POINT OF CARE COAGULATION TESTING

Dr Danny Morland
Royal Victoria Infirmary
Newcastle upon Tyne

11th October 2016
Introduction

Declarations of Interest: None
CONTENT

Introduction to POCT
Principles
Interpretation
Treatment
Literature
NUTH Experience
Point Of Care Testing (POCT)

Medical diagnostic testing at (or near) the point of care.
# POCT

## PROS
- Quick
- Convenient
- Reliable
- Efficient

## CONS
- Cost (potentially)
- Quality
- Training
- Workload
- Recording
- Risk of inappropriate decision-making
Point of Care Coagulation Testing (POCCT)

Viscoelastic properties of whole blood clot

Thromboelastography = Thromboelastometry
(TEG) (ROTEM)
Purported Benefits over Standard Tests

- Measures whole blood, not just plasma
- Looks at clot generation and propagation beyond the point of clot appearance
- Allows comment on clot ‘quality’
- Can identify fibrinolysis

FAST – potential information on clotting status within 5 mins of test starting
# POCCT vs Standard Lab Tests

<table>
<thead>
<tr>
<th>POCCT</th>
<th>LAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Whole blood</td>
<td>• Highly standardised</td>
</tr>
<tr>
<td>• Clot beyond first appearance</td>
<td>• Trained, professional staff</td>
</tr>
<tr>
<td>• Clot quality</td>
<td>• Quality control</td>
</tr>
<tr>
<td>• Identify fibrinolysis</td>
<td>• Well established</td>
</tr>
<tr>
<td>• FAST</td>
<td>• Complete picture</td>
</tr>
<tr>
<td></td>
<td>• Cost</td>
</tr>
</tbody>
</table>
PRINCIPLES
Viscoelasticity
Hardware
OUTPUTS
Panel Testing – Normal results

<table>
<thead>
<tr>
<th>EXTEM</th>
<th>INTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT: 67s</td>
<td>CT: 200s</td>
</tr>
<tr>
<td>CFR: 54mm</td>
<td>CFR: 54mm</td>
</tr>
<tr>
<td>CFT: 87s</td>
<td>CFT: 67s</td>
</tr>
<tr>
<td>α: 73°</td>
<td>α: 77°</td>
</tr>
<tr>
<td>MCF: 57mm</td>
<td>MCF: 61mm</td>
</tr>
<tr>
<td>ML: -%</td>
<td>ML: -%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIBTEM</th>
<th>AFTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT: 66s</td>
<td>CT: 74s</td>
</tr>
<tr>
<td>CFR: 9mm</td>
<td>CFR: 53mm</td>
</tr>
<tr>
<td>CFT: -s</td>
<td>CFT: 89s</td>
</tr>
<tr>
<td>α: 57°</td>
<td>α: 72°</td>
</tr>
<tr>
<td>MCF: 10mm</td>
<td>MCF: 61mm</td>
</tr>
<tr>
<td>ML: -%</td>
<td>ML: -%</td>
</tr>
</tbody>
</table>
INTERPRETATION
CT Clotting time
CFT Clot formation time
A5 Amplitude 5 min after CT
MCF Maximum clot firmness
ML Maximum lysis
LI30 Lysis index at 30 min
Normal

<table>
<thead>
<tr>
<th></th>
<th>EXTEM</th>
<th></th>
<th>INTEM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>67s</td>
<td>CFT</td>
<td>87s</td>
<td>α</td>
</tr>
<tr>
<td>CFR</td>
<td>54mm</td>
<td>MCF</td>
<td>57mm</td>
<td>ML</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>FIBTEM</th>
<th></th>
<th>APTEM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>66s</td>
<td>CFT</td>
<td>89s</td>
<td>α</td>
</tr>
<tr>
<td>CFR</td>
<td>9mm</td>
<td>MCF</td>
<td>61mm</td>
<td>ML</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>INTEM</th>
<th></th>
<th>FIBTEM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>200s</td>
<td>CFT</td>
<td>-s</td>
<td>α</td>
</tr>
<tr>
<td>CFR</td>
<td>54mm</td>
<td>MCF</td>
<td>61mm</td>
<td>ML</td>
</tr>
</tbody>
</table>
Low Platelets

