1 Introduction

ROTEM® (Rotational Thromboelastometry) is a point-of-care analyser which uses a citrated whole blood sample and analyses the viscoelastic properties of the blood as it clots. A panel of up to 4 simultaneous tests can be performed to identify clot formation and quality as well as the nature of any coagulopathy in real time. Thus it is useful in directing management of a bleeding patient in the Emergency Department, Operating Theatre and Intensive Care Department. Each test has a specific coagulation activator or inhibitor added to the sample to represent the various processes of haemostasis. The individual tests are:

**EXTEM**
- Extrinsic pathway screening test / not affected by heparin. Coagulation is activated by tissue factor (tissue thromboplastin) which leads to initiation of a clot within 70 seconds. The clot formation and quality can be assessed within 10 min

**FIBTEM**
- EXTEM with a platelet inhibitor included. When compared with EXTEM identifies the effect of fibrinogen concentration and function
APTEM
- EXTEM with aprotinin added to inhibit fibrinolysis. When compared with EXTEM confirms hyperfibrinolysis

INTEM
- Intrinsic pathway screening test/ heparin sensitive

HEPTEM
- Coagulation activated as per INTEM, with heparinise added to negate the effects of heparin. When compared to INTEM identifies heparin effect

The panel that we will be using for our trauma patients is EXTEM / INTEM / FIBTEM / APTEM. This panel assesses clotting factor deficiency, hypofibrinogenaemia, platelet dysfunction and hyperfibrinolysis.

2 Indications

ROTEM® is to be used at the discretion of the ED Consultant and only for patients with active bleeding and on whom a Trauma Respond AND Massive Transfusion Protocol (MTP) has been activated. Blood for ROTEM® is to be collected at the time that the MTP is activated. The benefit of ROTEM® will be that it will help target product replacement as part of the MTP. It has no role in patients who are not actively bleeding and for whom the MTP has not been activated.

We recognise that there is a time lag for ROTEM® results to be available (10 minutes from initiation of the test in Blood Bank), and that results may not be available until after the patient has left the ED. The same ROTEM® results will be available in real-time in theatre and in ICU. Thus it is of value to send a sample to the Blood Bank for initiation of ROTEM® as soon as practically possible (see ROTEM® Ordering below).

3 Procedure

ROTEM® ORDERING
- ROTEM® is only to be considered for a major trauma patient for which a Trauma Respond and the MTP has been activated i.e. patients with major trauma and ongoing bleeding
- ED Consultant to authorise and interpret ROTEM® testing
- Fill standard blue top coagulation tube to black arrowhead (3.5ml)
- Use pre-printed Queensland Pathology form as per below
• Send the sample and the form to blood bank and notify blood bank that it has been sent

• The results appear on the computers in Resus 3 and 4

• After 10 minutes of the test running, enough data becomes available to allow initial interpretation, the test will normally run for at least 40 mins

Stored results will not appear on Auslab until the following day

Viewing Results

The ROTEM® results will be displayed in real-time and available on the computers in Resus 3 and 4. Only one panel of 4 tests (EXTEM, FIBTEM, APTEM and INTEM), can be run at a time. One panel normally takes ~40-60 mins to complete but interpretation may commence as soon as 10 minutes (CT, A10). The results will not be available on Auslab until the following working day when they will be manually scanned into Auslab by the blood bank staff.

In the rare situation that a second panel needs to be run concomitantly, it may be possible to stop the first panel early or modify what tests of the first panel are kept running eg consider leaving EXTEM/ APTEM of first test running if hyperfibrinolysis a concern. This is not an ideal situation as it will not be possible to print out or record on Auslab separate for each patient.
To view the results:

1. Open the ROTEM® Secure Viewer (SV) on the desktop of the computer in Resus 3 or 4
2. Click to highlight “pah-rotem [10.242..6.10]” then click “GO”

3. Enter password “rotemremote” in authentication window:
A results window should appear that looks similar to this:

![Image of ROTEM results window]

Normal Values:

