New ways to manage massive haemorrhage - using ROTEM and fibrinogen concentrate

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Haemorrhage is the second commonest cause of death in major trauma patients
Incidence and etiology of mortality in polytrauma patients in a Dutch level I trauma center
Zainab El Mestouhi, Hamid Jalalzadeh, Georgios F. Giannakopoulos and Wietse P. Zuidema

95% blunt injuries

18% die of exsanguination
Trends in 1029 trauma deaths at a level 1 trauma center: Impact of a bleeding control bundle of care

Blessing T. Oyeniyi, Erin E. Fox, Michelle Scerbo, Jeffrey S. Tomasek, Charles E. Wade, John B. Holcomb*

Center for Translational Injury Research, Division of Acute Care Surgery, Department of Surgery, Medical School, The University of Texas Health Science Center at Houston, Houston, TX, USA

Injury, Int. J. Care Injured 48 (2017) 5–12

80% blunt injuries
25 -35 % die from haemorrhage
Causes of death after major trauma in England & Wales

- Bleeding: 30%
- Traumatic brain injury: 60%
- Other causes: 10%

Data summarised from TARN, England & Wales and Stanworth et al. 2016

95% of deaths due to blunt trauma
Trauma-associated haemorrhage

1. Tissue Injury
2. Coagulopathy
   a. Trauma-induced coagulopathy.
   b. Secondary coagulopathy from consumption, dilution and/or metabolic factors (acidosis, hypothermia).
3. Sometimes all of the above
Major haemorrhage in trauma

- Clinical indicators are poor predictors of which major trauma patients will have major haemorrhage (from Code Red activation research).
- <5-10% of major trauma patients (varies with definition of major trauma) present with major haemorrhage.
- Major haemorrhage in the trauma patient is uncommon and unpredictable but potentially deadly.
Bleeding control bundle of care.

1. Identify the bleeding patient
2. Prehospital and hospital damage control resuscitation
   - Prehospital and hospital extremity and junctional tourniquets
   - Prehospital and hospital pelvic binders
   - Prehospital and hospital hemostatic dressings
   - Resuscitative endovascular balloon occlusion of the aorta
3. Physical methods
4. Coagulation monitoring
Assessment of haemostasis

**Laboratory**

- PT, APTT, fibrinogen, platelet count.
- Turn around time too slow to make immediate diagnosis of coagulopathy or guide on-going resuscitation.
- Limited appreciation of dynamics of clot formation and unable to diagnose hyperfibrinolysis.
- Most trauma patients who receive a blood products (Code Red) have normal PT and APTT on admission.

**Viscoelastic tests**

- TEG® - predominantly USA but also UK.
- ROTEM® - predominantly Europe and Canada.

**Platelet function**
“Thromboelastographie” - Hartert 1948
ROTEM® - Rotational thromboelastometry
Cartridge-based ROTEM Sigma
Courtesy of Dr. Christian F. Weber, Univ Klinik Frankfurt
ROTEM

Amplitude (mm)

Time (min)

Activation of clotting factors
Thrombin
CLOT
Platelet activation/Fibrin
Normal

Trauma Bleeding Management: The Concept of Goal-Directed Primary Care

Herbert Schöchl, MD, * and Christoph J. Schlimp, MD

Anesth Analg 2014;119:1064-73
Fibrinogen/fibrin polymerisation

Normal - MCF 9-25 mm
If active or suspected bleeding: correct low FIBTEM (low fibrinogen) first

1. Check FIBTEM A5 first

FIBTEM

- A5 < 10
  - A5 < 5
    - 4 CRYO or Fibrinogen 6g
  - A5 5-9
    - 3 CRYO or Fibrinogen 4g
- A5 ≥ 10
  - Check EXTEM

2. Look at EXTEM CT and A5

EXTEM

- CT < 85
  - Check EXTEM A5
- CT ≥ 85
  - FIBTEM A5 ≥ 10
    - Check EXTEM A5
  - FIBTEM A5 < 10
    - 3-4 CRYO or Fibrinogen 4-6g

