Targeted Coagulation Management In Severe Trauma

Dr James Winearls
Intensivist GCUH
What will we cover...?

• Why a targeted coagulation management strategy?
  - A bit of background

• What is the technology?
  - This will focus on ROTEM
  - Not a comparison of ROTEM vs TEG (this is a minefield!)

• How did we do it?
  - The logistics of establishing a successful programme
  - Applicability to our patients / A couple of cases

• Evidence....?
  - Is there any
  - Current state of play
What is this talk NOT about?

• This is NOT an all encompassing ROTEM talk
• Not a talk on Traumatic Coagulopathy
• I am not an expert on coagulation
• Nor am I trying to sell ROTEM

NOT of

according to James
Why Bother ???

• We know all about coagulopathy......
• We all really know how to treat coagulopathy......
• We have tests that can diagnose coagulopathy.....
• Massive Transfusion Protocols .......
• If in doubt give a whole load of everything.......
What are we trying to prevent....?
Traumatic Coagulopathy

- Trauma is a leading cause of death worldwide
- Up to 40% of deaths are due to haemorrhage
- Understanding of coagulopathy in trauma is limited
- Much more complex than originally thought
- Multifactorial aetiology:
  - Acute Traumatic Coagulopathy
  - Acidaemia
  - Hypothermia
  - Haemodilution
  - On-going loss / consumption of factors
Acute Traumatic Coagulopathy

- Coagulopathy unique to severely injured trauma patients
- Coagulopathy at presentation in +/- 50% of severe trauma patients
- **Not** just Dilution / Factor Loss / Acidaemia / Hypothermia
- Direct Tissue Injury + Hypoperfusion

➢ Acute Traumatic Coagulopathy

- 4 fold increase in mortality
- A few postulated mechanisms

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**Acute Traumatic Coagulopathy**

*Karim Brohi, BSc, FRCS, FRCA, Jasmin Singh, MB, BS, BSc, Mischa Heron, MRCP, FFAEM, and Timothy Coats, MD, FRCS, FFAEM*

**Background:** Traumatic coagulopathy is thought to be caused primarily by fluid administration and hypothermia.  
**Methods:** A retrospective study was performed to determine whether coagulopathy resulting from the injury itself is a clinically important entity in severely injured patients.  
**Results:** One thousand eight hundred sixty-seven consecutive trauma patients were reviewed, of whom 1,088 had full data sets. Median Injury Severity Score was 20, and 57.7% had an Injury Severity Score > 15; 24.4% of patients had a significant coagulopathy. Patients with an acute coagulopathy had significantly higher mortality (46.6% vs. 10.9%; \( \chi^2, p < 0.001 \)). The incidence of coagulopathy increased with severity of injury, but was not related to the volume of intravenous fluid administered (\( r^2 = 0.25, p < 0.001 \)).

**Conclusion:** There is a common and clinically important acute traumatic coagulopathy that is not related to fluid administration. This is a marker of injury severity and is related to mortality. A coagulopathy is a common occurrence in severely injured patients.

**Key Words:** Traumatic coagulopathy, Hypothermia, Fluid administration.

*J Trauma. 2003;54:1127–1130.*
Massive Transfusion Protocols

• Balanced and Pre-defined fixed ratio transfusion of product
• Aim to prevent and ‘treat’ traumatic coagulopathy
• MTP forms an integral part of DCR
• They are good and have improved survival
• Much of the MTP data initially came from conflicts in Iraq + Afghanistan
• Translated into the civilian arena and non-trauma critical bleeding
• There is however a significant difference in mechanism of injury
MTP and Ratios....?

• Much controversy regarding optimum ratios
• Trend towards high product to blood ratio
• 1:1:1 Plasma:Platelets:PRBC
• Initial positive data from military
• Subsequent military data seemed to refute +ve findings of 1:1:1 ratio
• Complications with high volume allogenic blood product transfusion
  ➢ TRALI / TACO / Sepsis / MOF / Death
Characterizing the Epidemiology of Postoperative Transfusion-related Acute Lung Injury

Leanne Clifford, B.M., Qing Jia, M.D., Arun Subramanian, M.B.B.S., Hemang Yadav, M.B.B.S., Gregory A. Wilson, R.R.T., Sean P. Murphy, B.S., Jyotishman Pathak, Ph.D., Darrell R. Schroeder, M.S., Daryl J. Kor, M.D.