<table>
<thead>
<tr>
<th></th>
<th>EXTEM</th>
<th>INTEM</th>
<th>FIBTEM</th>
<th>APTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT:</td>
<td>57s</td>
<td>200s</td>
<td>67s</td>
<td>52s</td>
</tr>
<tr>
<td>A10:</td>
<td>23mm</td>
<td>23mm</td>
<td>15mm</td>
<td>25mm</td>
</tr>
<tr>
<td>CFT:</td>
<td>444s</td>
<td>449s</td>
<td>&quot;s</td>
<td>398s</td>
</tr>
<tr>
<td>MCF:</td>
<td>35mm</td>
<td>32mm</td>
<td>16mm</td>
<td>35mm</td>
</tr>
<tr>
<td>ML:</td>
<td>-%</td>
<td>-%</td>
<td>-%</td>
<td>-%</td>
</tr>
<tr>
<td>α:</td>
<td>80°</td>
<td>72°</td>
<td>-°</td>
<td>80°</td>
</tr>
</tbody>
</table>
Normal

**EXTEM**
- CT: 67s
- CFT: 87s
- α: 73°
- CFR: 54mm
- MCF: 57mm
- ML: -%

**INTEM**
- CT: 200s
- CFT: 67s
- α: 77°
- CFR: 54mm
- MCF: 61mm
- ML: -%

**FIBTEM**
- CT: 66s
- CFT: -s
- α: 57°
- CFR: 9mm
- MCF: 10mm
- ML: -%

**APTEM**
- CT: 74s
- CFT: 89s
- α: 72°
- CFR: 53mm
- MCF: 61mm
- ML: -%
Hypo-fibrinogenaemia

**EXTEM**
- CT: 109s
- CFT: 263s
- α: 48°
- A10: 31 mm
- MCF: 38 mm
- ML: -%

**INTEM**
- CT: 236s
- CFT: 220s
- α: 55°
- A10: 33 mm
- MCF: 42 mm
- ML: -%

**FIBTEM**
- CT: 185s
- CFT: -s
- α: -'
- A10: 3 mm
- MCF: 3 mm
- ML: -%

**APTEM**
- CT: 98s
- CFT: 276s
- α: 46°
- A10: 31 mm
- MCF: 40 mm
- ML: -%
Heparin Effect

**EXTEM**
- CT: 67s
- CFT: 104s
- A10: 50mm
- MCF: 57mm
- ML: 0%
- α: 68°

**INTEM**
- CT: 852s
- CFT: 198s
- A10: 41mm
- MCF: 48mm
- ML: 0%
- α: 51°

**FIBTEM**
- CT: 63s
- CFT: 7s
- A10: 6mm
- MCF: 8mm
- ML: 0%
- α: -°

**HEPTEM**
- CT: 202s
- CFT: 75s
- A10: 52mm
- MCF: 58mm
- ML: 0%
- α: 76°
Normal

<table>
<thead>
<tr>
<th>EXTEM</th>
<th>INTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT: 67s</td>
<td>CT: 200s</td>
</tr>
<tr>
<td>CFT: 87s</td>
<td>CFT: 67s</td>
</tr>
<tr>
<td>α: 73°</td>
<td>α: 77°</td>
</tr>
<tr>
<td>CFR: 54mm</td>
<td>CFR: 54mm</td>
</tr>
<tr>
<td>MCF: 57mm</td>
<td>MCF: 61mm</td>
</tr>
<tr>
<td>ML: -%</td>
<td>ML: -%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIBTEM</th>
<th>APTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT: 66s</td>
<td>CT: 74s</td>
</tr>
<tr>
<td>CFT: -s</td>
<td>CFT: 89s</td>
</tr>
<tr>
<td>α: 57°</td>
<td>α: 72°</td>
</tr>
<tr>
<td>CFR: 9mm</td>
<td>CFR: 53mm</td>
</tr>
<tr>
<td>MCF: 10mm</td>
<td>MCF: 61mm</td>
</tr>
<tr>
<td>ML: -%</td>
<td>ML: -%</td>
</tr>
</tbody>
</table>
TREATMENT
LIMITATIONS AND WARNINGS

• Treatment should be administered according to the clinical picture (e.g. volume & current rate of blood loss)

• Viscoelastic devices are not uniformly sensitive to all disturbances of coagulation status
  • e.g. platelet dysfunction, antiplatelets, LMWHs, warfarin, DOACs

• Pre-existing local protocols should be respected, given current level of evidence for POCCT devices.
Where is it useful?

