Thromboelastography – Introduction into a trauma service: benefits and evidence

Dr Dan Ellis

FACEM, FCICM, FCEM, FIMC & DRTM (RCSEd), FFICM, FRCS(Eng), MRCP, MRCA, DMCC, GCertCU

Acting Director of Trauma, Royal Adelaide Hospital

Retrieval Consultant, MedSTAR

SA Ambulance Service

Government of South Australia

SA Health

medSTAR Emergency Medical Retrieval


DANGER
HIGH VOLTAGE
DANGER
DANGER
NOT ONLY WILL
THIS KILL YOU
IT WILL HURT
THE WHOLE TIME
YOU'RE DYING

Objectives

- What is it…?
- Do I need it?
- How do I get it?
- What else do I need?
- Prove its easy to interpret…..
  - +/- cases (time..!)

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

Key points

- This is not hard:
  - To acquire
  - To use
  - To interpret
- It does not take a long time
- It has the potential:
  - To improve trauma care
  - Reduce blood/product use
  - Save money….

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

Real questions….?

- The Thromboelastogram:
- Is it a standard of care in trauma centres?
- Should it be an ED test?

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

The Technology

- Viscoelastic Haemostatic Assays
- The technology is not new
- Based on classical Thromboelastography
- First described in 1948 by Hartert
- ROTEM or TEG
  - Same process, different labels, similar consequences
- Give information on:
  - **Clot Formation**
  - **Clot Strength**
  - **Clot Lysis**

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

ROTEM or TEG?

- Don’t ask the rep….
- TEG – American
- ROTEM – German

- Bottom line
  - Either will do.

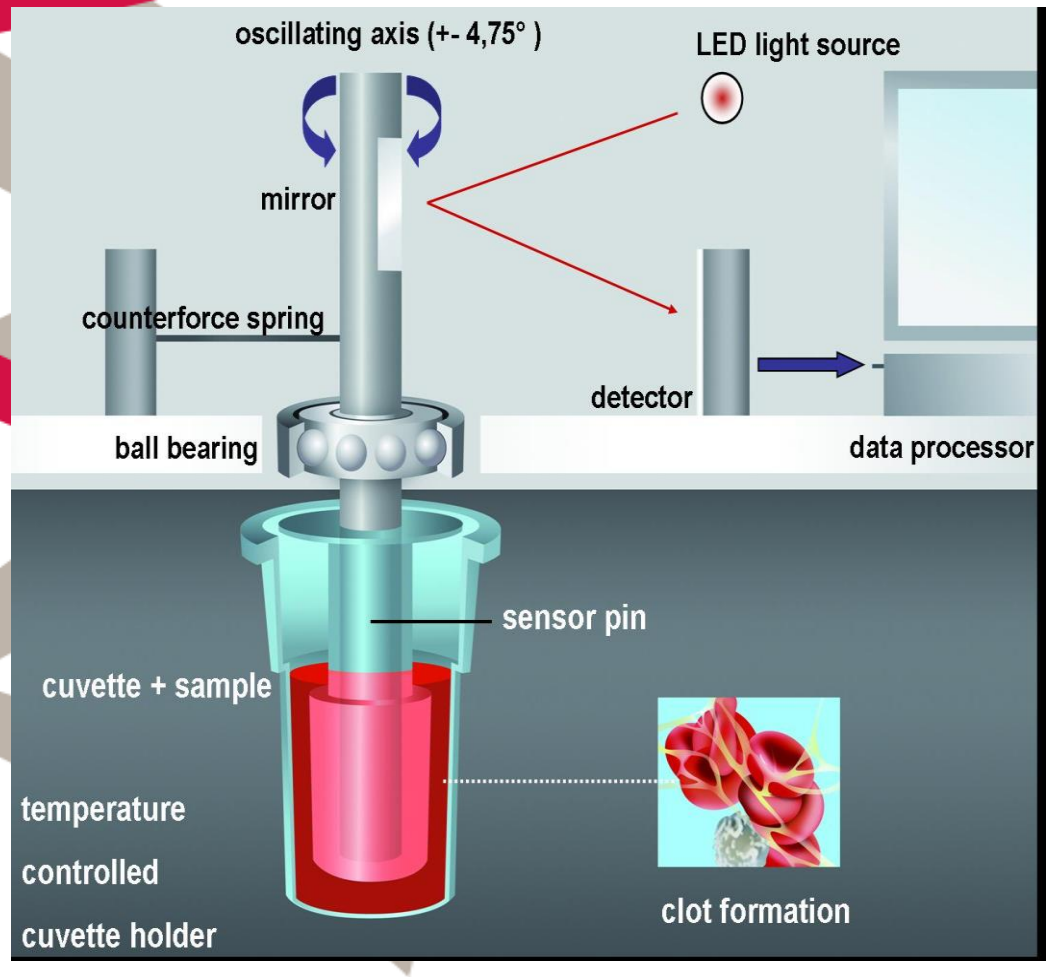
- We have a ROTEM
  - No conflict of interest

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

The design is simple



ROTEM® Thromboelastometry - technology

How thick & sticky the clot is

Ambulance Service

SA Health

medSTAR Emergency Medical Retrieval

When to use ROTEM

Active Haemorrhage

- Trauma
- Massive hemorrhage
- Obstetric hemorrhage
- Acquired coagulation disorders
- Cardiac and vascular surgery
- Bleeding patient

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

When NOT to use ROTEM

- Monitoring therapeutic effects of antithrombotic Tx
  - antiplatelet agents: clopidogrel, aspirin, prasugrel
  - Direct Oral Anticoagulants (DOAC):
    - Dabigatran, Rivaroxaban, Apixaban
    - ROTEM will detect the presence, but not the anticoagulant dosage effects, of these drugs
- ROTEM can be used in patients who are actively bleeding and on warfarin or heparin
  - HEPTEM can evaluate heparin effect
  - ROTEM is NOT for therapeutic monitoring of either warfarin or heparin

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

JNS SPINE

Rotational thromboelastometry–guided blo management in major spine surgery

Bhiken I. Naik, MBBCh,[1,2] Thomas N. Pajewski, MD, PhD,[1,2] David L. Bog
Zhiyi Zuo, MD, PhD,[1,2] Pamela Clark, MD, JD,[3] Abdullah S. Terkawi, MD,[1]
Marcel E. Durieux, MD, PhD,[1,2] Christopher I. Shaffrey, MD,[2] and Edward

Departments of [1]Anesthesiology, [2]Neurosurgery, and [3]Pathology, University of Virginia, Charlo

CONCLUSIONS In major spine surgery, ROTEM-guided transfusion allows for standardization of transfusion practices and early identification and treatment of hypofibrinogenemia. Hypofibrinogenemia is an important cause of the coagu-

CONCLUSION: The introduction of ROTEM significantly improved adherence to DCR practices. The transfusion differences suggest that aggressive DCR without thromboelastometry data may result in reduced hemostatic support and underestimate the need for PLT and CRYO. Thus, future controlled trials should include ROTEM-guided coagulation management in trauma resuscitation. (*J Trauma Acute Care Surg.* 2017;83: 373–380. Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.)

Thrombelastography early amplitudes in bleeding and coagulopathic trauma patients: Results from a multicenter study

Thomas H. Laursen, MD, Martin A.S. Meyer, MD, Anna Sina P. Meyer, MD, Tina Gaarder, MD, PhD, Paal A. Naess, MD, PhD, Jakob Stensballe, MD, PhD, Sisse R. Ostrowski, MD, PhD, DMSc, *and* Pär I. Johansson, MD, DMSc, MPA, *Copenhagen, Denmark*

British Journal of Anaesthesia **109** (3): 376–81 (2012)
Advance Access publication 19 June 2012 · doi:10.1093/bja/aes186

BJA

CRITICAL CARE

treatment algorithm for bleeding burn patients geneic blood product requirements

E. Schaden[1], O. Kimberger[1], P. Kraincuk[1], D. M. Baron[1], P. G. Metnitz[1] and S. Kozek-Langenecker[2]*

[1] Department of Anaesthesia, General Intensive Care and Pain Control, Medical University of Vienna, Austria
[2] Department of Anaesthetics and Intensive Care, Evangelical Hospital Vienna, Austria

Conclusions. The significant reduction in allogeneic blood product requirements during surgical burn wound excision is a prospective proof of concept that a bleeding management algorithm based on thromboelastometry is efficacious. Hypofibrinogenaemia

CONCLUSION: We found strong associations between TEG early amplitudes A5/A10 and maximum amplitude in rapid TEG, kaolin TEG, and TEG functional fibrinogen across trauma patients with coagulopathy and massive transfusion requirements. Introducing the use of early amplitudes can reduce time to diagnosis of coagulopathy and may be used in TEG monitoring of trauma patient. Further randomized controlled trials evaluating the role of TEG in guiding hemostatic resuscitation are warranted. (*J Trauma Acute Care Surg.* 2018;84: 334–341. Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Prognostic study, level III