Conclusions: Perioperative TRALI/possible TRALI is more common than previously reported and its risk increases with greater volumes of blood component therapies. No significant reduction in the combined incidence of TRALI/possible TRALI occurred between 2004 and 2011, despite the introduction of TRALI mitigation strategies. Future efforts to identify specific risk factors for TRALI/possible TRALI in surgical populations may reduce the burden of this life-threatening complication.

Characterizing the Epidemiology of Perioperative Transfusion-associated Circulatory Overload

Leanne Clifford, B.M., Qing Jia, M.D., Hemang Yadav, M.B.B.S., Arun Subramanian, M.B.B.S., Gregory A. Wilson, R.R.T., Sean P. Murphy, B.S., Jyotishman Pathak, Ph.D., Darrell R. Schroeder, M.S., Mark H. Ereh, M.D., Daryl J. Kor, M.D.

Results: A total of 2,162 and 1,908 patients met study criteria for 2004 and 2011, respectively. The incidence of TACO was 5.5% (119 of 2,162) in 2004 versus 3.0% (57 of 1,908) in 2011 ($P < 0.001$), with comparable rates for men (4.8% [98 of 2,023]) and women (3.8% [78 of 2,047]) ($P = 0.09$). Overall, vascular (12.1% [60 of 497]), transplant (8.8% [17 of 193]), and thoracic surgeries (7.2% [10 of 138]) carried the highest TACO rates. Obstetric and gynecologic patients had the lowest rate (1.4% [4 of 295]). The incidence of TACO increased with volume transfused, advancing age, and total intraoperative fluid balance (all $P < 0.001$).

Conclusions: The incidence of perioperative TACO is similar to previous estimates in nonsurgical populations. There was a reduction in TACO rate between 2004 and 2011, with incidence patterns remaining comparable in subgroup analyses. Future efforts exploring risk factors for TACO may guide preventive or therapeutic interventions, helping to further mitigate this transfusion complication. (ANESTHESIOLOGY 2015; 122:21-8)
• 10 American Level 1 Trauma Centres
• +/-1000 Patients
• Early use of high ratios associated with reduced mortality
• High ratios not associated with increased morbidity and mortality
Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients With Severe Trauma: The PROPPR Randomized Clinical Clinical Trial

- Pragmatic Randomised Optimal Platelet and Plasma Ratios Trial
- Large Multicentre RCT enrolled 680 patients
- Two Groups -> 1:1:1 (338 patients) or 1:1:2 (342 patients)
- 1º Outcomes -> 24 hr and 30 day mortality
- No difference in Primary outcome measures
- More patients in 1:1:1 group achieved haemostasis
- Less patients in 1:1:1 group died from exsanguination at 24 hours
- But underpowered
Hemostatic resuscitation is neither hemostatic nor resuscitative in trauma hemorrhage

Sirat Khan, MD, Karim Brohi, MD, Manik Chana, MD, Imran Raza, MD, Simon Stanworth, MD, Christine Gaarder, MD, PhD, Ross Davenport, MD, PhD, on behalf of the International Trauma Research Network (INTRN), London, United Kingdom

J Trauma Acute Care Surg. 2014;76: 561–568

This investigation questions the therapeutic mechanism and efficacy of HR in the acute phase of trauma hemorrhage. Aggressive high-volume replacement of plasma has little effect on deranged ROTEM coagulation parameters and hypoperfusion. Arrest of hemorrhage and cessation of transfusion seem necessary before TIC can be corrected and tissue perfusion restored.
Where does this leave us..?  

• Should we just do 1:1:1..?  
• 1:1:1 initially then coagulation testing guided..?  
• Guided by what..?
So What about VHA?