• Perioperative
  • Livers, cardiac, unanticipated bleeding

• Trauma
  • Pre- and in-theatre

• Obstetrics
  • PPH

• ITU
Algorithms
Quick ROTEM Results Guide

**FIBTEM**
- **NORMAL** (MCF > 9 mm)
  - EXTEm CT prolonged (> 60s)
    - Low Coag Factors
      - Consider FFP / Prothrombinex
  - EXTEm MCF low (≤ 50 mm)
    - Impaired Platelet Function
      - Consider Platelets

**FIBTEM**
- **LOW** (MCF ≤ 9 mm)
  - EXTEm MCF low (≤ 50 mm)
    - Low fibrinogen
      - Consider Cryoprecipitate
  - EXTEm MCF low (≤ 10 mm)

**INTEM**
- CT prolonged (> 325 s)
  - HEPTEM CT normal (< 245 s)
    - Heparin Effect: Give more PROTAMINE

**ROTEM Limitations:**
- Not sensitive to effect of platelet inhibitors (e.g., Aspirin, Clopidogrel)
- Does not assess Von Willebrand Factor
- Poor sensitivity to LMWH and Warfarin
Algorithms
Algorithms

KEMH ROTEM algorithm for the obstetric patient
For management of obstetric haemorrhage (bleeding in the 2nd and 3rd trimester)
Only treat abnormal values if active bleeding or at high risk of bleeding
Avoid hypothermia, hypovolaemia, acidosis, severe anemia

<table>
<thead>
<tr>
<th>ABNORMAL ROTEM</th>
<th>CRITERIA</th>
<th>DIAGNOSIS</th>
<th>INTERVENTION</th>
<th>CORRECTED ROTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIBTEM A5 ≤12mm?</td>
<td>Low fibrinogen</td>
<td>Cryoprecipitate OR fibrinogen concentrate (see fibrinogen dosing guide overview)</td>
<td>Consider tranexamic acid 1g IV</td>
<td></td>
</tr>
<tr>
<td>EXTENTS A5 ≤35mm OR FIBTEM CT ≤50s (flat)?</td>
<td>Early indication of a high likelihood of excess fibrinolysis</td>
<td>Consider tranexamic acid 1g IV (if not already given)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTENTS ML ≤5% within 60 minutes OR FIBTEM ML ≤19%?</td>
<td>Excess fibrinolysis</td>
<td>Tranexamic acid 1g IV (if not already given)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTENTS A5 ≤35mm BUT FIBTEM A5 ≤12mm?</td>
<td>Low platelets</td>
<td>Correlate with platelet count Platelets: 1 adult dose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTENTS A5 ≤35mm AND FIBTEM A5 ≤12mm?</td>
<td>Low platelets AND Low fibrinogen</td>
<td>Correlate with platelet count Platelets AND fibrinogen as above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTENTS CT &gt;80s BUT FIBTEM A5 ≥12mm?</td>
<td>Low coagulation factors</td>
<td>FFP: 1-2U OR Protrombax 12.5U/kg (to nearest 50U)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTENTS CT 80-140s AND FIBTEM A5 ≤12mm?</td>
<td>Low fibrinogen and possibly low coagulation factors</td>
<td>Correct fibrinogen and reassess</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTENTS CT &gt;140s AND FIBTEM A5 ≤12mm?</td>
<td>Low fibrinogen AND Low coagulation factors</td>
<td>Correct fibrinogen AND factors and reassess</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Repeat ROTEM 10 minutes after intervention to assess response

Endorsed by the Department of Anaesthesia and Pain Medicine and the Hospital Transfusion Committee on September 9th 2015
LITERATURE
Detecting, managing and monitoring haemostasis: viscoelastometric point-of-care testing (ROTEM, TEG and Sonoclot systems) (DG13)

1 Recommendations

Cardiac surgery

1.1 The ROTEM system and the TEG system are recommended to help detect, manage and monitor haemostasis during and after cardiac surgery.