Anaesthesia 2017, 72, 519–531 doi:10.1111/anae.13765

Review Article

CPD available at http://www.learnataagbi.org

Thromboelastography (TEG) or rotational thromboelastometry (ROTEM) to monitor haemostatic treatment in bleeding patients: a systematic review with meta-analysis and trial sequential analysis

A. Wikkelsø,[1] J. Wetterslev,[2] A. M. Møller[3] and A. Afshari[4]

Summary

Coagulopathy and severe bleeding are associated with high mortality. We evaluated haemostatic treatment guided by the functional viscoelastic haemostatic assays, thromboelastography or rotational thromboelastometry in bleeding patients. We searched for randomised, controlled trials irrespective of publication status, publication date, blinding status, outcomes published or language from date of inception to 5 January 2016 in six bibliographic databases. We included 17 trials (1493 participants), most involving cardiac surgery. Thromboelastography or rotational thromboelastometry seemed to reduce overall mortality compared to any of our comparisons (3.9% vs. 7.4%, RR (95%CI) 0.52 (0.28–0.95); I^2 = 0%, 8 trials, 717 participants). However, the quality of evidence is graded as low due to the high risk of bias, heterogeneity, imprecision and low event rate. Thromboelastography or rotational thromboelastometry significantly reduced the proportion of patients transfused with red blood cells (RR (95%CI) 0.86 (0.79–0.94); I^2 = 0%, 10 trials, 832 participants), fresh frozen plasma (RR (95%CI) 0.57 (0.33–0.96); I^2 = 86%, 10 trials, 832 participants) and platelets (RR (95%CI) 0.73 (0.60–0.88); I^2 = 0%, 10 studies, 832 participants). There was no difference in proportion needing surgical re-interventions (RR (95%CI) 0.75 (0.50–1.10); I^2 = 0%, 9 trials, 887 participants). Trial sequential analysis of mortality suggests that only 54% of the required information size has been reached so far. Transfusion strategies guided by thromboelastography

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

What should we aspire to?

- Don’t necessarily need to give 1:1:1 (or any other ratio)
- Actually give what you need….
- Do a ROTEM/TEG and at 5 mins assess that need…..

- Surely this is best practice….?

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

Royal Adelaide Hospital blood usage study

- 2016 - pre
- 2017 – intro of ROTEM late in the year
- 2018 – post

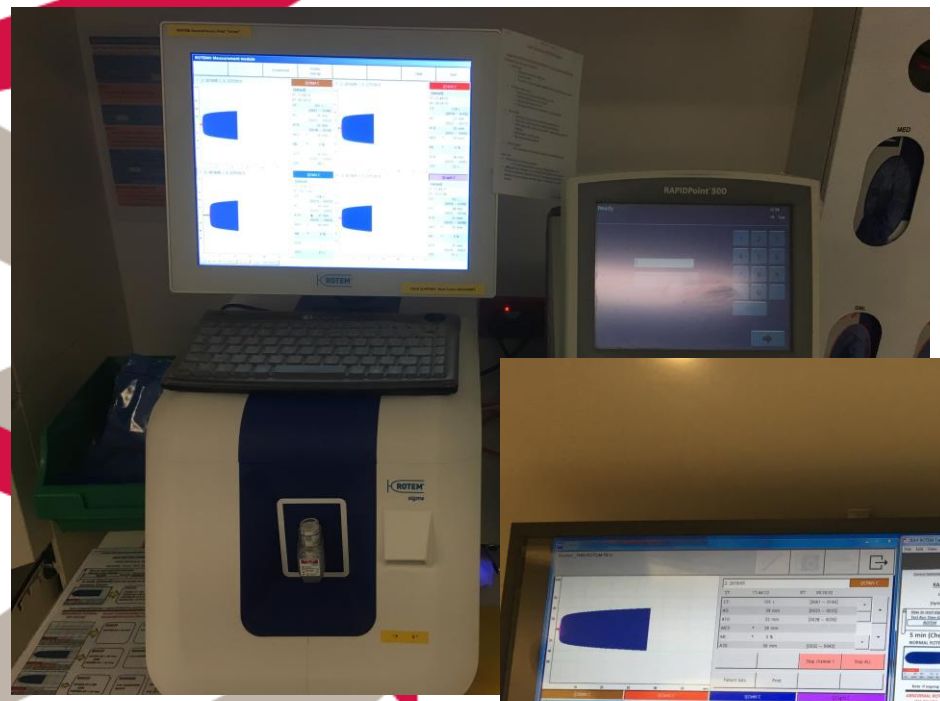
- Awaiting the results of 2018 data…..

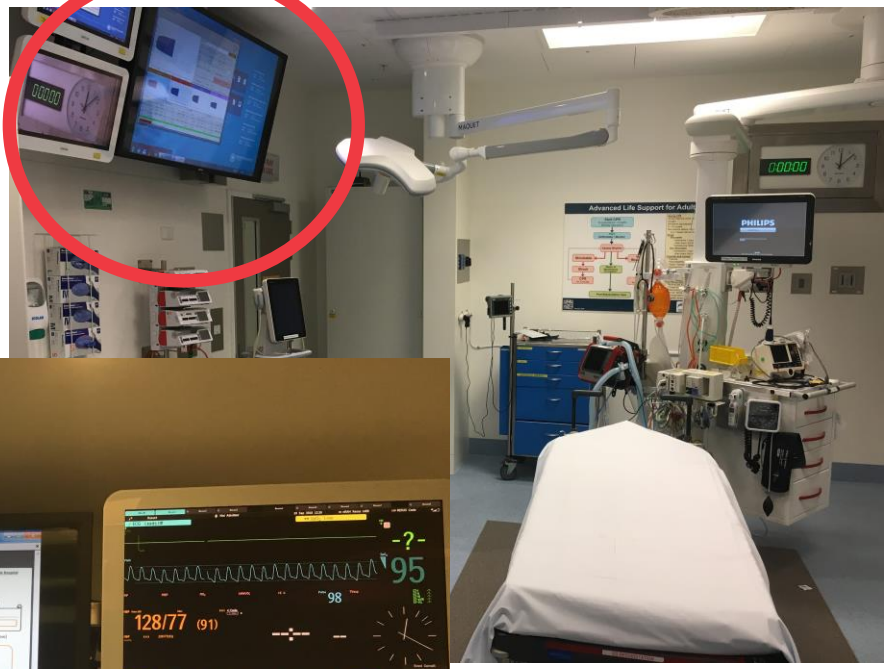
SA Ambulance Service

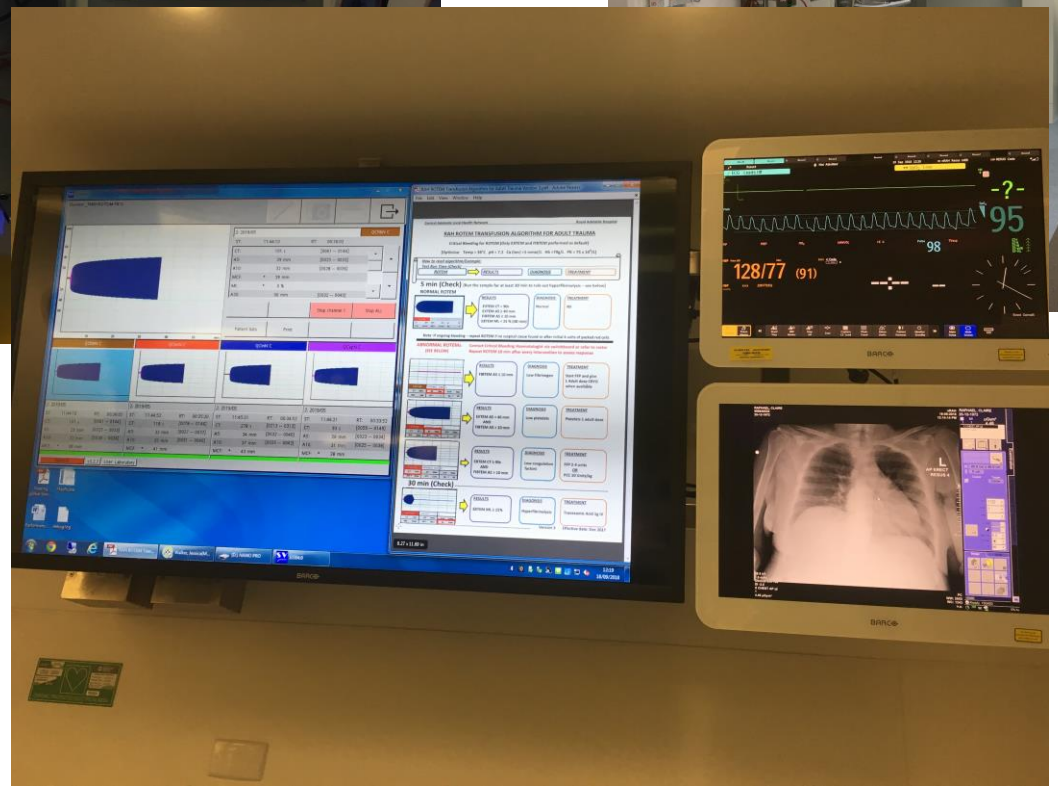
Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

How do I get it?