- Viscoelastic Haemostatic Assays
- The technology is not new
- Based on classical Thromboelastography
- First described in 1948 by Hartert
- TEG or ROTEM
- Give information on:
  - Clot Formation
  - Clot Strength
  - Clot Lysis
Vorsprung durch Technik

Fixed Cup and Pin supported by Ball Bearing
ROTEM

• Uses citrated whole blood (test within 4 hours)
• Viscoelastic measurement of clot kinetics
• Real time graphical and numerical display
• Assessment of the phases of clot formation
  ➢ Initiation
  ➢ Amplification
  ➢ Propagation
  ➢ Lysis
ROTEM

• 4 Channels can be run simultaneously
• Different activators
• Detection and differentiation of specific haemostatic defects:
  ➢ Hypofibrinogenaemia
  ➢ Hyperfibrinolysis
  ➢ Heparin and/or Protamine Effect
  ➢ Platelet Dysfunction
  ➢ Coagulation Factor Deficiency
EXTEM – Tissue Factor Activation

- Clot Formation
- Fibrin Polymerisation
- Fibrinolysis
- Via Extrinsic Pathway (rTF)

FIBTEM – TF Activation + Cytochalasin D

- Same as EXTEM activation
- But with Platelet Inhibition
- Functional Fibrinogen Assessment
INTEM – Contact Activation

• Clot Formation
• Fibrin Polymerisation
• Fibrinolysis
• Via Intrinsic Pathway (Ellagic Acid)
• Heparin Sensitive

HEPTEM – Contact Activation + Heparinase

• Compared to INTEM
• Specific detection of Heparin
• Analysis without Heparin effects
• Clot kinetics in Heparinised patients
• Useful in Cardiac Surgery
CT (clotting time)
*Green display 0-2mm*
Time in seconds from start of measurement until initiation of clotting. Initiation of clotting, thrombin generation and start of clot polymerization.

CFT (clot formation time)
*Pink display 2-20mm*
Time in seconds from initiation of clotting until a clot firmness of 20 mm is detected. Fibrin polymerisation, stabilisation of the clot with platelets & FXIII.

A10 (amplitude in mm)
*Blue display if >20mm*
*Otherwise stays pink*
Early assessment of clot firmness. Increasing stabilisation of the clot by the polymerised fibrin, platelets as well as FXIII.

The Squiggles

• Typical reaction curves – TEMOGRAM

• Clot dynamics
  • Initiation phase
  • Propagation phase
  • Clot generation
  • Velocity data/profile
  • Clot lysis phase

• Dynamic visualisation of physical properties of a clot

• Numerical data about all phases of clotting/lysis

• Abnormal results are marked/highlighted

• Clot firmness = Clot Quality
In a Nutshell

• Clotting Time (CT)
  Adequate Clotting Factors
  Inhibited Clotting Factors

• Amplitude (A5/A10/MCF)
  Assessment of Clot Strength
  Fibrinogen / Platelets / FXIII

• Fibrinolysis
  Clot degradation over time
  Lysis Index (LI) / Max Lysis (ML)
There are some drawbacks......

- Does not replace SLTs such as APTT and INR
- Not used for monitoring of Heparin or Warfarin therapy
- Insensitive to effects of antiplatelet agents
- Does not detect the effects of vWF
- Normal results do not exclude effects of the NOAC’s
- Does not predict bleeding risk
- Limited evidence
Usefulness of standard plasma coagulation tests in the management of perioperative coagulopathic bleeding: is there any evidence?

T. Haas¹*, D. Fries², K. A. Tanaka³, L. Asmis⁴, N. S. Curry⁵ and H. Schöchl⁶,⁷

In general, SLTs are widely available and frequently used, but there is no sound evidence from well-designed studies that confirm that SLTs are useful for diagnosis of coagulopathy or to guide haemostatic therapy. Secondly, the turnaround times of SLTs are too protracted for emergency scenarios, where quick decision-making is mandatory. Alternatives, such as viscoelastic analysers, provide data much more quickly and provide a more comprehensive overview of the whole coagulation process.
Standard Laboratory Tests

• Speed
  - Turnaround time of 30 – 60 mins
  - Results often retrospective / historical

• INR and APTT
  - Designed for monitoring therapeutic anticoagulation
  - Not for use in multifactorial coagulopathies
  - Nor to guide therapy in massive transfusion

• Test performed on Plasma
  - VHA performed on whole blood

• Traditional SLT give no information on:
  - Clot strength
  - Interaction between different components of haemostasis
  - Hyperfibrinolysis
  - Platelet function
The Race

3 mins after sampling

10 mins

20 mins
And the winner is....

