TEG in TRAUMA

Kerry Gunn
Department of Anaesthesia and Perioperative Medicine
Auckland City Hospital

Auckland District Health Board
A small proportion (4%) need an aggressive approach to transfusion.

Systems that include fibrinogen substrates seem to improve outcome.

The challenge is to develop systems that deliver fibrinogen rapidly enough to these patients.

TEG then can help us direct fibrinogen and drugs to the patients that need it.

Unless we include POC monitoring of coagulopathy we risk replacing exsanguination with thrombosis.
No Transfusion

10 units RBC in 4 hrs

Focused Tx

10 units RBC in 24 hrs

DCR
Table 1. Investigations to be performed during massive transfusions

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Target value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemoglobin; haematocrit</td>
<td>10 g/dl; 0.32</td>
</tr>
<tr>
<td>Platelet count</td>
<td>&gt; 50 × 10⁹/l</td>
</tr>
<tr>
<td>Prothrombin time</td>
<td>&lt; 1.5 × control</td>
</tr>
<tr>
<td>Partial thromboplastin time</td>
<td>&lt; 1.5 × control</td>
</tr>
<tr>
<td>Fibrinogen</td>
<td>&gt; 0.8 g/l</td>
</tr>
</tbody>
</table>

BSCH guidelines for massive transfusion 1998
Thromboelastography

- measures viscoelastic properties
- incorporates input from clotting, platelets and fibrinolysis
- dynamic
- rapid results
Schematic Diagram of Normal Thromboelastography Tracing
Platelet Dysfunction

TEG Monitoring Program - Detail of Completed Channel 1

Time On: 12:38:00 pm  Date: Thu Mar 23, 2006  Time Off: 1:35:58 pm

Patient Name:  Patient Number: ON PUMP

Sample Type: Celite-Activated Whole Blood

TEG Index: -5.91
Normal Range: -2.0 to +2.0

10 mm scale
SP (mm) R (mm) K (mm) MA (mm) Ang (deg) LY30 (%) LY60 (%)
P: 13.5 14.5 10.0 39.0 49.0
NR: 10-14 3-6 59-68 54-67

ENTER to exit, F6 prints large, F7 prints small, LEFT or RIGHT to scroll
After Platelet Transfusion

TEG MONITORING PROGRAM - DETAIL OF COMPLETED CHANNEL 6 (1)

Time On: 3:02:04 pm  Date: Thu Mar 23, 2011  Time Off: 4:16:37 pm
Patient Name: ____________  Patient Number: VITH PLT
Sample Type: Celite-Activated Whole Blood

TEG Index: +3.21
Normal Range: -2.0 to +2.0

<table>
<thead>
<tr>
<th>10 mm</th>
<th>SP (mm)</th>
<th>R (mm)</th>
<th>K (mm)</th>
<th>MA (mm)</th>
<th>Ang (deg)</th>
<th>LY30 (%)</th>
<th>LY60 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>scale</td>
<td>Pt: 7.5</td>
<td>8.5</td>
<td>2.5</td>
<td>72.0</td>
<td>71.5</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NR: 10-14</td>
<td>3-6</td>
<td>59-68</td>
<td>54-67</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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APPARATUS

Point-of-care testing Measurement of coagulation

J. Hirsch, T. Wendt, P. Kuhly and W. Schaffartzik

1. Senior House
2. Department of Anaesthesia
3. Free University

Can RapidTEG Accelerate the Search for Coagulopathies in the Patient With Multiple Injuries?

Victor Jeger, MS, Heinz Zimmermann, MD, and Aristomenis E. Eustathopoulos, MD

Hypothesis: Early recognition of coagulopathy may improve the care of patients with multiple injuries. Rapid thromboelastography (RapidTEG) is a novel variant of thromboelastography (TEG), in which coagulation is initiated by the addition of z-methacholine. The time of coagulation and the time of measurement were compared for two variants of TEG RapidTEG and conventional TEG, in which coagulation is initiated with kaolin. The measurements were performed on blood samples from 10 patients with multiple injuries. The RapidTEG results were also compared with conventional measurements of blood coagulation. The mean time for the RapidTEG test was 19.2 ± 3.1 minutes (mean ± SD), in comparison with 28.9 ± 3.3 minutes for kaolin TEG and 34.1 ± 14.3 minutes for conventional coagulation tests. The mean time for the RapidTEG test was 30.8 ± 7.7 minutes, in comparison with 41.2 ± 6.6 minutes for kaolin TEG and 64.9 ± 18.8 for conventional coagulation tests—measured from admission of the patient to the resuscitation bay until the results were available. There were significant correlations between the RapidTEG results and those from kaolin TEG and conventional coagulation tests. RapidTEG is the most rapid available test for providing reliable information on coagulopathy in patients with multiple injuries. This has implications for improving patient care.