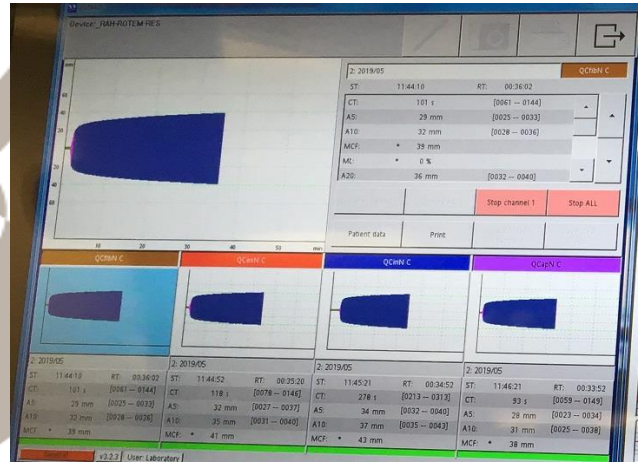




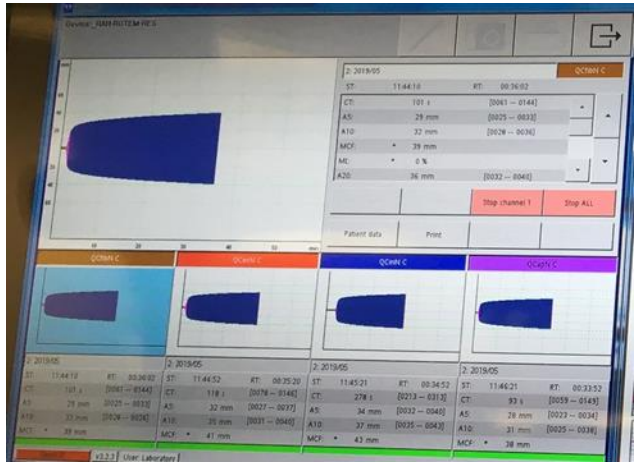
Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

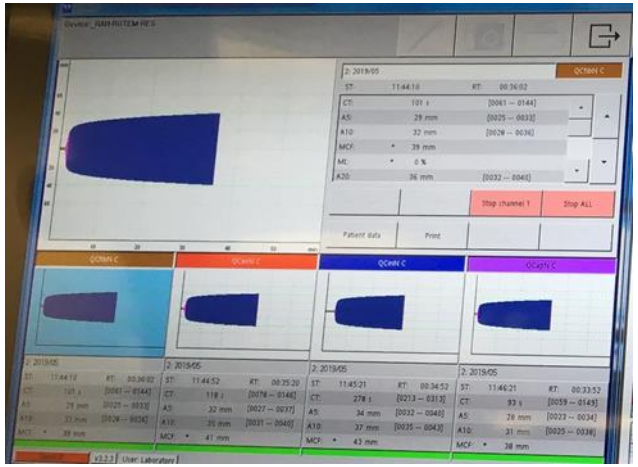
Versatile software



ED



ICU



Transfusion

Theatre

SA Ambulance Service

- Not particularly expensive to purchase
- Nor to use
- Check you don't have access to one already
  - Cardiothoracics
  - Transplant
  - Obstetrics
  - Haematology

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

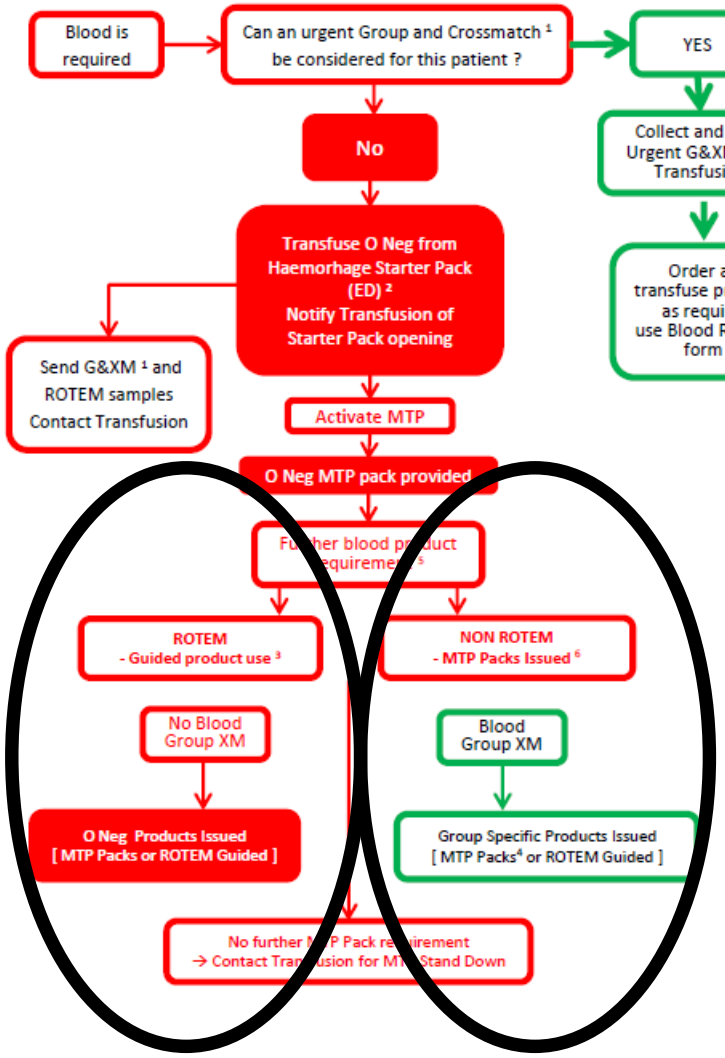
- But you need:
  - A champion (or more than one….)
  - Willingness to adopt
  - Multidisciplinary buy in
    - ED
    - Surgery/Anaesthesia/ICU
    - Haematology
  - Parallel process (ie use or not use)

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

Critical Bleeding Algorithm - RAH



Special consideration

- For Warfarin reversal
  Vitamin K 5-10 g iv
  Prothrombinex – 50 IU/kg
- Platelets for antiplatelet drugs
- Dabigatran reversal
  Idarucizumab/Praxbind
- Rivaroban/ Apixaban reversal
  Contact critical bleeding specialist

Additional Therapies

- Within 3 hrs of injury
  TXA 1g over 10min
  Followed by TXA 1g over 8hrs
- Check ionized calcium on blood gas

1. Correctly labelled blood group & hold (G&XM) specimen and form [1] sent to Transfusion
2. Haemorrhage starter pack opened and usage form sent to Transfusion via shute
3. Check patient`s ROTEM via SQ screen – request/use required blood products
4. Group specific and/or patient named MTP packs and crossmatched units can only be provided with provision of completed Blood Request form (fax or shute)
5. Contact Critical Bleeding specialist for advice
6. Regular coagulation tests used