All required info available in 15 mins
1 Hour and 5 Mins !!!
In Reality

• We don’t really know how to treat coagulopathy
• We don’t really understand the coagulopathy associated with trauma
• SLT aren’t great at diagnosing or monitoring treatment of coagulopathy
• Wide variety in clinical MTP guidelines
• Lack of evidence base to support current guidelines
• Exposing patients to risks with inappropriate blood product transfusion
• ROTEM is not perfect
• In my opinion provides a more comprehensive picture than SLT
GCUH Model
GCUH Approach

- There is no ‘right’ way to implement a targeted approach
- Laboratory vs Clinical Arena
- Depends on logistical consideration at each individual facility
- Services provided will differ between facilities
- Either approach requires input from laboratory and clinicians
- Won’t work unless collaboration
- Implementation as part of a before and after cohort study
GCUH Approach

- Clinician driven bedside model
- Laboratory and Blood Bank support
- Rigors of laboratory whilst maximising clinical utility
- Laboratory support ensures:
  - Policies and Procedures
  - Quality Measures
  - Training & Education
  - Stock Control
  - Data Collection
GCUH Approach

• All our trauma patients are managed with ROTEM
• ROTEM on admission to ED
• Blood product transfusion responsibility of ICU
  ➢ ICU second line component of trauma team
  ➢ Defined role in a complex multidisciplinary environment
  ➢ Majority of patients will require further ICU input
• Sequential ROTEM analysis from ICU admission
• Part of Before and After Cohort study
ROTEM at GCUH – Key Trauma People

Obstetric Anaesthetist
Anaesthetic Tech
Cardiac Anaesthetist
Cardiac Anaesthetist
Theatre Nurse
Intensivist
Trauma CNC
Cardiac Surgeon
Converted Sceptic
Transfusion CNC
ICU NUM and CNC
ICU Nurse
Cardiac Surgeon
Director Orthopaedics
Cardiac Perfusionist
Director of Trauma
Beautiful Assistant
Director ICU
Now What.....
It's all about the size of the sausage....
Big Fat Sausage is Good
Little Weiner is Bad....
Chipolata is Disappointing

<table>
<thead>
<tr>
<th>EXTEM</th>
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<tbody>
<tr>
<td>CT</td>
<td>59s</td>
<td>CFT</td>
<td>130s</td>
<td></td>
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<tr>
<td>A10</td>
<td>44mm</td>
<td>MCF</td>
<td>48mm</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>ML</td>
<td>100%</td>
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GCUH Algorithm:

- Always evolving
- Evidence and Experience
- Simple to Teach
- Simple to Understand
- Simple to Use
- Stepwise Approach
Detection of acute traumatic coagulopathy and massive transfusion requirements by means of rotational thromboelastometry: an international prospective validation study

Jostein S Hagemo¹²*, Sarah C Christiaans³⁴, Simon J Stanworth⁵, Karim Brohi⁶, Pär I Johansson⁷⁸, J Carel Goslings³, Paal A Naess⁹ and Christine Gaarder⁹

Conclusions: This study confirms previous findings of ROTEM CA5 as a valid marker for ATC and predictor for MT. With optimum threshold for EXTEM CA5 ≤ 40 mm and FIBTEM CA5 ≤ 9 mm, sensitivity is 72.7% and 77.5% respectively. Future investigations should evaluate the role of repeated viscoelastic testing in guiding haemostatic resuscitation in trauma.
GuH Trauma & Critical Bleeding - Rotem Transfusion Algorithm

Thromboelastometry Treatment Triggers for Clinically Significant Bleeding

Physiological Targets:
- Temp >30°C
- pH >7.2
- ICA >1 mmol/L
- Hb >70 g/L

1a. FIBTEM A10 < 10 mm
   Low Fibrinogen
   Cryoprecipitate 1 unit / 5 kg BW

1b. FIBTEM A10 < 8 mm
   Low Fibrinogen
   Fibrinogen Concentrate: 1 g / 25 kg

- FIBTEM can be GREEN if very LOW

2. FIBTEM A10 < 10 mm
   EXTEN A10 < 40 mm
   Poor Platelet Contribution
   Platelets 1 dose

3. FIBTEM A10 > 10 mm
   EXTEN CT > 90 sec
   Low Coagulation Factors
   PTX 12.5 units / kg BW OR FFP 2-4 units

4. EXTEN ML > 5%
   Hyperfibrinolysis
   Tranexamic Acid 1 gm

5. FIBTEM A10 > 15 mm
   EXTEN A10 > 50 mm
   EXTEN CT < 60 sec
   IF Bleeding Continues
   Consider Surgical Haemostasis

Repeat ROTEM tests 10 mins after therapy

GCUH - ROTEM Transfusion Algorithm

FIBTEM
- Fibrinogen Contribution
- Extrinsic Pathway
- Platelet/Fibrinogen Interaction

EXTEN
- Intrinsically Pathway
- Compare to INTEN CT
- Heparin Effect

HEPTEN
- No sensitivity to platelet inhibitors: AADP, Clopidogrel, warfarin, aspirin, fish oil, garlic or Ginseng etc. 72 h to last 7 days.

