TEG/ROTEM: Applications for New Brunswick (Atlantic Canada)

ATEM conference
Dr. Michael Crozier

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Acknowledgement

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Conflicts of Interest: None Declared
Objectives

- Introduction to trauma resuscitation and applications for thromboelastography
- How the technology works
- How to integrate TEG/ROTEM into your hospital or trauma system
What is the best way to resuscitate bleeding patients?
- Trauma, Anesthesia, Critical Care, Obstetrics, Cardiac Surgery

How do we do this vs. how should we do this?
- Traditional vs. Incipient Approaches

Implications:
- Patient Morbidity and Mortality
- Blood products
- Cost
Introduction

trauma = lots bleeding
bleeding = can’t clot
bleeding patients = die

Exsanguination & Coagulopathy

40% Head

51% Exsanguination & Coagulopathy

Sauaia et al J Trauma 1995;38:185
Background

Acute Trauma Coagulopathy

- early, organ failure
- 25% patients
- shock, injury, hypothermia
- dilution worsen
- blood, ICU, ventilation,
- 3x death
How does it all work?

Too complex + poor understanding

Simple:
- Clot/clotting factors
- fibrinogen (*obstetric*)
- platelets (*cardiac sx*)
- anti-fibrinolytics

Little by little we advance
Bleeding is a Challenge to Manage

Clinical prediction = sensitivity 66%, PPV 35%

Mechanical  Coagulopathic
Strategy 1 – Crystalloid

Crystalloid-based resuscitation

XX century = crystalloid is bad
brain, lung, bowel edema
open abdomen

dilution = more coagulopathy
more transfusion
more hypothermia
Strategy 2 – Ratio

Blood-based hemostatic resuscitation
Presume coagulopathic
Standard of care – hypotension = blood

Damage control resuscitation 1:1:1
• RBC + plasma + platelet
• blood early, blind, < crystalloids

MTP – blood bank + TR + OR + lab
Strategy 3 – Customized

Goal-directed resuscitation

1. Entire medicine is changing

2. High-stress situation – wrong decisions:
   - acute & massive bleeding
   - high risk of dying & time is essential
   - multiple professionals
   - activate MTP, blood transfusion, OR vs. CT scan

3. Directed by what? Lab tests?
ROTEM/TEG – Why to use it?
Many reasons:

a. diagnose hyper fibrinolysis
b. fibrinolysis shutdown
c. presence anticoagulants
d. decide what blood product
e. decide when to stop
Conventional lab **NOT** good

INR – warfarin; PTT – hemophilia

- poor plat plasma
- no correlation *in vivo* bleeding
- interpretation unknown
- extrapolated for trauma
- clinical interpretation
- **TIME** – 88 min *(10-15 min)*
Summary

Coagulopathy: complex, change time, dynamic

Trauma resuscitation (or any major bleeding)
Not much time – initiate blood 1:1:1
Prone errors – customize resuscitation

TEG/ROTEM (not perfect)
  a. diagnose hyper fibrinolysis
  b. fibrinolysis shutdown
  c. presence anticoagulants
  d. decide what blood product
  e. decide when to stop
Summary

- Why don’t we have this strategy available to us in New Brunswick (Atlantic Canada)?
- Should we?
TEG TALK

Thromboelastography and its clinical relevance
Introduction

Invited critical review

Why is everyone so excited about thromboelastography (TEG)?

Brad S. Karon *

Department of Laboratory Medicine and Pathology, Mayo Clinic, 200 First Street SW, Rochester, MN 55905
Components of Coagulation

- Local tissue effects
- Platelet aggregation  \(\sim\text{Plt count}\)
- Intrinsic Pathway (F 8, 9, 11, 12)  \(\sim\text{PTT}\)
- Extrinsic Pathway (tissue Fctr and F7)  \(\sim\text{PT}\)
- Common Pathway (Xa, thrombin, fibrinogen)  \(\sim\text{TT}\)

\(~\text{fibrinogen}\)

Fibrinolysis (plasmin \(\rightarrow\) plasminogen) and fibrin split products  \(\sim\text{D-dimers}\)
Coagulation

Clot formation

Platelet part

Fibrinolysis

Fibrinolytic part

Enzymatic part

Initiation

Clotting Factors

Enzymatic part: Initiation of coagulation is dependent on coagulation factor concentration

Platelet part: Thrombin generation on the activated platelets generate fibrin from fibrinogen, which cross links with platelets building the clot. Dependent on platelets and fibrinogen

Fibrinolytic part. Dissolves the clot, dependent on fibrin and tPA (from endothelial cells)
Viscoelastography

- monitors the clotting of whole blood in a cup or small container
- TEG (thromboelastography) is just one type.
- Two commercial types:
  - TEG  (cup spins / pin stationary)
  - ROTEM (cup stationary / pin spins)
TEG Assay

- A whole blood sample (citrated or non-citrated) is placed into a cuvette and a cylindrical pin is immersed.
- The pin is free-pending and the cup oscillates.
- The clotting process is detected via a torsion wire.
- The TEG is extremely sensitive to vibrations and mechanical shocks.

