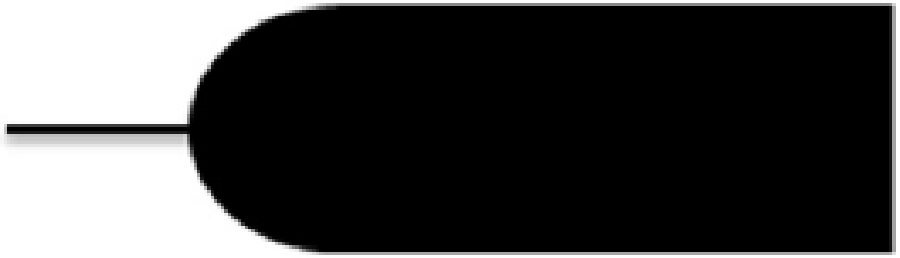


TEG

TEG : Intrinsic

Rapid TEG: Extrinsic and Intrinsic

Normal



Limitations

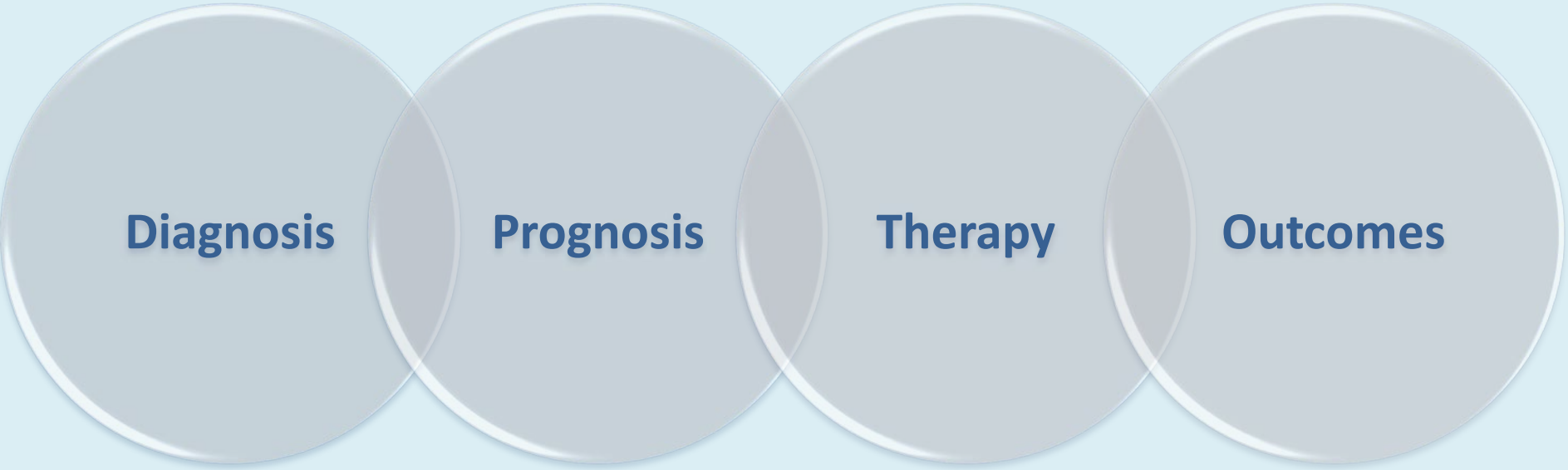
- Vascular endothelium
- Hypocalcemia and hypothermic effects
  - Calcium added
  - Temperature 37^0C
- Antiplatelet therapy
  - Aspirin
  - Clopidogrel
- Interoperator variability

Utility in trauma

Cardiac Surgery

Liver transplants

Obstetrics ✓



Cost

TEM and TEG VS standard laboratory tests

SLTs

- Ev
- TA

31 publications

Trauma

- VE tests more effective than SLTs
- Cost savings per patient (material costs)

ROTEM : 668£

TEG : 721£

Viscoelastic point-of-care testing to assist with the diagnosis, management and monitoring of haemostasis: a systematic review and cost-effectiveness analysis

HEALTH TECHNOLOGY ASSESSMENT

Penny Whiting, Maiwenn Al, Marie Westwood, Isaac Corro Ramos, Steve Ryder, Nigel Armstrong, Kate Misso, Janine Ross, Johan Severens and Jos Kleijnen

VOLUME 19 ISSUE 58 JULY 2015

Rugeri L et al,J Throm Hemostasia, 2007
Kaufmann CR et al, J Trauma,1997
Doran CM et al, J trauma,2010

ROTEM and TEG Interchangable?

ROTEM vs TEG?