1.2 The Sonoclot system is only recommended for use in research to help detect, manage and monitor haemostasis during and after cardiac surgery. Research is recommended into the clinical benefits and cost effectiveness of using the Sonoclot system during and after cardiac surgery (see section 7.1).

1.3 Healthcare professionals using the ROTEM system and the TEG system during cardiac surgery should have appropriate training and experience with these devices.

Emergency control of bleeding

1.4 There is currently insufficient evidence to recommend the routine adoption of viscoelastometric point-of-care testing (ROTEM, TEG and Sonoclot systems) in the NHS to help detect, manage and monitor haemostasis in the emergency control of bleeding after trauma and during postpartum haemorrhage. Research is recommended into the clinical benefits and cost effectiveness of using viscoelastometric point-of-care testing to help in the emergency control of bleeding after trauma or during postpartum haemorrhage (see section 7.2).
Hunt H, Stanworth S, Curry N, Woolley T, Cooper C, Ukoumunne O, Zhelev Z, Hyde C.
Thromboelastography (TEG) and rotational thromboelastometry (ROTEM) for trauma induced coagulopathy in adult trauma patients with bleeding.
*Cochrane Database of Systematic Reviews* 2015, Issue 2. Art. No.: CD010438.
DOI: 10.1002/14651858.CD010438.pub2.

www.cochranelibrary.com

**Objectives**
The objective was to determine the diagnostic accuracy of thromboelastography (TEG) and rotational thromboelastometry (ROTEM) for TIC in adult trauma patients with bleeding, using a reference standard of prothrombin time ratio and/or the international normalized ratio.

**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.
Wikkelsø A, Wetterslev J, Møller AM, Afshari A.
Thromboelastography (TEG) or thromboelastometry (ROTEM) to monitor haemostatic treatment versus usual care in adults or children with bleeding.

DOI: 10.1002/14651858.CD007871.pub3.

www.cochranelibrary.com

**Objectives**

We assessed the benefits and harms of thromboelastography (TEG)-guided or thromboelastometry (ROTEM)-guided transfusion in adults and children with bleeding. We looked at various outcomes, such as overall mortality and bleeding events, conducted subgroup and sensitivity analyses, examined the role of bias, and applied trial sequential analyses (TSAs) to examine the amount of evidence gathered so far.

**Selection criteria**

We included all RCTs, irrespective of blinding or language, that compared transfusion guided by TEG or ROTEM to transfusion guided by clinical judgement, guided by standard laboratory tests, or a combination. We also included interventional algorithms including both TEG or ROTEM in combination with standard laboratory tests or other devices. The primary analysis included trials on TEG or ROTEM versus any comparator.

**Authors’ conclusions**

There is growing evidence that application of TEG- or ROTEM-guided transfusion strategies may reduce the need for blood products, and improve morbidity in patients with bleeding. However, these results are primarily based on trials of elective cardiac surgery involving cardiopulmonary bypass, and the level of evidence remains low. Further evaluation of TEG- or ROTEM-guided transfusion in acute settings and other patient categories in low risk of bias studies is needed.
Major trauma: assessment and initial management

Other considerations

Overall, the GDG concluded that there was not sufficient evidence of improved accuracy to currently recommend point of care testing in major trauma patients. However, the GDG did consider POC ROTEM and TEG to be potentially useful in the trauma setting. This was in light of their successful adoption in surgery and ICU settings and the limited comparability of the reference standards against which they were evaluated in the trauma studies. The GDG stated that the evidence base does not currently answer the following question: Is the use of POC coagulation testing (ROTEM and TEG) to target treatment better than using standard laboratory coagulation testing?
The 5-year TACTIC project is a multi-component study, a main focus of which is the development of European-wide clinical trial, entitled "Implementing Treatment Algorithms for the Correction of Trauma Induced Coagulopathy (TACTIC)".

**Background**

Currently, severely injured and bleeding patients are resuscitated with transfused blood products following a Massive Transfusion Protocol (MTP) in place in each hospital. A MTP aims to replace the different components found within the blood that have been lost and to assist the injured patient in making adequate blood clots to prevent further bleeding. A MTP uses conventional hospital laboratory tests of blood clotting to guide therapy.