Keywords: Thromboelastography, Traumatic coagulopathy, Multiple injuries, z-methacholine.


Linda Shore-Lessers
Sanjeet Francis, BSc,
Departments of *Anaesthesia

T. C. Collyer+, D. J. Gray, R. Sandhu, J. Berridge and G. Lyons

1. Academic Unit of Anaesthesia, Royal Perth Hospital, Perth, Australia. 2. Department of Anaesthesia, St James's University Hospital, Leeds, UK. 3. Department of Anaesthesia, Leeds General Infirmary, Leeds, UK.

*Corresponding author. E-mail: tomcollyer@doctors.org.uk

HEAD-TO-HEAD

The TEG® vs the ROTEM® th thromboelastometry systems

G. N. B. Jackson, K. J. Ashpole and S. M. Yentis

1. Fellow 2. Lecturer Consultant, 3. Consultant, St George’s Hospital, London, UK

Does Thromboelastography Predict Postoperative Thromboembolic Events? A Systematic Review of the Literature

Yue Dai, MB, MSc
Anna Lee, PhD
Lester A. H. Critchley, MD
Paul F. White, PhD, MD

BACKGROUND: Since thromboelastography (TEG) can detect hypercoagulable states, it is a potentially useful test for predicting postoperative thromboembolic complications. Therefore, we performed a systematic review of the literature to evaluate the accuracy of TEG in predicting postoperative thromboembolic events. METHODS: PUBMED and EMBASE electronic databases were searched by two independent investigators to identify prospective studies involving adult patients undergoing operative procedures in which a TEG test was performed perioperatively and outcomes were measured by reference standards. The quality of included studies was assessed and measures of diagnostic test accuracy were...
Does TEG predict these coagulation changes in haemorrhagic and shocked trauma patients?
Table 6: Prediction of transfusion by CCT, Rapid TEG*, and Kaolin TEG*.

<table>
<thead>
<tr>
<th></th>
<th>Cut-offs</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single indicator</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INR</td>
<td>&gt;1.2</td>
<td>38%</td>
<td>88%</td>
<td>57%</td>
<td>77%</td>
<td>73%</td>
</tr>
<tr>
<td>INR</td>
<td>&gt;1.5</td>
<td>19%</td>
<td>96%</td>
<td>67%</td>
<td>74%</td>
<td>73%</td>
</tr>
<tr>
<td>aPTT (sec)</td>
<td>&gt;60.0</td>
<td>5%</td>
<td>98%</td>
<td>50%</td>
<td>69%</td>
<td>74%</td>
</tr>
<tr>
<td>Fibrinogen (g/L)</td>
<td>&lt;3.0</td>
<td>90%</td>
<td>48%</td>
<td>43%</td>
<td>92%</td>
<td>74%</td>
</tr>
<tr>
<td>Thrombin time [sec]</td>
<td>&gt;13.2</td>
<td>48%</td>
<td>73%</td>
<td>45%</td>
<td>75%</td>
<td>53%</td>
</tr>
<tr>
<td>Rapid K (min)</td>
<td>&gt;1.8</td>
<td>68%</td>
<td>78%</td>
<td>61%</td>
<td>83%</td>
<td>79%</td>
</tr>
<tr>
<td>Kaolin K (min)</td>
<td>&gt;1.7</td>
<td>68%</td>
<td>59%</td>
<td>46%</td>
<td>78%</td>
<td>67%</td>
</tr>
<tr>
<td>Rapid α-Angle (deg)</td>
<td>&lt;74.7</td>
<td>84%</td>
<td>57%</td>
<td>49%</td>
<td>88%</td>
<td>77%</td>
</tr>
<tr>
<td>Kaolin α-Angle (deg)</td>
<td>&lt;58.5</td>
<td>72%</td>
<td>61%</td>
<td>47%</td>
<td>82%</td>
<td>66%</td>
</tr>
<tr>
<td>Rapid MA (mm)</td>
<td>&lt;59.6</td>
<td>68%</td>
<td>80%</td>
<td>63%</td>
<td>83%</td>
<td>75%</td>
</tr>
<tr>
<td>Kaolin MA (mm)</td>
<td>&lt;58.4</td>
<td>56%</td>
<td>88%</td>
<td>70%</td>
<td>80%</td>
<td>70%</td>
</tr>
<tr>
<td>Rapid TMA (min)</td>
<td>&gt;17.3</td>
<td>76%</td>
<td>57%</td>
<td>46%</td>
<td>83%</td>
<td>69%</td>
</tr>
<tr>
<td>Kaolin TMA (min)</td>
<td>&gt;24.7</td>
<td>64%</td>
<td>63%</td>
<td>46%</td>
<td>78%</td>
<td>58%</td>
</tr>
<tr>
<td>Rapid G (d/sc)</td>
<td>&lt;7374</td>
<td>68%</td>
<td>78%</td>
<td>61%</td>
<td>83%</td>
<td>73%</td>
</tr>
<tr>
<td>Kaolin G (d/sc)</td>
<td>&lt;7073</td>
<td>56%</td>
<td>88%</td>
<td>70%</td>
<td>80%</td>
<td>70%</td>
</tr>
</tbody>
</table>