[4] Blood Product Request form required when issuing Blood Group matched blood

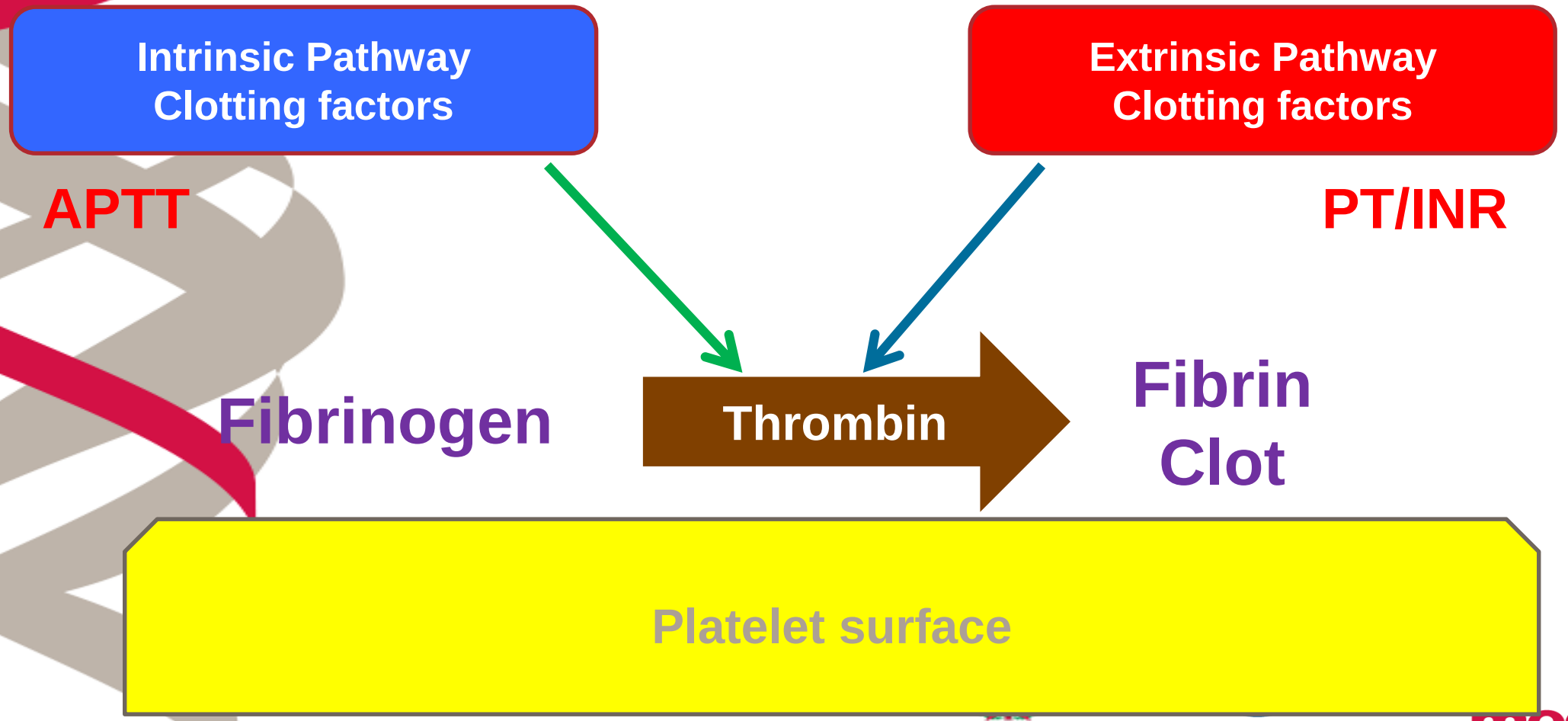
MTP Pack Contents				
	RC	FFP	Plts	Cryo
MTP 1	5	3	1	-
MTP 2	5	4	1	1
MTP 3	5	4	1	1

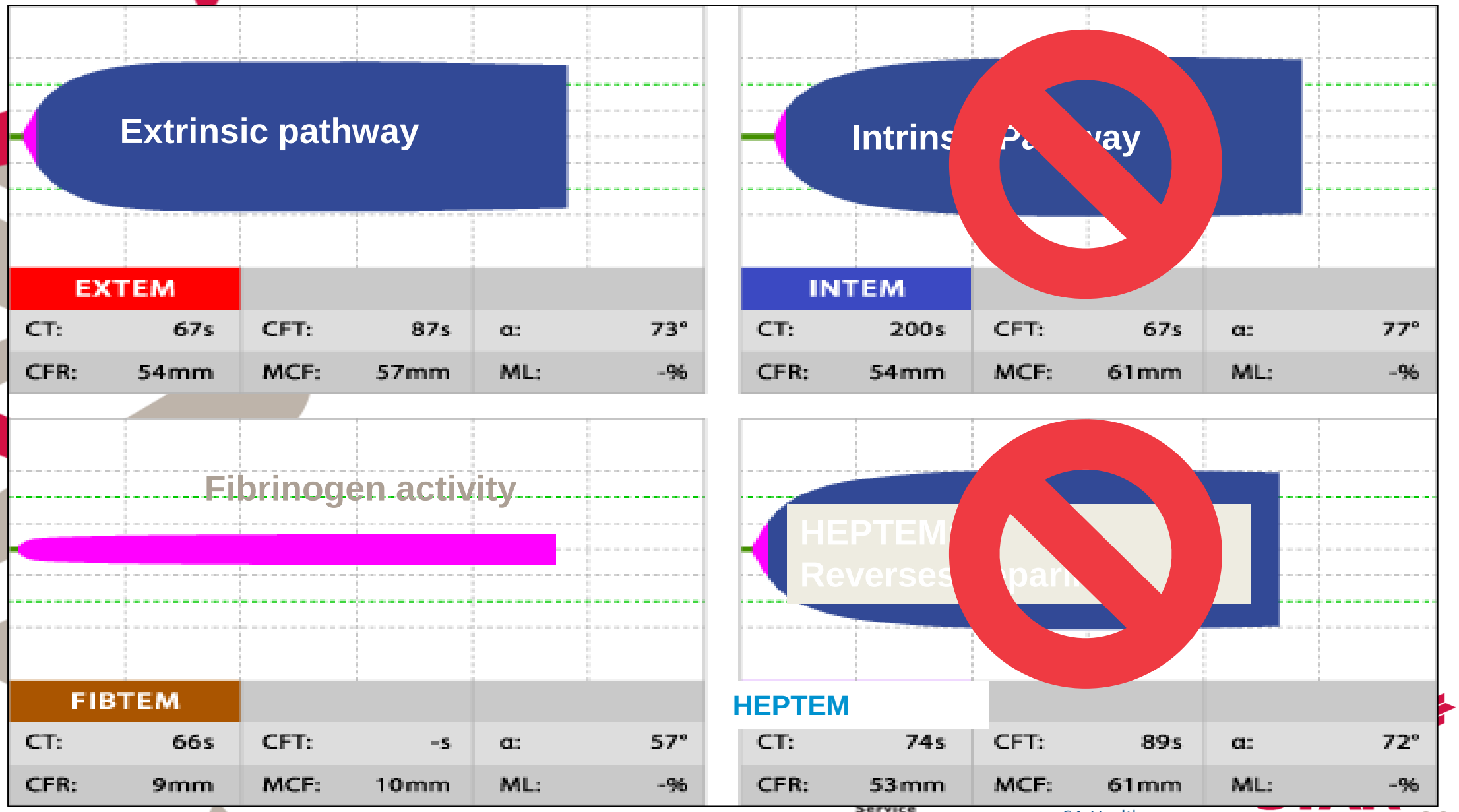
Interpretation

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

Hemostasis simplified




Extrinsic pathway
EXTEM
CT: 67s
CFT: 87s
α: 73°
CFR: 54mm
MCF: 57mm
ML: -%
Intrins Pa way
INTEM
CT: 200s
CFT: 67s
α: 77°
CFR: 54mm
MCF: 61mm
ML: -%
Fibrinogen activity
FIBTEM
CT: 66s
CFT: -s
α: 57°
CFR: 9mm
MCF: 10mm
ML: -%
HEPTEM
Reverses par
HEPTEM
CT: 74s
CFT: 89s
α: 72°
CFR: 53mm
MCF: 61mm
ML: -%

ROTEM Assays

EXTEM Extrinsic pathway screening test
CT not sensitive for heparin (up to 6 U/ml UFH in blood)
CT sensitive for factor deficiency (factor deficiency detected when approximately = <30% factors are left)
Amplitude (A) & CFT influenced by fibrinogen & platelets

INTEM Intrinsic pathway screening test
CT sensitive for heparin (UFH)
CT prolongation from > 0.15 U/ml UFH in blood
CT sensitive for factor deficiency (factor deficiency is only detected when approximately = <30% factors are left)
Amplitude (A) and CFT influenced by fibrinogen & platelets

FIBTEM
identifies isolated fibrinogen contribution to clot firmness
EXTEM activation with platelet inhibition reagent added
Amplitude influenced by fibrinogen concentration & function

HEPTEM
identifies heparin effect when CT compared with INTEM CT
INTEM activation & heparin inhibition with heparinase

APTEM
confirms presence of hyperfibrinolysis
compare EXTEM ML / LI% with APTEM ML / LI%
EXTEM activation & fibrinolysis inhibition with aprotinin