STOP the cause of bleeding!
- Physical
- Surgical

Tranexamic acid

Targets
- Hb 90-100 g/L if bleeding
- Platelets > 50 x 10⁹/L
- Systolic BP 80-100 mmHg
- Mean BP ≥ 80 if brain injury
- Temperature 35 - 37°C
- pH > 72

Doses
- Cryoprecipitate (5u/bag)
  - 4 bags ~ 6g Fibrinogen
  - 3 bags ~ 4.5g
  - 2 bags ~ 3g
- Fibrinogen 25-50 mg/kg
- Platelets – 1 pool
- FFP 20 ml/kg
- Tranexamic acid 2g (10-30 mg/kg)

Dual anti-platelet drugs or DOAC – ask specialist help

**ROTEM® - guided intervention in critical bleeding**
The key role of Factor I
Fibrinogen is a major coagulation protein and deficiency develops earlier than other coagulation factors
What happens to Fibrinogen in trauma?

ACIT-2 data (n = 517)

**Fibrinogen levels on admission**
- Non-coagulopathic: 2.5g/L
- Coagulopathic: 1.6g/L

**Admission Fibrinogen**
- Independent predictor of 24h & 28 day mortality (p<0.001)

Rourke et al, 2012 JTH
**Is blood needed immediately?**
- Arrange collection of **PACK A**
  (4 units of red cells & 4 units cryoprecipitate)

**Blood samples**
- FBC; G&S; Clotting; Fibrinogen
- Blood gas and/or Haemocue
- Send a separate second G&S sample

**Arrange collection of **PACK B**
(6 units of type specific red cells; 2 units cryo; 4 units FFP)
## Adult Massive Transfusion Protocol

**Trauma**

<table>
<thead>
<tr>
<th>Emergency Department</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suspected critical bleeding requiring emergency blood transfusion</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indications for activating Code Red</th>
<th>Major trauma and 2 or more of</th>
<th>Or</th>
<th>Major trauma and</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Penetrating injury</td>
<td></td>
<td></td>
<td>Senior clinician’s suspicion of</td>
</tr>
<tr>
<td>2. FAST scan - abdominal fluid+</td>
<td></td>
<td></td>
<td>ongoing bleeding</td>
</tr>
<tr>
<td>3. HR &gt; 120/min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. SBP &lt; 90 mmHg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Non-trauma**

<table>
<thead>
<tr>
<th>Other locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bleeding &gt; 150 ml/min</td>
</tr>
<tr>
<td>• Blood loss &gt; 1500ml</td>
</tr>
<tr>
<td>• Loss of half the circulating blood volume in less than 2 hours</td>
</tr>
<tr>
<td>• Rapid blood loss leading to circulatory failure despite ongoing volume resuscitation</td>
</tr>
<tr>
<td>TRAUMA or non-trauma</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Request Pack A</strong></td>
</tr>
<tr>
<td>Send baseline血液</td>
</tr>
<tr>
<td>Prepare Pack A</td>
</tr>
<tr>
<td>Send Red cells and Fibrinogen</td>
</tr>
<tr>
<td>Perform ROTEM</td>
</tr>
</tbody>
</table>

**Pack A**

4 units red cell concentrate (RED Cell)  
+  
Fibrinogen concentrate 6g

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If > 4 units RED Cells required:  
**Request Pack A again**  

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Request PLATELETS if patient still bleeding after 6-8 units RED cells

Give additional products according to ROTEM
1. Pack A
   • Four units of Packed Red Cells
   • Fibrinogen Concentrate 6g
2. Pack B
   • Four units of Packed Red Cells
   • Fibrinogen Concentrate 6g
3. Additional blood products guided by ROTEM
4. Packs C & D
Bleeding control bundle of care.