<table>
<thead>
<tr>
<th></th>
<th>CT Clotting Time (secs)</th>
<th>CFT Clot Formation Time (secs)</th>
<th>A10 Amplitude at 10 mins (mm)</th>
<th>A20 Amplitude at 20 mins (mm)</th>
<th>MCF Maximum Clot Firmness (mm)</th>
<th>ML Maximum Lysis (% of MCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTEM</td>
<td>38-79</td>
<td>34-159</td>
<td>43-65</td>
<td>50-71</td>
<td>50-72</td>
<td>&lt;15</td>
</tr>
<tr>
<td>FIBTEM</td>
<td>n/a</td>
<td>9-24</td>
<td>7-23</td>
<td>8-24</td>
<td>9-25</td>
<td>&lt;15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A10 or MCF &lt;9 mm – reduced fibrinogen level or impairment fibrin polymerisation</td>
<td>A10 or MCF &gt;25 mm – increased fibrinogen level</td>
<td>May lead to normal clot formation in EXTEM or INTEM in spite of thrombocytopenia</td>
<td></td>
</tr>
<tr>
<td>APTEM</td>
<td>Normalised clotting (shortened CT, higher MCF) in APTEM assay as compared to EXTEM is a sign for fibrinolysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEM</td>
<td>100-240</td>
<td>30-110</td>
<td>44-66</td>
<td>50-71</td>
<td>50-72</td>
<td>&lt;15</td>
</tr>
<tr>
<td>HEPTEM</td>
<td>100-240</td>
<td></td>
<td>Normalised CT in HEPTEM compared to INTEM is indicative to a heparin effect</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Management

Only treat abnormal results if clinically significant bleeding.
Consider repeating ROTEM® after intervention.

<table>
<thead>
<tr>
<th>Result</th>
<th>Cause</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prolonged Clotting Time (CT)</strong></td>
<td><strong>EXTEM-CT &gt;90 secs &amp; APTEM-CT &gt;90 secs</strong></td>
<td>Low coagulation factors</td>
</tr>
<tr>
<td></td>
<td><strong>EXTEM-CT &gt;90 secs &amp; APTEM-CT &lt;90 secs</strong></td>
<td>Hyperfibrinolysis</td>
</tr>
<tr>
<td><strong>Low A10</strong></td>
<td><strong>EXTEM-A10 ≤40 mm &amp; FIBTEM-A10 ≤9 mm</strong></td>
<td>Low Fibrinogen or poor platelet contribution</td>
</tr>
<tr>
<td></td>
<td><strong>EXTEM-A10 &gt;40 mm &amp; FIBTEM-A10 ≤9 mm</strong></td>
<td>Low fibrinogen</td>
</tr>
<tr>
<td></td>
<td><strong>EXTEM-A10 ≤40 mm &amp; FIBTEM-A10 &gt;9 mm</strong></td>
<td>Poor platelet contribution</td>
</tr>
<tr>
<td></td>
<td><strong>EXTEM-A10 ≤40 mm &amp; APTEM-A10 ≥40 mm</strong></td>
<td>Hyperfibrinolysis</td>
</tr>
<tr>
<td><strong>High Maximal Lysis (ML)</strong></td>
<td><strong>EXTEM-ML &gt;15% &amp; APTEM-ML &lt;15%</strong></td>
<td>Hyperfibrinolysis</td>
</tr>
<tr>
<td></td>
<td><strong>Fibrinolysis &lt;20mins</strong></td>
<td>Fulminant fibrinolysis</td>
</tr>
<tr>
<td></td>
<td><strong>Fibrinolysis 20-40 mins</strong></td>
<td>Early fibrinolysis</td>
</tr>
<tr>
<td></td>
<td><strong>Fibrinolysis &gt;40 mins</strong></td>
<td>Clot retraction or late fibrinolysis</td>
</tr>
<tr>
<td><strong>Ongoing Bleeding</strong></td>
<td><strong>EXTEM-CT &lt;80 secs &amp; EXTEM A10 &gt;50 mm &amp; FIBTEM A10 &gt;15 mm</strong></td>
<td>Surgical bleeding</td>
</tr>
</tbody>
</table>
Limitations

Platelet Inhibitors:
- No detection of aspirin / clopidogrel / other anti-platelet effects
- No detection of von Willebrand Syndrome

Anticoagulants:
- Poor sensitivity to low molecular weight heparins
- Poor sensitivity to oral anticoagulants (warfarin, Dabigatran, Rivaroxiban)