Rotational Thromboelastometry (ROTEM)
A Basic Guide to Clinical Interpretation

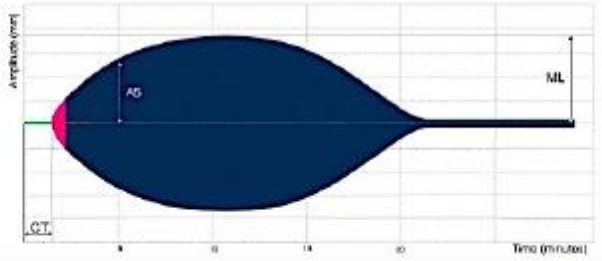
www.haemoview.com.au

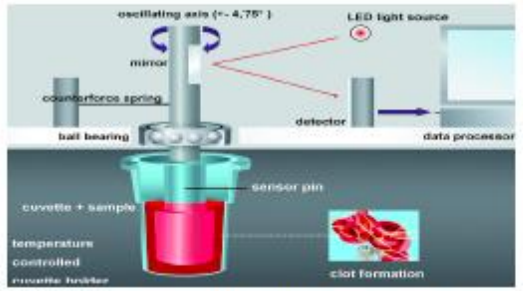
Key components	
EXTEM CT Clotting Time	Thrombin generation
EXTEM A5 Amplitude at 5 minutes	Fibrinogen and platelet concentration and function
FIBTEM A5 Amplitude at 5 minutes	Fibrinogen concentration and function
ML % Maximal lysis	Degree of fibrinolysis over temogram

Green = CT
Clotting Time
Initiation
0 – 2 mm

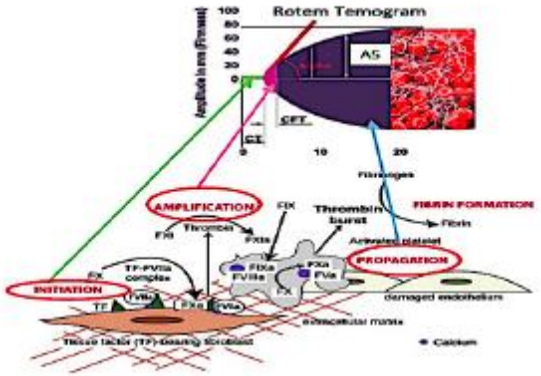
Pink = 2 – 20 mm
Amplification

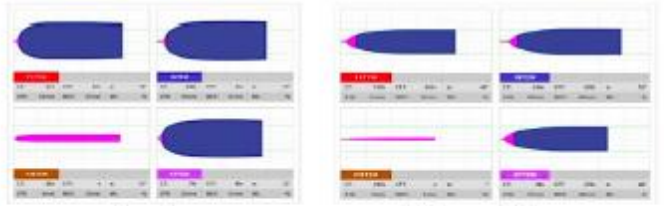
Blue = A5
Propagation
Fibrin Formation

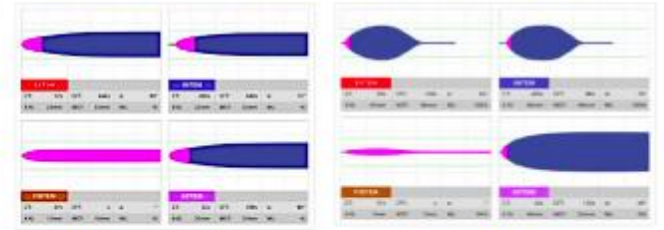


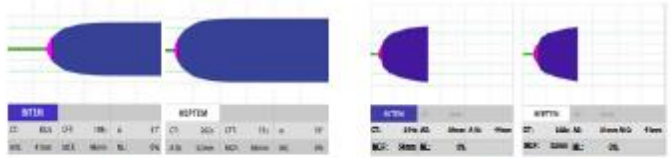


How it works- Cup and Pin Technology









ROTEM Assays

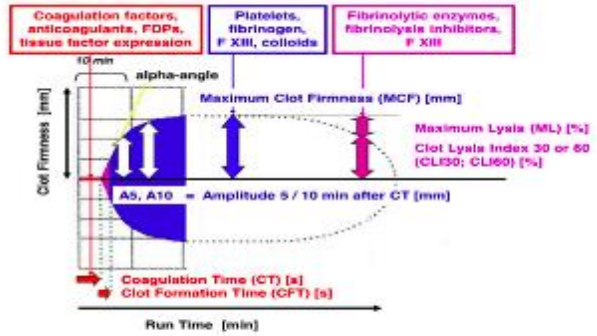
EXTEM Extrinsic pathway screening test
- CT not sensitive for heparin (up to 5 U/ml UFH in blood)
- CT sensitive for factor deficiency (factor deficiency detected when approximately = <30% factors are left)
- Amplitude (A) & CFT influenced by fibrinogen & platelets

INTEM Intrinsic pathway screening test
- CT sensitive for heparin (UFH)
- CT prolongation from > 0.15 U/ml UFH in blood
- CT sensitive for factor deficiency (factor deficiency is only detected when approximately = <30% factors are left)
- Amplitude (A) and CFT influenced by fibrinogen & platelets

FIBTEM
- identifies isolated fibrinogen contribution to clot firmness
- EXTEM activation with platelet inhibition reagent added
- Amplitude influenced by fibrinogen concentration & function

HEPTEM
- identifies heparin effect when CT compared with INTEM CT
- INTEM activation & heparin inhibition with heparinase

APTEM
- confirms presence of hyperfibrinolysis
- compare EXTEM ML / LI% with APTEM ML / LI%
- EXTEM activation & fibrinolysis inhibition with tranexamic acid



Fibrinogen Dosing Guide FIBTEM A5 Target: ≥12mm			
FIBTEM A5	Increase required	Cryoprecipitate*	Fibrinogen Concentrate
8-10mm	2-3 mm	10 Units	2g
7-8mm	4-5 mm	15 Units	3g
4-6mm	6-8 mm	20 Units	4g
<4mm	≥8mm	25 Units	5g
*Cryoprecipitate dosing is for standard adult units (Cryo 6 units / Fib Conc 1g = Fibtem A5 increase of approx 2mm)			

Always repeat ROTEM 10 mins after treatment

Importance of Clinical Picture

- **Starting Point**
  - **Bleeding Patient**
  - **High Risk of Bleeding Procedure**
    - **Baseline/Underlying Situation**

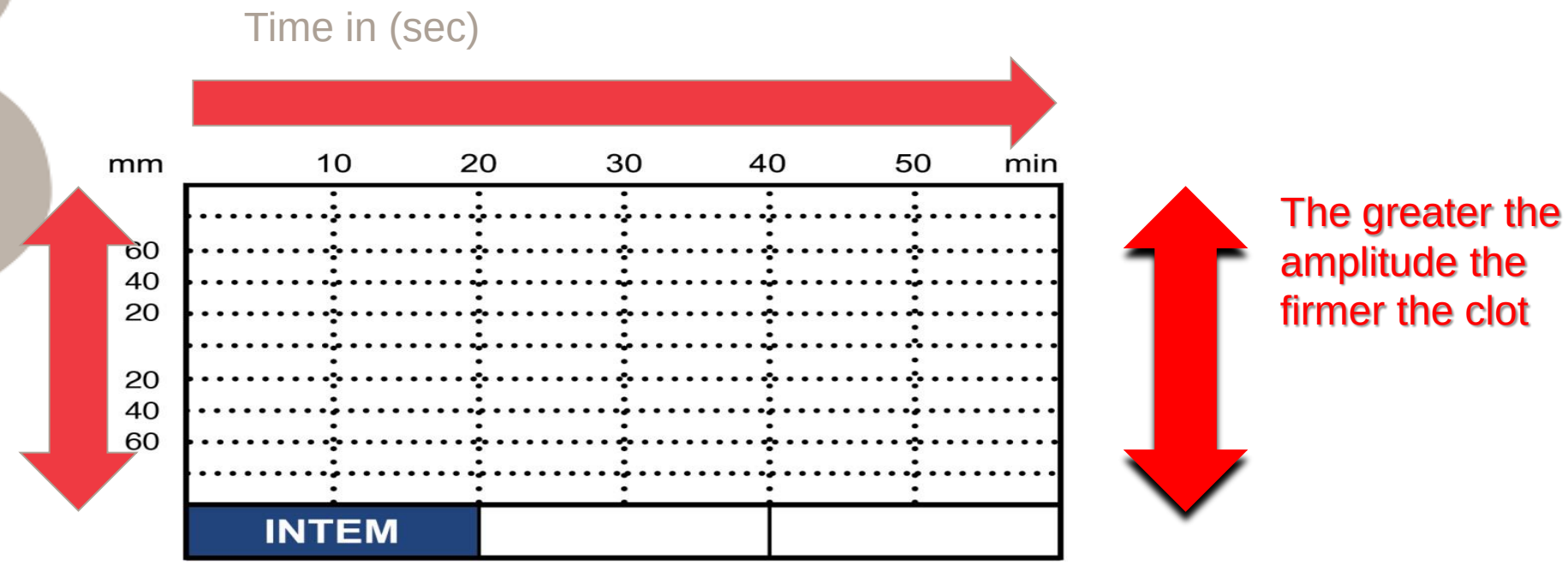
- **‘Link’ ROTEM Diagnostic Findings to Clinical Situation**