Assay Time = 15-20 min
https://youtu.be/gJwU7g0mn8M
EVERY NORMAL CANADIAN NEEDS A SNOW SHOVEL
The Grave Digger
TIME TO PLANT DAISIES
Figure 5. A depiction of a normal TEG output as compared to output seen in various coagulopathic states.
Remote visualization
Where available local testing (Rotem or TEG) are acceptable tools in a Goal Directed Approach to Massive Transfusion.

Specific lab tests used, and the goals of therapy, can be locally determined with emphasis on the value of tests with rapid turn around.
The International Normalized Ratio overestimates coagulopathy in stable trauma and surgical patients

Sean P. McCully, MD, MS, Loic J. Fabricant, MD, Nicholas R. Kunio, MD, Tahnee L. Groat, MPH, Katherine M. Watson, BA, Jerome A. Differding, MPH, Thomas G. Deloughery, MD,
and Martin A. Schreiber, MD, Portland, Oregon

J Trauma and Acute Care Surgery Jan 2013 vol 75 p. 947-
Assessing specific platelet function with PlateletMapping

3. Define effect of agonist on platelet contribution to clot strength
   ADP (Plavix®)
   AA (Aspirin)

   Agonist-induced platelet contribution ($MA_{ADP}$)
   Clot without platelets ($MA_A$)
Cost / Benefits

- Not designed for mass testing
- U.S. studies show reduced blood prod use in Massive Bleeds
- Possible reductions in the 4 Ts
  - TRIM transfusion related immuno-modulation
  - TACO transfusion assoc circulatory overload
  - TRALI transfusion related acute lung injury
  - TAE thrombotic adverse events
“HEMOVIGILANCE”

- Optimize pre-op erythropoiesis
- Reduce operative loss
- Optimize physiologic tolerance to loss
- Use anti-fibrinolytics (when can)

**GOAL DIRECT:**

- red cells
- Plt
- clotting factors
- and
- Fluids
Risk Factors and Clinical Outcomes Associated with Perioperative Transfusion-associated Circulatory Overload

Leanne Clifford, B.M., Qing Jia, M.D., Arun Subramanian, M.B.B.S., Hemang Yadav, M.B.B.S., Darrell R. Schroeder, M.S., Daryl J. Kor, M.D.
TACO - most common transfusion complication

25% of all transfusions Occur peri-operatively

75% of TACO occurs in Non-emergent surgeries

MAY be preventable

“Why is better recognition and prevention of transfusion-associated circulatory overload important?”
Outcomes from TACO

- 2X risk of post op mechanical ventilation (70% vs 30%)
- ~2X ICU Length of stay (11d vs 6d)
- 2X hospital length of stay (20d vs 9d)
- Reduced one year mortality 28% vs 16%
Conclusion

“Until targeted therapies are available to treat TACO, prevention remains paramount with the avoidance of unnecessary transfusions being critically important. Particularly careful consideration regarding the appropriateness of a transfusion episode and the management of nonsanguineous fluid therapies should be employed”
Morbidity and Mortality after High-dose Transfusion

Daniel J. Johnson, B.S., Andrew V. Scott, B.S., Viachaslau M. Barodka, M.D., Sunhee Park, M.D., Jack O. Wasey, B.M., B.Ch., Paul M. Ness, M.D., Tom Gniadek, M.D., Ph.D., Steven M. Frank, M.D.
TEG or ROTEM-based Approach in Laboratory Medicine
**ROTEM :**

- Approved by FDA in 2011
- Approved by Health Canada in 2012
ROTEM

- Gives quick data about whole coagulation system in real time
- Whole blood is used, no need to process or handle the sample
- Numerical results are compared to well-established reference ranges
- Can be used as POC device or Laboratory –based analyser
- Testing results facilitates in goal-directed management of critically ill patients (trauma, surgical, ICU)
- Helps to decrease unnecessary blood product usage and further risks of blood transfusions
- Especially crucial for early detection of unwanted fibrinolysis or fibrinolytic shut-down

“ROTEM-Based Coagulation Management in Cardiac Surgery and Major Trauma”; Kenichi A. Tanaka et al. J of Cardiothoracic and Vascular Anesthesia, 2012
POC vs Lab-based ROTEM

Advantages

- **Point of Care**
  - No specimen transport
  - Faster TAT (Turnaround time) and real time management

- **Lab-based**
  - Quality assurance and lab. accreditation standards are maintained
  - All users are standardized, no need to train staff in multiple clinical areas
  - Prevents mistakes from inappropriate use
  - Increases involvement of Hematopathologists and TM specialists
POC vs Lab-based ROTEM

**Disadvantages**

- **Point of Care**
  - Multiple analysers needed in multiple clinical areas or use will be restricted based on accessibility
  - Requires dedicated staff (RT, RN, Physician) to be taken away from active patient management
  - No automated entry of results into LIS and EHR
  - QA and QC protocols still requires regular Lab. oversight and involvement