Robust

Amplitude: Platelets vs Fibrinogen

Injury, Int. J. Care Injured 44 (2013) 600–605

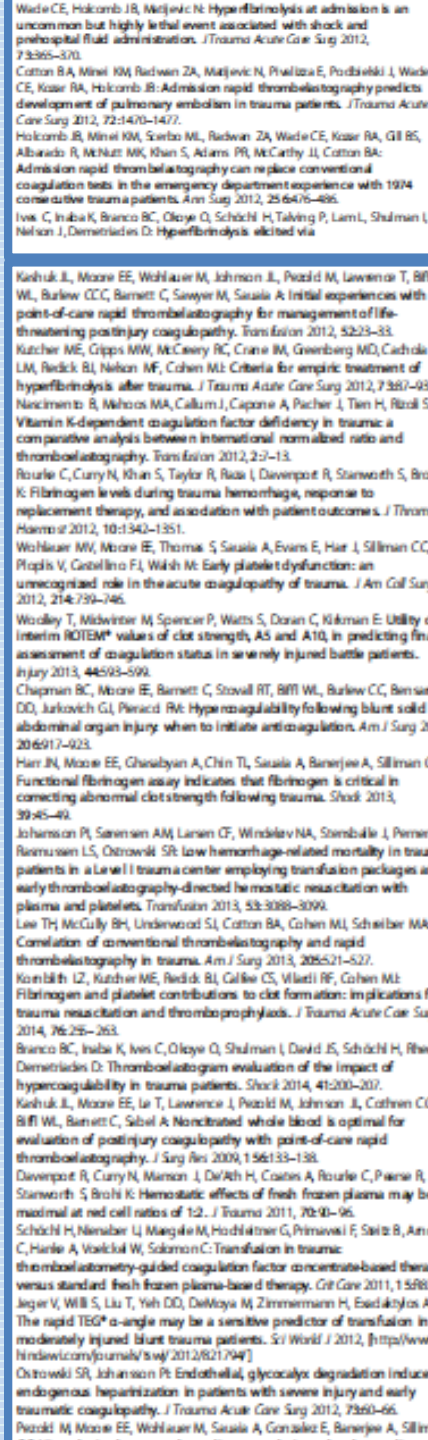
Evaluation of TEG® and RoTEM® inter-changeability in trauma patients

Jostein S. Hagemo[a,b,*], Paal A. Næss[c], Pär Johansson[d], Nis A. Windeløv[e], Mitchell Jay Cohen[f], Jo Røislien[a,g], Karim Brohi[h], Hans Erik Heier[i,j], Morten Hestnes[k], Christine Gaarder[c]

Predictive ability

- Massive transfusion
  - Clotting times
  - Hyperfibrinolyis
  - ROTEM and TEG
- Organ dysfunction (several studies p< 0.05)
  - Hyperfibrinolysis on ROTEM
- Mortality (several studies p< 0.05)
  - Hyperfibrinolysis(77% vs 41%)
  - Weak clot strength (amplitude)

Da Luz TL et al, Crit Care,2014



Wade CE, Holcomb JB, Matijevic N: Hyperfibrinolysis at admission is an uncommon but highly lethal event associated with shock and prehospital fluid administration. *J Trauma Acute Care Surg* 2012, 73:365–370.

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Kutcher ME, Cripps MW, McCreery RC, Crane IM, Greenberg MD, Cachola LM, Redick BJ, Nelson MF, Cohen MJ: Criteria for empiric treatment of hyperfibrinolysis after trauma. *J Trauma Acute Care Surg* 2012, 73:87–93.

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Rourke C, Curry N, Khan S, Taylor R, Raza I, Davenport R, Stanworth S, Brohi K: Fibrinogen levels during trauma hemorrhage, response to replacement therapy, and association with patient outcomes. *J Thromb Haemost* 2012, 10:1342–1351.

Wohlauer MV, Moore EE, Thomas S, Sauaia A, Evans E, Harr J, Silliman CC, Ploplis V, Castellino FJ, Walsh M: Early platelet dysfunction: an unrecognized role in the acute coagulopathy of trauma. *J Am Coll Surg* 2012, 214:739–746.

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Lee TH, McCully BH, Underwood SJ, Cotton BA, Cohen MJ, Schreiber MA: Correlation of conventional thromboelastography and rapid thrombelastography in trauma. *Am J Surg* 2013, 205:521–527.

Kornblith LZ, Kutcher ME, Redick BJ, Calfee CS, Vilardi RF, Cohen MJ: Fibrinogen and platelet contributions to clot formation: Implications for trauma resuscitation and thromboprophylaxis. *J Trauma Acute Care Surg* 2014, 76:255–263.

Branco BC, Inaba K, Ives C, Okoye O, Shulman I, David JS, Schöchl H, Rhee P, Demetriades D: Thromboelastogram evaluation of the impact of hypercoagulability in trauma patients. *Shock* 2014, 41:200–207.

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Davenport R, Curry N, Manson J, De'Ath H, Coates A, Rourke C, Pearse R, Stanworth S, Brohi K: Hemostatic effects of fresh frozen plasma may be maximal at red cell ratios of 1:2. *J Trauma* 2011, 70:90–96.

Schöchl H, Nienaber U, Maegele M, Hochleitner G, Primavesi F, Steitz B, Arn K, Görlinger C, Haas T, Voelckel W, Solomon C: Transfusion in trauma: thromboelastometry-guided coagulation factor concentrate-based therapy versus standard fresh frozen plasma-based therapy. *Crit Care* 2011, 15:R83.