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

The graph information or “TEMogram”



The graph demonstrates the change in amplitude (clot firmness) over a time period

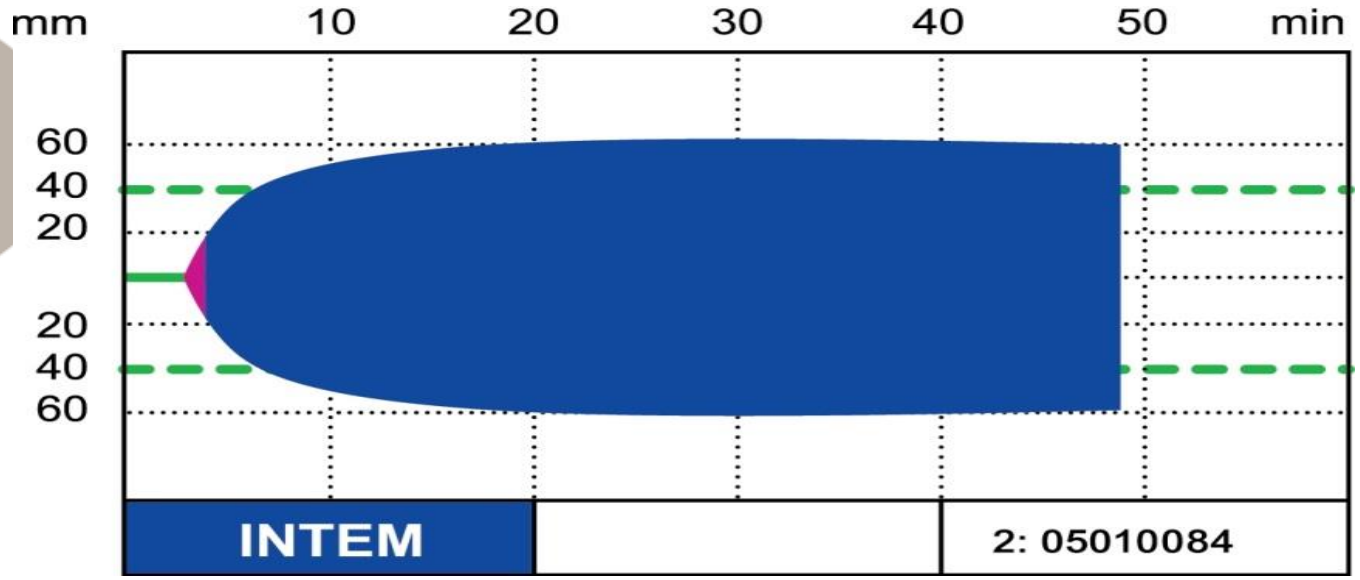
SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

ROTEM® RESULTS

The “TEMograms”



SA Ambulance Service

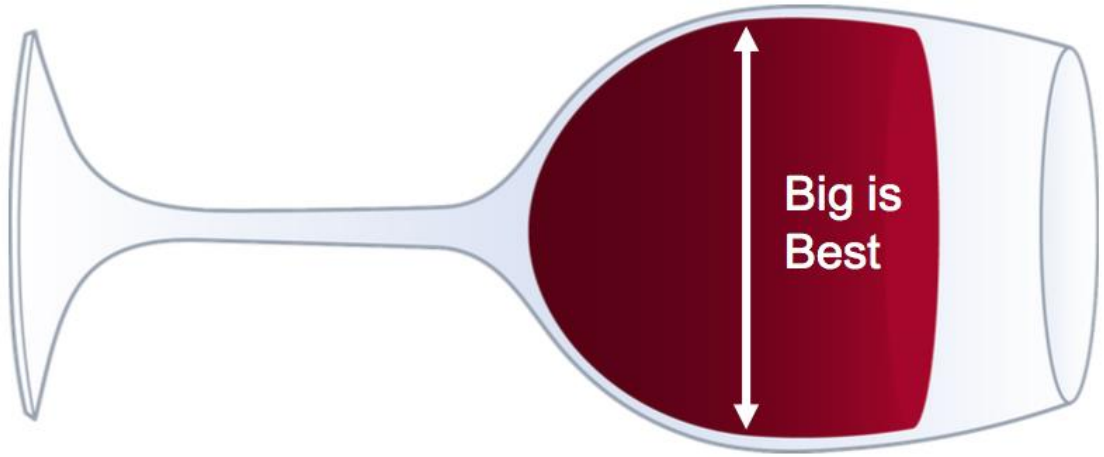
Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

The fatness of the curve is called
"Maximal clot firmness"

or
"MCF"

or
" Amplitude
A5/A10"



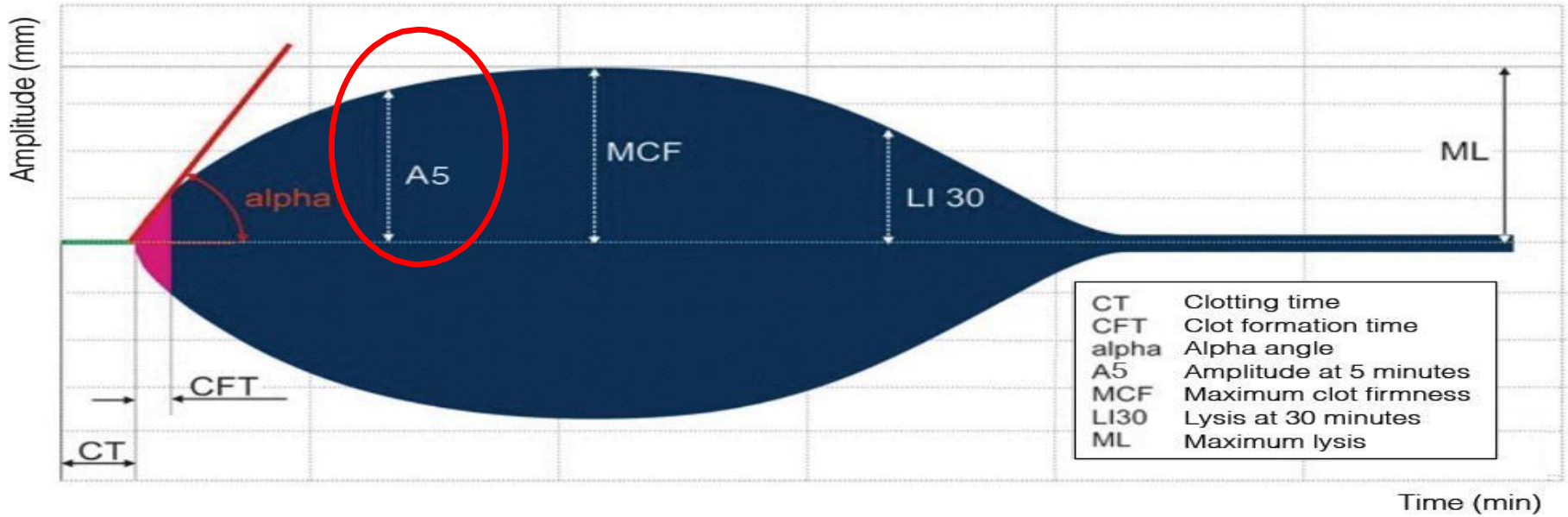
5/10 refers to minutes…..

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

Clot Amplitude = A5/A10/MCF



A5 = amplitude at 5min A10 = amplitude at 10min

MCF = maximum clot firmness These represent the “clot strength”.