- **Lab-based**
  - Requires good communication between care areas and Lab. for faster TAT
  - Specimen transport to the Lab. delays the testing (5-10 min)
  - Well-established specimen transport protocols needed if pneumatic tube system is used
Result Reporting

ROTEM Connect – Live – streaming of data

Courtesy of Dr. Trudeau, Vancouver Coastal Health
ROTEM-based Transfusion Algorithms

ROTEM Guided Bleeding Management for TRAUMA – A Guideline

1. Clinically significant bleeding? •
   - Hgb > 80 g/L
   - T > 35°C
   - Ca > 1 mmol/L
   - pH > 7.2

2. Massive bleeding? Follow TEP protocol until ROTEM guided approach possible

3. ROTEM
   - Optimize Fibrinogen
     - A10 EXTEM ≤ 40mm (or CFT > 130s) + A10 FIBTEM < 10mm
     - Fibrinogen concentrate 4 g or Cryoprecipitate 10U

4. Optimize Platelets
   - A10 EXTEM ≤ 40mm (or CFT > 130s) + A10 FIBTEM ≥ 10mm
   - Platelets - 1 adult dose

5. Optimize Factors
   - CT EXTEM ≥ 100 sec
   - FP 2-4 U (15 cc/kg)
   - If CT < 100 sec, administer FP as part of balanced resuscitation

6. Treat hyperfibrinolysis
   - ML EXTEM > 10%
   - Tranexamic acid 2 g

To view results: http://rotem.vch.ca
ROTEM-based Transfusion Algorithms

**Blood Transfusion Algorithm**

1. Rewarmed on CPB (Temp 36°C)
   - Protamine (1 mg / mg initial heparin dose) post-CPB
   - ACT normalized (≥ 10% of baseline if normal at baseline)
   - Measure Blood Loss (Must use 5-minute packing method)

2. If ACT elevated, give additional protamine and repeat ACT

3. Sponges Weight < 60 gm (or no sponges weighed)
   - No Blood Products

4. Sponges Weight ≥ 60 gm

5. Functioning platelets < 75,000 x 10^6
   - Platelets 1 pool

6. A10-EXTEM < 35 mm or A10-FIBTEM > 7 mm

7. CT-EXTEM ≥ 100 s

8. A10-FIBTEM ≤ 7 mm

9. Plasma 10 - 15 ml/kg

10. Cryoprecipitate 10 U

* Does not apply to RBC transfusions, which will be based on hemoglobin levels (triggers: ~7 g/dL during CPB; ~8 g/dL post-CPB; ~9 g/dL in bleeding or unstable patients)

† If an additional protamine dose does not shorten ACT, consider low fibrinogen (low A10-FIBTEM) or an acquired deficiency of enzymatic coagulation factors (prolonged CT-EXTEM) as a reason for prolonged ACT and treat it according to the algorithm (maximum overall protamine dose: 1.2 mg/mg initial heparin dose)

‡ No need to weigh sponges if there is massive bleeding, in which case may initiate transfusion without weighing sponges and combine steps if meet criteria

§ Must treat one step at a time and re-assess bleeding after each step, unless there is massive bleeding or sponges > 120 gm. If re-warming POC tests normal in bleeding patient, repeat tests and follow algorithm

± Consider 2 pools of platelets in massively bleeding patients, functioning platelets < 15,000, or recent use of potent anti-platelet drugs.

¶ Consider PCC ~ 20 IU/kg if RV failure, volume overload, or recent warfarin use

UHN, Blood Transfusion Algorithm for Cardiac Cases
A Canadian study…

Evaluation of a Novel Transfusion Algorithm Employing Point-of-care Coagulation Assays in Cardiac Surgery

A Retrospective Cohort Study with Interrupted Time–Series Analysis

Keyvan Karkouti, M.D., Stuart A. McCluskey, M.D., Ph.D., Jeannie Callum, M.D., John Freedman, M.D., Rita Selby, M.D., Tarik Timourmi, M.D., Debasish Roy, M.D., Vivek Rao, M.D., Ph.D.

<table>
<thead>
<tr>
<th></th>
<th>Pre-algorithm (n = 1131)</th>
<th>Post-algorithm (n = 1170)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBC Transfusions</td>
<td>52%</td>
<td>41%</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>PLT Transfusions</td>
<td>34%</td>
<td>23%</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FFP Transfusions</td>
<td>34%</td>
<td>14%</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>≥ 4 RBC units</td>
<td>13%</td>
<td>7%</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>rFVIIa</td>
<td>3%</td>
<td>1%</td>
<td>&lt; 0.001</td>
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</tbody>
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In Summary

- ROTEM testing will be a useful tool in goal-directed management of critically ill patients.
- We would have centralized approach and perform all ROTEM testing in the Lab.
- Results are reported in real time to patient care areas.
- Using the goal-oriented transfusion algorithm, clinicians may appropriately select necessary transfusion components instead of empirically administering all components with potential hazardous effects.
- ROTEM testing implemented Canadian sites report in-return cost savings (reduced blood product use and other lab. test ordering).
QUESTIONS?

- CADTH report
- Thank you