4 Additional Information

Test Results

Parameters for all tests:

**CT (Clotting Time):** time from start of measurement until initiation of clotting
Reflects: initiation of clotting, thrombin formation, start of clot polymerisation

**CFT (Clot Formation Time):** time from initiation of clotting until a clot firmness of 20 mm is detected
Reflects: fibrin polymerisation, stabilisation of the clot with thrombocytes, fibrinogen and FXIII
α angle (alpha angle): rate of initial fibrin polymerisation

MCF (Maximum Clot Firmness): measure of clot quality and strength
Reflects: increasing stabilisation of the clot by the polymerised fibrin, thrombocytes as well as FXIII

A10 (Amplitude at 10 minutes): early measure of clot quality and strength (10 min after Clotting Time). A10 correlates well with subsequent A20 result in studies.

A20 (Amplitude at 20 minutes): later measure of clot quality and strength (20 min after Clotting Time)

ML (Maximum Lysis): percentage reduction of the clot firmness after MCF in relation to MCF
Reflects: stability of the clot. ML<15% represents a stable clot and ML>15% within 1h represents premature clot breakdown by fibrinolysis.

Tests:

EXTEM
- Prolonged EXTEM-CT represents factor deficiency in extrinsic clotting pathway
- EXTEM-CT is not affected by heparin
- Low EXTEM-A10 and prolonged EXTEM-CFT reflects low fibrinogen and / or low platelets and / or poor platelet function

FIBTEM
- Low FIBTEM-A10 reflects low fibrinogen concentration

APTEM
- Normalisation of APTEM-ML to <15% compared to an elevated EXTEM-ML >15% reflects hyperfibrinolysis

INTEM
- Prolonged INTEM-CT represents heparin effect and / or clotting factor deficiency in intrinsic clotting pathway (clotting factor deficiency in the trauma population we will be testing)
- Low INTEM-A10 and prolonged INTEM-CT reflects low fibrinogen and / or platelets and / or poor platelet function
HEPTEM (For completeness, we will not be using this test in our trauma panel)

- Assesses heparin effect
- If HEPTEM-CT normalises compared to INTEM-CT this represents a heparin effect
- If HEPTEM-CT does NOT shorten compared to INTEM-CT this represents an intrinsic factor deficiency or protamine effect

5 Further Reading / References

- ROTEM® Analysis Targeted Treatment of Acute Haemostatic Disorders. Andreas Calatzis, Michael Spannagl, Matthias Vorweg. 2009
- Tauber H et al. Prevalence and impact of abnormal ROTEM assays in severe blunt trauma: results of the Diagnosis and Treatment of Trauma-Induced Coagulopathy (DIA-TRE-TIC) study. BJA. 2011; 107(3); 378-87
6 Appendix

PAH ED ROTEM Algorithm

Indication: clinically significant bleeding

Optimise
- $T > 36^\circ C$
- $pH > 7.2$
- $iCa > 1.0 \text{ mmol/L}$
- $Hb > 7 g/dL$
- $Plt > 75$

ROTEM RESULT → INTERPRETATION → MANAGEMENT

Do not treat unless clinically significant bleeding

- **EXTEM-CT > 90 sec or APTEM-CT > 90 sec**
  - Low Coagulation Factors
  - **FFP**

- **EXTEM CT > 90 sec & APTEM CT < 90 sec**
  - Hyperfibrinolysis
  - **Tranexamic Acid**

- **EXTEM A10 ≤ 40 mm & FIBTEM A10 ≤ 9 mm**
  - Low Fibrinogen
  - **Cryoprecipitate ? Platelets**

- **EXTEM A10 ≤ 40 mm & FIBTEM A10 > 9 mm**
  - Poor Platelet contributions
  - **Platelets ?ddAVP**

- **EXTEM ML > 15% & APTEM ML < 15%**
  - Hyperfibrinolysis
  - **Tranexamic Acid**

- **EXTEM CT < 80 mm & A10 EXTEM > 50 mm & A10 FIBTEM > 15**
  - Ongoing Bleeding
  - Consider Surgical Haemostasis

Repeat ROTEM test 10 mins after treatment