Clot firmness = **Clot Quality**

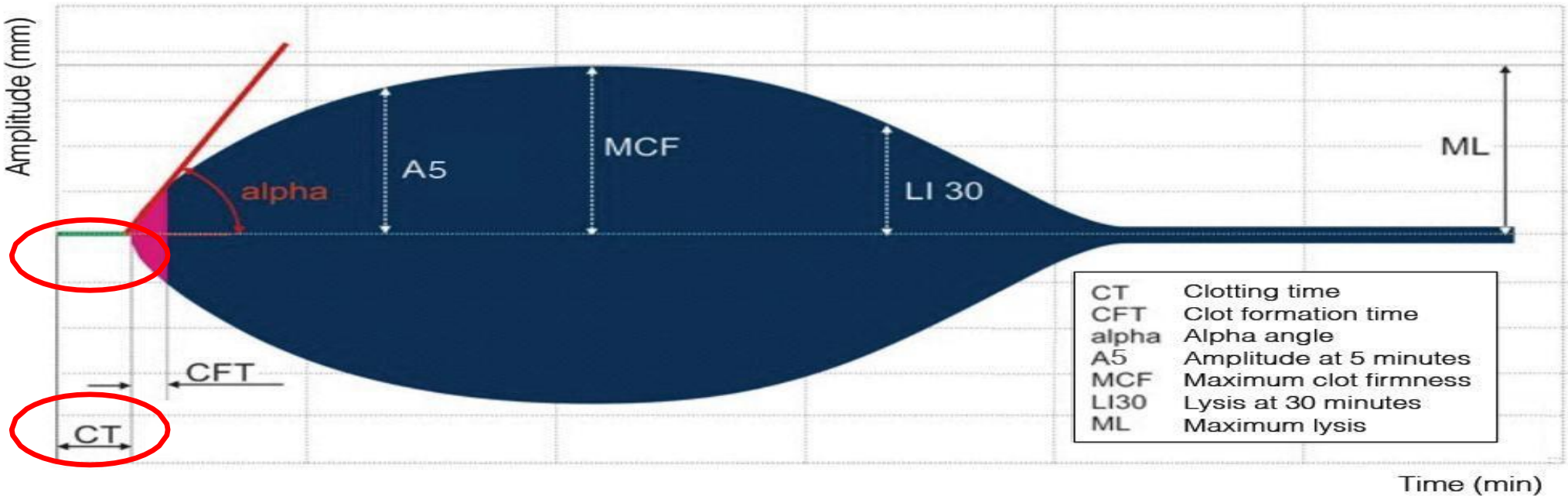
Decreased clot strength is predictive of bleeding

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

Clotting Time CT

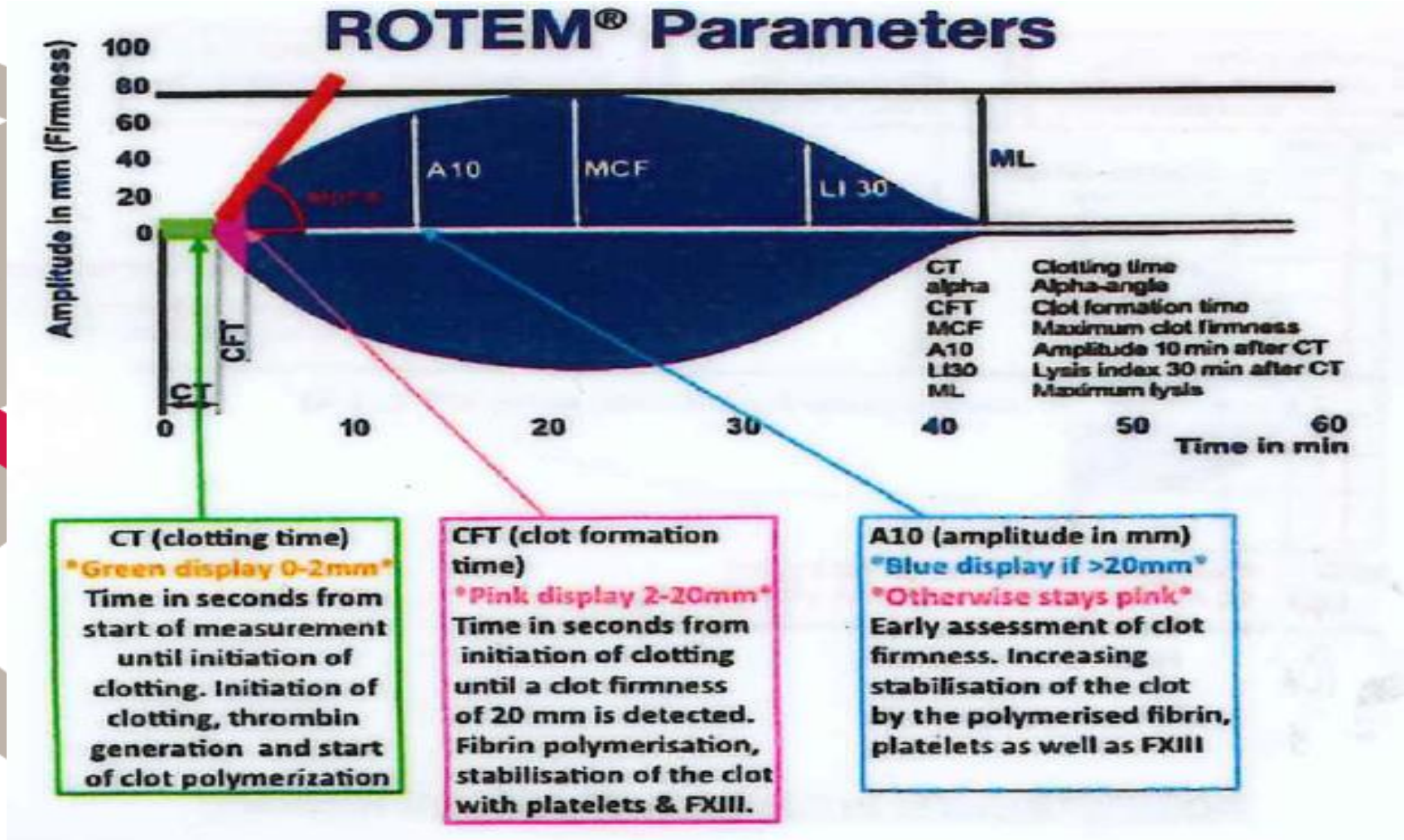


- This represents the time taken for the clot to start forming
- A prolonged clot time can be associated with increased bleeding
- There are a number of potential causes:
  - low fibrinogen
  - low clotting factors (decreased thrombin generation)
  - anticoagulant effect

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval


ROTEM® Parameters
Amplitude in mm (Fimness)
100
80
60
40
20
0
A10
MCF
LI 30
ML
alpha
CT
CFT
0
10
20
30
40
50
60
Time in min
CT Clotting time
alpha Alpha-angle
CFT Clot formation time
MCF Maximum clot firmness
A10 Amplitude 10 min after CT
LI30 Lysis index 30 min after CT
ML Maximum lysis
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

In a Nutshell – “Time to Treat”

Clotting Time (CT)

- Adequate Clotting Factors
- Inhibited Clotting Factors

- **Amplitude (A5/A10)**
  - Assessment of Clot Strength
  - Fibrinogen / Platelets / FXIII
  - Correlates well with Max Clot Firmness
- **Fibrinolysis**
  - Clot degradation over time
  - Max Lysis (ML)

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

Emergency department test?

- Arrival time is T_{ZERO}
- Time of first bloods….
- Time to CT…..
- Time to theatre/angio….

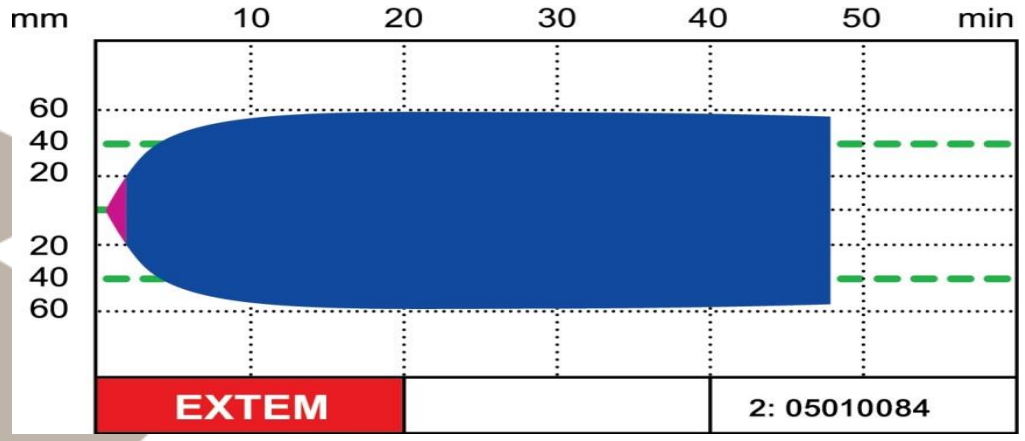
- When do you plan to give product?
- ROTEM is not a once off test