- Consider limitations for interpretation and always combine with clinical parameters.
- Low sensitivity to oral anticoagulants (Warfarin, GIP IIb/IIIa antagonists, LMWH, Heparins).

EXTEM / HEMI Comparative Analysis (Platelets or Fibrinogen)

- CT (Clotting Time)
  - Green display: 2-20 min
  - Time in seconds from start of measurement until initiation of clotting, initiation of clotting, thrombin generation & start of clot polymerization.

- EXTEN
  - CFT (Clot Formation Time)
    - Pink display: 2-20 min
    - Time in seconds from initiation of clotting until a clot firmness of 20 mm is detected, fibrin polymerization, stabilization of the clot with platelets & FIBTEM.

- INTEN
  - CFT (Clot Formation Time)
    - Blue display: 2-20 min
    - Early assessment of clot firmness, increasing stabilization of the clot by the polymerized fibrin, platelets as well as FIBTEM.

- A50 (Amplitude in mm)
  - Blue display: >20 mm
  - Amplitude (A50) ≥ 20 mm

Dr. James WINEARS

VIEW RESULTS REMOTELY DESKTOP ICON
Damage control resuscitation using blood component therapy in standard doses has a limited effect on coagulopathy during trauma hemorrhage.

There was no clear benefit to high-dose FFP therapy in any parameter. Only combined high-dose FFP, cryoprecipitate and platelet therapy with a high total fibrinogen load appeared to produce a consistent improvement in coagulation. Conclusions: Damage...
Step 1 - Fibrinogen

1a. FIBTEM A10 < 10 mm
   Low Fibrinogen
   Cryoprecipitate 1 unit / 5 kg BW

1b. FIBTEM A10 < 8 mm
   Low Fibrinogen
   FIBRINOGEN CONCENTRATE - 1g / 25 kg
   (CONSULTANT x2 ONLY for sign off / Alternative – CRYO 20 units)
Conclusions: Hypofibrinogenaemia is common in trauma and strongly associated with poor outcome. Below an estimated critical fibrinogen concentration value of 2.29 g/L a dramatic increase in mortality was detected. This finding indicates that the negative impact of low fibrinogen concentrations may have been previously underestimated. A number of clinically identifiable factors are associated with hypofibrinogenaemia. They should be considered in the management of massively bleeding patients. Interventional trials with fibrinogen substitution in high-risk patients need to be undertaken.
A Quick Bit on Fibrinogen

• First coagulation factor that reaches critically low levels
• Especially in Trauma
• Fibrinogen in form of Cryo often comes late in the MTP
• We probably under dose with current MTP
• Variability in Fibrinogen concentration in Cryo
• Not much Fibrinogen in FFP
• We use 1 Unit Cryo / 5Kg body weight
• In carefully selected cases Fibrinogen Concentrate
FIBTEM provides early prediction of massive transfusion in trauma

Herbert Schöchl¹,²*, Bryan Cotton³, Kenji Inaba⁴, Ulrike Nienaber⁵, Henrik Fischer⁶, Wolfgang Voelckel² and Cristina Solomon¹,⁷

Conclusions: FIBTEM A10 and FIBTEM MCF provided similar predictive values for massive transfusion in trauma patients to the most predictive laboratory parameters. Prospective studies are needed to confirm these findings.
Management of bleeding and coagulopathy following major trauma: an updated European guideline

We recommend that viscoelastic methods also be performed to assist in characterising the coagulopathy and in guiding haemostatic therapy. (Grade 1C)

Fibrinogen and cryoprecipitate

Recommendation 27 We recommend treatment with fibrinogen concentrate or cryoprecipitate in the continuing management of the patient if significant bleeding is accompanied by thromboelastometric signs of a functional fibrinogen deficit or a plasma fibrinogen level of less than 1.5 to 2.0 g/l. (Grade 1C)