|                |          |             |             |     |     |     |
| Combined indicators |          |             |             |     |     |     |
| α-Angle + Heart Rate | Rapid α-Angle (deg) | <75 | 84% | 75% | 62% | 90% |
| Heart Rate (bpm)  | >75      |             |             |     |     |     |
| α-Angle + Hct     | Rapid α-Angle (deg) | <75 | 88% | 73% | 61% | 93% |
| Hct (%)           | <41      |             |             |     |     |     |

*Cut-offs determined by the data.

Jeger et al Scientific World Journal 2012 p 821794
Can the TEG explain the coagulation changes in haemorrhagic and shocked trauma patients?
Trauma Induced Coagulopathy

- Usually has an adequate Thrombin burst
- Fibrinogen levels are reduced
- Fibrin laydown and cross-bridging is impaired
- Fibrinolysis is increased
Can TEG **direct** product treatment in haemorrhagic and shocked trauma patients?
Most of the benefit in TEG in improving blood management outside trauma is in

- **Stopping** blood product use when it isn’t required
- **Targeting** specific product use when a defect exists (as opposed to a reduced conc of something)
ADHB Adult Massive Transfusion Protocol (MTP)

Massive bleeding with either shock or abnormal coagulopathy

Ensure delivery of X-match specimen to Blood Bank

Give 3 Units O-neg or type specific RBC

Ring Blood Bank to Activate Massive Transfusion Protocol

REQUEST, DELIVER AND TRANSFUSE AS BELOW:

TXA 1G

MTP BOX ONE
2 Whole Blood or 2U RBC and 2U FFP

MTP BOX TWO
4 RBC
4 FFP
1 adult Platelets

MTP BOX THREE
4 RBC
4 FFP
+ 3U Cryoprecipitate

MTP BOX FOUR
4 RBC
4 FFP
1 adult Platelets

and alternate 3 & 4...

Check Coags / Platelets / FBC ABGs/TEG/ Ca**

Check Coags / Platelets / FBC ABGs / TEG / Ca**

Repeat every 30 min

Check Coags / Platelets / FBC ABGs/TEG/ Ca**
## The place of TEG?

### Appendix 1: Thrombelastography (TEG) treatment algorithm for patients with ongoing bleeding

<table>
<thead>
<tr>
<th>TEG Parameter</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>R 11–14 min</td>
<td>$2 \times$ FFP or 10 ml/kg</td>
</tr>
<tr>
<td>R &gt; 14 min</td>
<td>$4 \times$ FFP or 20 ml/kg</td>
</tr>
<tr>
<td>MA 45–50 mm</td>
<td>1 platelet concentrate</td>
</tr>
<tr>
<td>MA &lt; 45 mm</td>
<td>2 platelet concentrates</td>
</tr>
<tr>
<td>Angle &lt; 52</td>
<td>$2 \times$ FFP or fibrinogen</td>
</tr>
<tr>
<td>Ly30 &gt; 8%</td>
<td>Antifibrinolytics</td>
</tr>
</tbody>
</table>

R: R-time, minutes; MA: maximum amplitude; Ly30: lysis in percent 30 min after MA is reached; FFP: fresh-frozen plasma.

One platelet concentrate pooled from the buffy-coat from four donors.