In one quarter of bleeding trauma patients, the ability to form adequate blood clots is lost. This condition is termed Trauma Induced Coagulopathy (TIC). C4TS has been undertaking pioneering research into TIC for many years. Studies such as ACT and TACTIC are exploring the clinically significant mechanisms by which the body's inflammation and coagulation pathways are activated immediately following major trauma, with a view to improving diagnosis and treatment of TIC.

Our research to date has shown that patients with TIC have worse outcomes, but current MTPs fail to detect TIC early or correct it during major bleeding.

TACTIC is designed to find out if a rapid, detailed blood clotting test called Vasoelastic Assay (VHA) can be used to identify TIC early and to guide a MTP for that individual patient’s needs. The study will compare the outcomes of patients treated using the conventional blood transfusion strategy with the outcomes of patients treated using a personalised blood transfusion strategy guided by VHA.
CONTROVERSY


Coagulation point-of-care testing on the labour ward should be mandatory

Proposer: R. Collis
Department of Anaesthetics, University Hospital of Wales, Cardiff, UK
Original Article

Introduction of an algorithm for ROTEM-guided fibrinogen concentrate administration in major obstetric haemorrhage

S. Mallaiah,¹ P. Barclay,¹ I. Harrod,² C. Chevannes¹ and A. Bhalla²

¹ Consultant Anaesthetist, ² Specialist Trainee in Anaesthesia, Liverpool Women’s Hospital, Liverpool, UK
OUR EXPERIENCE
NUTH Experience

• Introduced POCCT end of 2014 after an evaluation period to assess feasibility, reliability and accuracy.

• Trialled TEG 5000, ROTEM Delta in theatre (POCCT), TEG and ROTEM in lab and compared with standard lab tests coag tests.

• Findings
  • Generally good concordance between POCT and lab tests
  • Higher user error for more complicated procedures
  • Sending samples to lab could introduce a delay of 50mins over POCT
NUTH algorithm

Physiological Targets:
- Temp >36°C
- pH >7.2, Base Excess < -6
- iCa >1.0, K+ <5.5
- Hb >80, Plt > 100, Fib >1.5

RVI ROTEM Treatment Algorithm

There may be > 1 clotting defect. Treat all defects simultaneously.

Patient has significant on-going bleeding?

- YES
  - EXTEM result NORMAL
    - YES
      - Continue as per Major Haemorrhage Policy
    - NO
      - ExTEM – CT > 90 sec
        - +/-
        - ExTEM – A10 <40mm
          - +/-
          - ExTEM – LI30 >5%

- NO
  - OBSERVE
  - Re assess & Repeat ROTEM

- YES
  - Give 4 FFP
  - FIBTEM A10 <10mm
    - Give 2 Unit Cryoprecipitate
  - FIBTEM A10 > 10mm
    - Give 1 Pool Platelets
  - Give Tranexamic Acid 1g bolus

NOTE – ROTEM does not reliably detect effects of:
- Warfarin
- Aspirin, Clopidogrel
- Direct Oral Anticoagulants
- LMWH
Effect of heparin should be assessed using:
- INTEM & HEPTEM tests

Use these Products to supplement NOT replace the Major Haemorrhage Packs
Replace ongoing losses + correct specific deficit = Give contents of MHP + additional products as directed by ROTEM
NUTH Experience since...

- Valuable technology, very useful addition to arsenal.
- Can be ‘transfusion-sparing’; imparts confidence that management strategy is correct.
- Speed of testing and results

**Issues**
- Training
- Regular use
- QC
- Interpretation
- IT
- Interference with MHP
When is it useful?

- To confirm that MHP is addressing specific transfusion requirements of patient (e.g. bleed then DIC)

- In cases of slow, steady transfusions that haven’t reached MHP level

- To exclude ‘anaesthetic’ bleeding

- To confirm that transfusion goals have been achieved
SUMMARY

- Viscoelastic, POCCT devices offer the prospect of rapid assessment and rational, individually tailored transfusion therapy in the management of major haemorrhage.

- Barriers remain to their effective and efficient use, and in many areas a protocolised transfusion strategy may still produce the best outcomes overall.

- Evidence of effectiveness is lacking still, but it is difficult to imagine these devices will not be more widely used in the near future.
THANK YOU