We suggest an initial fibrinogen concentrate dose of 3 to 4 g or 50 mg/kg of cryoprecipitate, which is approximately equivalent to 15 to 20 single donor units in a 70 kg adult. Repeat doses may be guided by
Fibrinogen Concentrate

• Controversial / No good evidence that better than Cryo
• Widespread use in Northern Europe (Cryo not available)
• Expensive +/- $720 per gram
• Easier to administer
• Quicker to give
• Known dose

Efficacy and safety of fibrinogen concentrate in trauma patients—a systematic review

C. Aubron, MD, PhD a,*, M.C. Reade, MBBS, MPH, DPhil, FANZCA, FCICM b, J.F. Fraser, MBChB, PhD, MRCP, FRCA, FFARCSI, FCICM c, D.J. Cooper, BMBS, MD, FRACP, FCICM a
Step 2 - Platelets

- Role of platelets in traumatic coagulopathy not fully understood
- Most patients have normal platelet count on admission
- What about platelet dysfunction?
- Insensitive to anti-platelet agents
- Addition of Whole Blood Aggregometry devices (Multiplate or ROTEM Platelet)
Step 3 - Factors

- Thrombin is key but not substantially impaired in early trauma
- PCC vs FFP Controversial
- PCC definitely prothrombotic
- Use a smaller dose
- Very limited evidence in Trauma
- 3 Factor vs 4 Factor concentrates
<table>
<thead>
<tr>
<th>Citation</th>
<th>Study Design</th>
<th>Inclusion/Exclusion Criteria</th>
<th>No. Patients</th>
<th>Criteria for Administering PCC</th>
<th>No. Patients Receiving PCC (%/Dose)</th>
<th>Main Efficacy Results</th>
<th>Main Safety Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schöchl et al. [26]</td>
<td>Retrospective cohort study (trauma)</td>
<td>Patients who received ≥5 units of erythrocytes within 24h after trauma center arrival</td>
<td>131 (all received concentrate-based therapy)</td>
<td>Prolonged EXTEM CT (&gt;1.5 times normal)</td>
<td>98 (75%) (median 1,600 IU)</td>
<td>Observed mortality of 24 vs. 34% predicted by TRMSS (P = 0.032)</td>
<td>Outcome parameters apart from trauma not assessed</td>
</tr>
<tr>
<td>Schöchl et al. [37]</td>
<td>Retrospective case-control study (trauma)</td>
<td>Injury severity score ≥16. Concentrate-based therapy group: treated at Salzburg trauma center, received fibrinogen and/or PCC but no FFP. FFP-based therapy group: information obtained from German trauma registry. Received FFP but no fibrinogen concentrate or PCC</td>
<td>681 (80 received concentrate-based therapy; 601 received FFP-based therapy)</td>
<td>Prolonged EXTEM CT (&gt;1.5 times normal)</td>
<td>43 (54%) (median 1,000 IU)</td>
<td>Transfusion avoidance rates for concentrate-based therapy vs. FFP-based therapy: erythrocytes, 29 vs. 33%; platelets, 91 vs. 56%; P &lt; 0.001 for both comparisons</td>
<td>Safety aspects not evaluated</td>
</tr>
<tr>
<td>Innerhofer et al. [28]</td>
<td>Prospective cohort study designed to evaluate characteristics and treatment of trauma-induced coagulopathy</td>
<td>Admission to Innsbruck Trauma Center, injury severity score ≥15, multiple blunt injury, survival for at least 24h, received hemostatic therapy</td>
<td>144 (68 received coagulation factor concentrates only; 76 received concentrates plus FFP)</td>
<td>PT &lt;50% or INR &gt;1.5 and/or EXTEM CT &gt;90 s</td>
<td>Not specified (median 8 IU with concentrates only, 750 IU with concentrates plus FFP)</td>
<td>Patients treated with concentrates only showed sufficient hemostasis and received significantly fewer units of erythrocytes and platelets than patients receiving concentrates plus FFP (median erythrocyte transfusion 2 vs. 9U; platelets 0 vs. 1U; P &lt; 0.001 for both comparisons)</td>
<td>Thromboembolism was reported in six recipients of concentrates only (9%) and in six recipients of concentrates plus FFP (8%) (P = ns)</td>
</tr>
<tr>
<td>Göblinger et al. [5]</td>
<td>Retrospective case study (cardiovascular surgery)</td>
<td>Patients undergoing cardiac surgery before and after implementation of a concentrate-based coagulation management algorithm</td>
<td>3,865 (2,147 treated according to the concentrate-based algorithm; 1,718 controls treated before introduction of the algorithm)</td>
<td>EXTEM CT &gt;90 s, 20-25 IU/kg; CT &gt;105 s, 35-40 IU/kg</td>
<td>191 (9%) (not specified)</td>
<td>The concentrate-based approach decreased the rate of transfusion of any allogeneic blood product from 63 to 42% (P = 0.001), erythrocytes (50 to 40%; P = 0.001), and FFP (19% to 11%; P &lt; 0.001), but increased platelet transfusion from 10 to 13% (P = 0.004)</td>
<td>Rate of thrombotic/thromboembolic events decreased from 3.2 to 1.8% (P = 0.012)</td>
</tr>
<tr>
<td>Göblinger et al. [79]</td>
<td>Retrospective case-control study (cardiovascular surgery; visceral surgery; and liver transplant surgery)</td>
<td>Patients undergoing the defined types of surgery in Essen, before and after implementation of a concentrate-based coagulation management algorithm</td>
<td>Total not specified (data from a 1-year period after introduction of concentrate-based therapy [n = 7,869] compared with controls treated before the algorithm)</td>
<td>EXTEM CT &gt;80 s</td>
<td>Not specified</td>
<td>Transfusion of blood products was reduced after introduction of concentrate-based therapy, with percentage reductions as follows: 79-98% for FFP; 8-62% for erythrocytes; 85-66% for platelets except in cardiovascular surgery where a five-fold increase in dual antiplatelet therapy increased transfusion of platelets by 15%.</td>
<td>Not reported</td>
</tr>
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</table>
Step 4 - Hyperfibrinolysis