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Ostrowski SR, Johansson PI: Endothelial glycocalyx degradation induces endogenous heparinization in patients with severe injury and early traumatic coagulopathy. *J Trauma Acute Care Surg* 2012, 73:60–66.

Pezold M, Moore EE, Wohlauer M, Sauaia A, Gonzalez E, Banerjee A, Silliman

Impact on blood product use

Algorithm guided protocols

- Hospital use and Combat casulaties
- US survey
  - 191 surgeons
  - 125 units
  - 9% use TEG or TEM with MTP
- European survey L1 Trauma Centres
  - 50% TEM and TEG
- Paucity of consensus

Thromboelastography and Rotational Thromboelastometry use in trauma
Kareem Abdelrahman, Michael W. Cripps*
ARTICLE IN PRESS
International Journal of Surgery

Etchill E et al, Transfusion,2016
Schafer N et al,Scan J trauma resus Emergency Med, 2015

Reduced PRBC TF
Reduced platelets

Nienaber U et al,2011
Schaden E et al,2012
Schochl H et al,2011
Gorlinger K et al,2011

Modelling study
Reduced FFP TF
73% to 54% (p=0.03)

Kashuk JL et al,2009

Clinical impact

Systematic Review

Effect of thromboelastography (TEG®) and rotational thromboelastometry (ROTEM®) on diagnosis of coagulopathy, transfusion guidance and mortality in trauma: descriptive systematic review

Luis Teodoro Da Luz[1], Bartolomeu Nascimento[2], Ajith Kumar Shankarakutty[3], Sandro Rizoli[4] and Neill KJ Adhikari[1*]

- S

ard?

- More data required

Thromboelastography (TEG) and rotational thromboelastometry (ROTEM) for trauma ; induced coagulopathy in adult trauma patients with bleeding (Review)

Cochrane Database of Systematic Reviews

Hunt H, Stanworth S, Curry N, Woolley T, Cooper C, Ukoumunne O, Zhelev Z, Hyde C

Authors' conclusions

We found no evidence on the accuracy of TEG and very little evidence on the accuracy of ROTEM. The value of accuracy estimates are considerably undermined by the small number of included studies, and concerns about risk of bias relating to the index test and the reference standard. We recognise that the reference standards of PT and INR are imperfect, but in the absence of embedded clinical consensus these are judged to be the best reflection of current clinical practice. We are unable to offer advice on the use of global measures of haemostatic function for trauma based on the evidence on test accuracy identified in this systematic review. This evidence strongly suggests that at present these tests should only be used for research. We consider more thoroughly what this research could be in the Discussion section.

- Insufficient evidence (L2)
- RCTs
- BUT…
  - SLTs (L2)
  - Trials not included
  - Guidelines

Mortality: Retrospective trials

- Lower crude mortality rate(n=68)
- ROTEM guided resuscitation- less than predicted mortality(n=131,p=0.03)
- No difference: n=681
- Ben Taub Hospital
  - TEG vs MTP(1:1:1)
    - Penetrating trauma
      - ≥ 6 U PC: Simailar mortality
      - ≥10U PC: MTP higher mortality

Nicole M. Tapia,

AAST 2012 Plenary Paper

TEG-guided resuscitation is superior to standardized MTP resuscitation in massively transfused penetrating trauma patients

J Trauma Acute Care Surg Volume 74, Number 2

Kashuk JL et al,Transfusion, 2012

Schochl H et al Crit Care,,2010

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Impact

ed Hemostatic Resuscitation of
-induced Coagulopathy

ical Trial Comparing a Viscoelastic Assay to
al Coagulation Assays

Eduardo Gonzalez,

Ann Surg 2016;263:1051–1059

n=111

MTP

SCTs vs TE

- D28M
- Produc
  - Overa
  - First 4 h
    - Less pla
    - Less plate
- ICU stay halved(16 p<0.01)

RCT

TEG Guided MTP

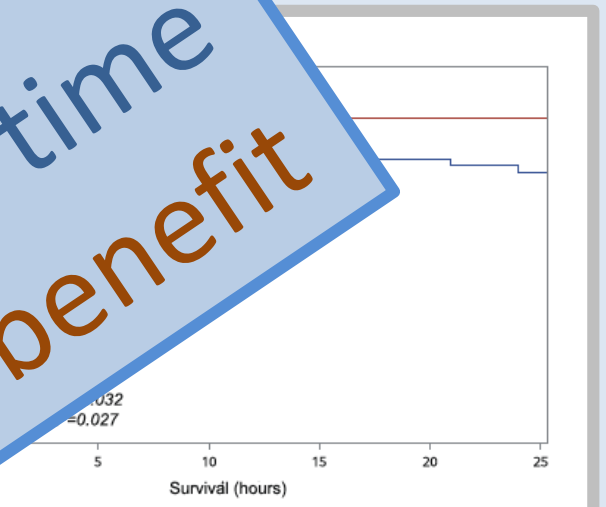
Intervening with

appropriate

products at

appropriate time

Mortality benefit



Current role in traumatic hemorrhagic shock

- Shock on admission (blunt or penetrating trauma)
- MTP recipients (to continue or stop products)
- Clinically suspect hemorrhage or coagulopathy