---

Johanson Vox Sanguinis 96 111-118
<table>
<thead>
<tr>
<th>TEG parameter*</th>
<th>Coagulopathy</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>R &gt; 10 min</td>
<td>Coagulation factors ↓</td>
<td>FFP 10–20 ml/kg (if FFP is without clinical efficacy, consider cryoprecipitate 3–5 ml/kg)</td>
</tr>
<tr>
<td>Angle &lt; 52 °</td>
<td>Hypofibrinogenemia?</td>
<td>→ Functional Fibrinogen (FF) analysis</td>
</tr>
<tr>
<td>MA &lt; 49 mm and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MA&lt;sub&gt;FF&lt;/sub&gt; &lt; 14 mm</td>
<td>Fibrinogen ↓</td>
<td>FFP 20–30 ml/kg /</td>
</tr>
<tr>
<td>Fibrinogen konc. 25–50 mg/kg /</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cryoprecipitate 5 ml/kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MA &lt; 49 mm and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MA&lt;sub&gt;FF&lt;/sub&gt; &gt; 14 mm</td>
<td>Platelets ↓</td>
<td>Platelets 5–10 ml/kg</td>
</tr>
<tr>
<td>Ly30 &gt; 8%</td>
<td>Primary hyperfibrinolysis</td>
<td>Tranexamic acid 1–2 g IV (adults)</td>
</tr>
<tr>
<td>Children 10–20 mg/kg IV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ly30 &gt; 8% and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle and/or MA ↑↑</td>
<td>Reactive hyperfibrinolysis</td>
<td>Tranexamic acid contraindicated</td>
</tr>
<tr>
<td>Difference in R &gt; 2 min between st-TEG and hep-TEG</td>
<td>Heparinization</td>
<td>Protamine sulphate or FFP 20–30 ml/kg</td>
</tr>
</tbody>
</table>

R, Reaction time; Angle, α-angle; MA, Maximum amplitude; MA<sub>FF</sub>, Maximum amplitude by Functional Fibrinogen* analysis; Ly30, Lysis after 30 min; st-TEG, standard TEG; hep-TEG, heparinase TEG.

*Reference values (Haemonetics Corp.): R 3–8 min, Angle 55–78 °, MA 51–69 mm, Ly30 0–8%, MA<sub>FF</sub>=14–24 mm.
Goal-directed coagulation management of major trauma patients using thromboelastometry (ROTEM®)-guided administration of fibrinogen concentrate and prothrombin complex concentrate

Herbert Schöchl1,2, Ulrike Nienaber3, Georg Hofer4, Wolfgang Voelckel1, Csilla Jambor4, Gisela Scharbert5, Sibylle Kozek-Langenecker5 and Cristina Solomon*6

- Trauma patients receiving >5 units RBCs
- fibTEM guided therapy if <10mm
- 131 patients
- 128 received fibrinogen, 98 patient received PCC
Algorithm for immediate effective therapy of trauma-induced coagulopathy as advocated by the authors and implemented at the University Hospital Innsbruck, Austria.

- Clinical evaluation
  - Insert lines
  - ROTEM, BGA
  - RBC type and screen
  - Warming

- Age < 50 years
  - Polytrauma
  - Bleeding
  - Poor capillary refill
  - Pallor conjunctiva

- Fibrinogen deficiency and coagulopathy most likely
  - Order 5 U RBCs (O neg.)
  - Announce need for platelets

- ROTEM
  - BGA
  - ROTEM

- Fibtem = 0
  - TXA 20–50 mg/kg

- FIB A$_5$ < 5
- Hb ≤ 10
- BD > 6
- pH < 7.2
- CTEX > 90

- Fibrinogen 50 mg/kg
- RL or balanced solution
- Gelatin solution, 2–4 U RBCs
- Avoid 0.9% NaCl, HES
- Treat acidosis and hypothermia
- PCC 30 IU/kg and FXIII 30 IU/kg

- Bleeding or ongoing surgery and A20$_{Ex}$ declining (>10%) A20$_{AP}$ constant
- FIB$_{A20}$ < 10
- A$_{20}$ < 40

- TXA 20–50 mg/kg
- Fibrinogen 50 mg/kg

- Platelets

- Re-evaluate ROTEM, BGA

HES, hydroxyethyl starch solutions; RBC, red blood cell.
Electron microscopic scan of a ×2000 magnified blood clot.

- fibTEM > 10mm
- Fibrinogen > 1.5-2.0 g/L

undiluted

65% haemodiluted

Post fibrinogen administration
Fibrinolysis on a TEG?
TEG before TXA

![Graph showing TEG results before TXA intervention.](image-url)
TEG 30 mins after TXA 1G
Summary

- TEG is a more intuitive coagulation test for replacement of factors in bleeding
- It has the potential to focus on better prediction of TIC
- It has the potential to increase our understanding of TIC
- It may be the tool to move us to MTP 2.0