- Rare occurrence and associated with poor outcome
- VHA actually insensitive / No value of APTEM
- We don’t see much -> Widespread use TXA
- Don’t withhold TXA on basis of ROTEM
- PATCH Trial will be interesting
- More complex than originally thought
Caveats

- Only treat patient if active bleeding
- Repeat after therapeutic intervention
- Pay attention to basics – Acidaemia / Temperature / Ca$^{2+}$
- Only useful if used as part of DCR approach:
  - Damage Control Surgery
  - Haemostatic Resuscitation
  - Permissive Hypotension (Limit Crystalloid)
Case 1: Multi-Trauma

- MBA
- Gold Coast Hinterland
- Greater than 1 hour at scene
- Helicopter retrieval
- Pre-Hospital Rx:
  - I+V
  - Bilateral Thoracostomies
  - x2 PRBC
  - TXA

In ED:
- Hypotensive
- pH 6.8 / Lact 10 / BE -20
- Bilateral ICC for
- Multiple Rib #’s / Pelvic #
- Stabilisation – PRBC’s / Lines etc
- CT to OT
Case 1: Multi-Trauma

- 20 Cryo
- 4 PRBC
Case 1: Multi-Trauma in OT

- Ongoing Bleeding
- Splenectomy
- 1.5L in each ICC
- Ex-Fix Femur

Further Product:
- 20 Cryo
- 1 Platelet
- 6 PRBC
Case 1: Multi-Trauma Progress

Further Product:
- 20 Cryo
- 4 PRBC

ICU Next Morning
Case 1: Multi-Trauma Progress

- **Multiple Injuries:**
  - Bilateral Rib #’s 1 – 10
  - Splenic Rupture
  - R Kidney Laceration
  - Multiple Mesenteric Tears
  - Complex Pelvic #
  - Compound R Femur #
  - Compound L Tibia #

- **Blood Products 1st 24 Hours**
  - 17 PRBC
  - 60 Cryo
  - 2 Platelets
  - 1 FFP (By mistake)
  - 2g TXA

- Delayed ORIF Pelvic #
- Definitive management other orthopaedic injuries
- No MOF / Extubated D14
- D/C Home after 6 weeks
Case 2: Multi-Trauma

- MBA Southport
- T-Bone
- Propelled +/- 50m
- Hypotensive at scene
- Scoop and run to ED