1. Identify the bleeding patient
2. Prehospital and hospital damage control resuscitation
   - Prehospital and hospital extremity and junctional tourniquets
   - Prehospital and hospital pelvic binders
   - Prehospital and hospital hemostatic dressings
   - Resuscitative endovascular balloon occlusion of the aorta
3. Physical methods
4. Coagulation monitoring with ROTEM
5. TXA for patients with significant fibrinolysis
   - Decreased time to operating room
   - Decreased time to interventional radiology
6. Goal directed resuscitation with blood products as bleeding slows
6 Months On – ROTEM in Blood Transfusion

Changes in MHP

Case Studies

Impacts of Change
<table>
<thead>
<tr>
<th>Pack</th>
<th>2011 - 2018</th>
<th>2018 - current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pack A</td>
<td>4 RBC</td>
<td>4 RBC</td>
</tr>
<tr>
<td></td>
<td>4 Cryo</td>
<td>6g Fibrinogen conc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ROTEM after 30 min</td>
</tr>
<tr>
<td>Pack B</td>
<td>4 RBC</td>
<td>4 RBC</td>
</tr>
<tr>
<td></td>
<td>2 Cryo</td>
<td>6g Fibrinogen conc</td>
</tr>
<tr>
<td></td>
<td>4 FFP</td>
<td>ROTEM after 30 min</td>
</tr>
<tr>
<td></td>
<td>1 Platelets</td>
<td></td>
</tr>
<tr>
<td>Pack C</td>
<td>Repeat pack B until lab results available</td>
<td>1 Platelets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ROTEM after 30 min</td>
</tr>
<tr>
<td>Pack D</td>
<td></td>
<td>4 RBC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 FFP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 Cryo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ROTEM after 30 min</td>
</tr>
</tbody>
</table>
AIM IS TO ESTABLISH ROTEM GUIDED ISSUE OF BLOOD PRODUCTS AS EARLY AS POSSIBLE
Case 1

Polytrauma Code Red

Pack A Issued and given in Resus

Pack A - 4 RBC + 6g Fibrinogen

Patient taken to Theatre

• Rotem performed post Pack A

• Fibtem – A5 14 mm

• Extem – A5 37 mm

• Extem – CT 74 secs

• No further products required.
Case 2

Polytrauma Code Red

Pack A Issued and given in Resus
Baseline ROTEM showed the need for Fibrinogen

ROTEM repeated
1 Pool Platelets given.

ROTEM repeated
No further products required.
Case 3
Code Red Trauma

Given in Resus;

Pack A – 4 RBC + 6g Fibrinogen
Pack B – 4 RBC + 6g Fibrinogen
Pack C – Platelets

Then ROTEM guidance used

• ROTEM 1 – Give 3 Cryo or 6g Fibrinogen
• ROTEM 2 – Give 3 Cryo or 6g Fibrinogen
• ROTEM 3 – Give 3 Cryo or 6g Fibrinogen
• ROTEM 4 – Give FFP
• ROTEM 5 – No result – gave platelets, cryo and rVIIa.
**ROTEM Interpretation;**

Check FIBTEM A5 first if active or suspected bleeding –

Correct low fibrinogen first.

<table>
<thead>
<tr>
<th>FIBTEM A5</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>Give 3 Cryo or 6g Fibrinogen</td>
</tr>
<tr>
<td>5-9</td>
<td>Give 2 Cryo or 4g Fibrinogen</td>
</tr>
<tr>
<td>&gt;10</td>
<td>Check EXTEM</td>
</tr>
</tbody>
</table>
ROTEM STATISTICS SO FAR

Aug, Sept, Oct – 31 tests
November – 25 tests
December – 43 tests
January – 47 tests
## Evaluation of results

<table>
<thead>
<tr>
<th></th>
<th>No products</th>
<th>1 product</th>
<th>2 products</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 2018</td>
<td>9</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>December 2018</td>
<td>17</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>January 2019</td>
<td>25</td>
<td>19</td>
<td>3</td>
</tr>
</tbody>
</table>
MOVING FORWARD

Helipad open in 2019 - ? More complex cases

Increased theatre/ITU capacity

Will the ROTEM decrease our blood product usage?

Does it improve patient outcome?