- Hypotensive
- pH 7.0 / Lact 13 / BE -15
- Bilateral ICC for Pneumothorax
- Rib #’s / Pelvic #
- Compound Femur #
- FAST +ve
- Red Blanket to OT
Case 2: Multi-Trauma Progress

ROTEM in ED

- 20 Cryo
- 4 PRBC
- TXA
Case 2: Multi-Trauma Progress

- Laparotomy
- Vascular Injuries
- GIT Injuries
- Abdomen Open
- Pelvic Embolisation
- Ex-Fix Pelvis
- Ex-Fix Femur

- 8g FC
- 6 PRBC
- 1 Platelet
Case 2: Multi-Trauma Progress

- **Multiple Injuries:**
  - Bilateral Rib #’s
  - Multiple Mesenteric Tears
  - Multiple SB Tears
  - Complex Pelvic #
  - Compound R Femur #
  - Compound R Tibia #

- **Blood Products 1st 24 Hours**
  - 14 PRBC
  - 8g FC
  - 20 Cryo
  - 1 Platelets
  - 2g TXA

- ORIF Pelvic and Lower Limb #’s
- Open abdomen with entero-cutaneous Fistula
- No MOF / 45 Day ICU Admission
- D/C home yesterday
So Where to Now??

ROTEM vs SLT vs MTP
Where does this leave us...?

- Targeted approach makes theoretical sense
- No good evidence to support targeted approach in trauma
- Significant geographical variation
- Two main camps
Effect of thromboelastography (TEG®) and rotational thromboelastometry (ROTEM®) on diagnosis of coagulopathy, transfusion guidance and mortality in trauma: descriptive systematic review

Luis Teodoro Da Luz¹, Bartolomeu Nascimento², Ajith Kumar Shankarakutty³, Sandro Rizoli⁴ and Neill KJ Adhikari¹*

Results: Fifty-five studies (12,489 patients) met inclusion criteria, including 38 prospective cohort studies, 15 retrospective cohort studies, two before-after studies, and no randomized trials. Methodologic quality was moderate

Conclusions: Limited evidence from observational data suggest that TEG®/ROTEM® tests diagnose early trauma coagulopathy and may predict blood-product transfusion and mortality in trauma. Effects on blood-product transfusion, mortality, and other patient-important outcomes remain unproven in randomized trials.
2014 Consensus conference on viscoelastic test–based transfusion guidelines for early trauma resuscitation:
Report of the panel

Kenji Inaba, MD, Sandro Rizoli, MD, Precilla V. Veigas, MSc, Jeannie Callum, MD,
Ross Davenport, MD, John Hess, MD, Marc Maegele, MD,
and the Viscoelastic Testing in Trauma Consensus Panel, Los Angeles, California

ABSTRACT: There has been an increased interest in the use of viscoelastic testing to guide blood product replacement during the acute resuscitation of the injured patient. Currently, no uniformly accepted guidelines exist for how this technology should be integrated into clinical care. In September 2014, an international multidisciplinary group of leaders in the field of trauma coagulopathy and resuscitation was assembled for a 2-day consensus conference in Philadelphia, Pennsylvania. This panel included trauma surgeons, hematologists, blood bank specialists, anesthesiologists, and the lay public.

Nine questions regarding the impact of viscoelastic testing in the early resuscitation of trauma patients were developed before the conference by panel consensus. Early use was defined as baseline viscoelastic test result thresholds obtained within the first minutes of hospital arrival—when conventional laboratory results are not available. The available data for each question were then reviewed in person using standardized presentations by the expert panel. A consensus summary document was then developed and reviewed by the panel in an open forum. Finally, a two-round Delphi poll was administered to the panel of experts regarding viscoelastic thresholds for triggering the initiation of specific treatments including fibrinogen, platelets, plasma, and prothrombin complex concentrates. This report summarizes the findings and recommendations of this consensus conference. (J Trauma Acute Care Surg. 2015;78: 00–00. Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.)

KEY WORDS: Consensus conference; guidelines; viscoelastic testing; early resuscitation; trauma.
Where does this leave us…?

• ROTEM is good but not perfect
• There will always be a place for MTP but we can refine it
• Targeted vs Fixed Ratio MTP still controversial
• Needs a large multicentre study
• Australia is well positioned to perform such a study