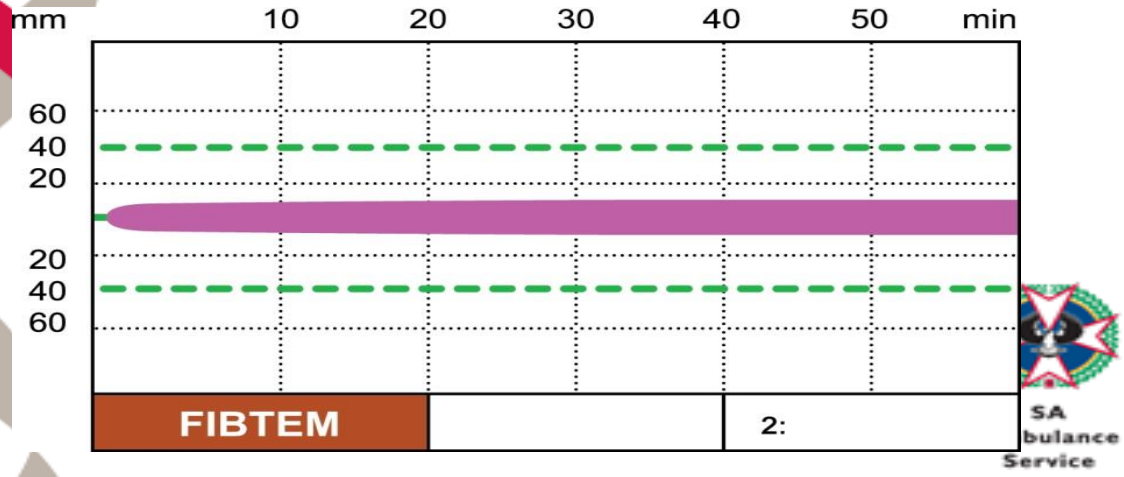
SA Ambulance Service

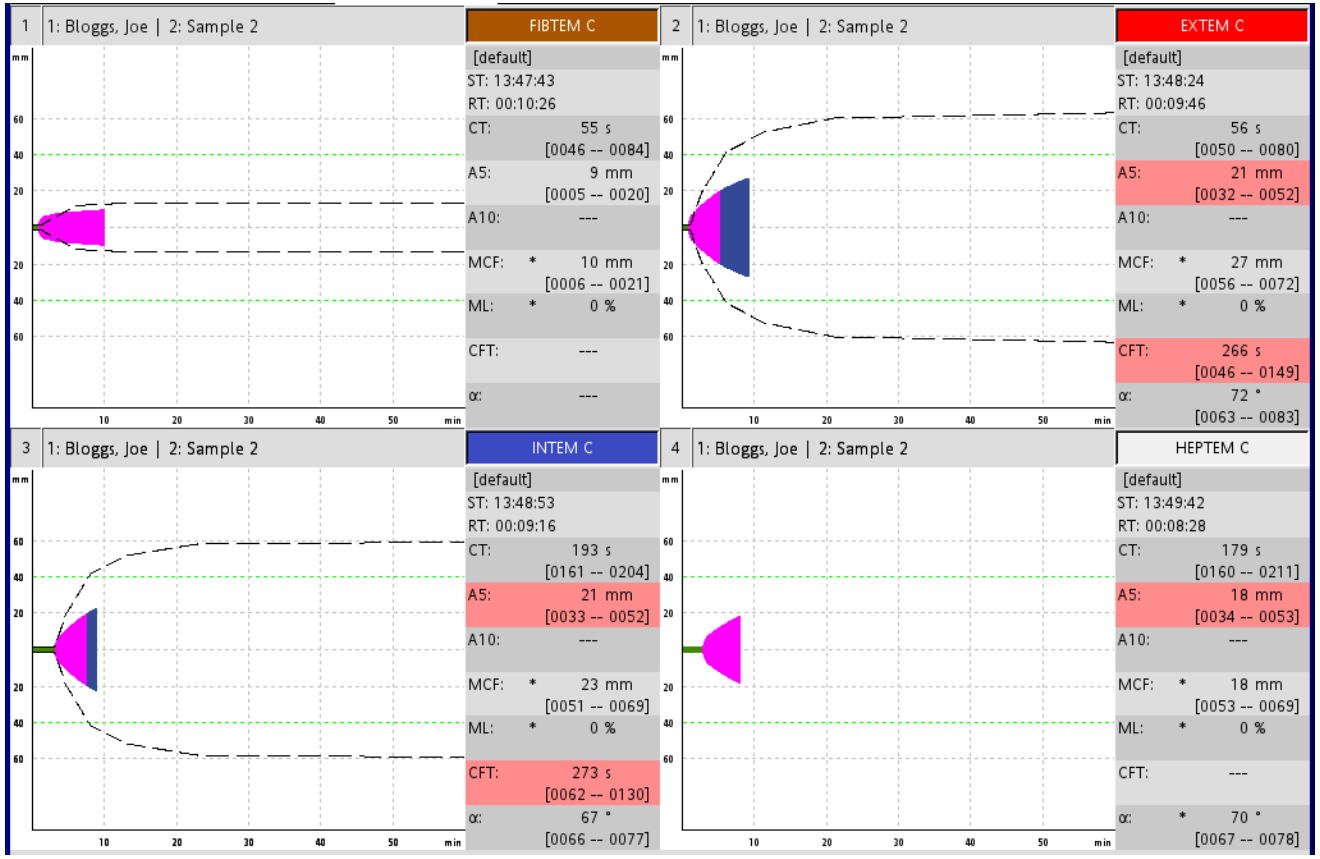
Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

“Normal” ROTEM® TEMograms







SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

Note:

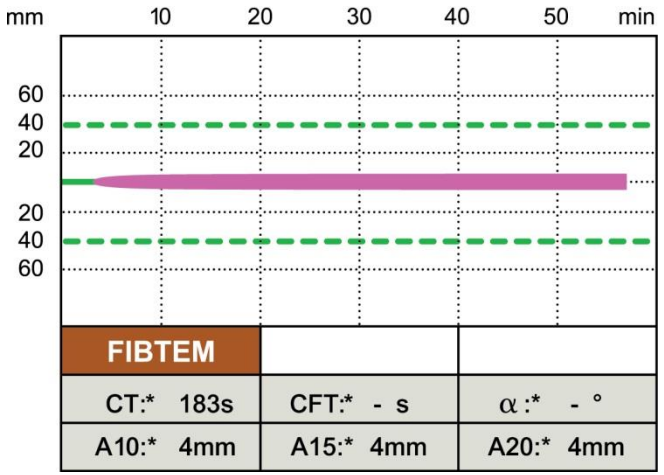
- Test can be aborted after 5-10 mins if required
- So you can give product and repeat
- Or allow another department to do a ROTEM if greater clinical need

SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

In your bleeding patient, ROTEM demonstrates:

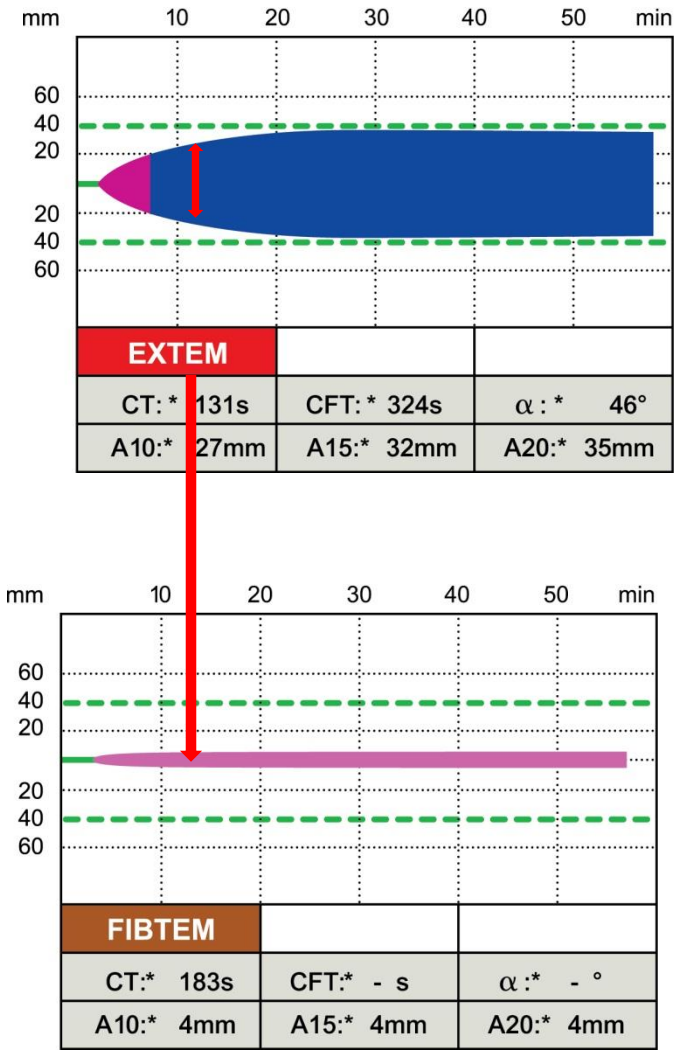


A5/10$_{FIBTEM}$ *Reduced*

A5/10 = 4 mm (>10mm)

Suggests inadequate fibrin contribution to clot firmness: low fibrinogen

In your bleeding patient, ROTEM demonstrates:



A5/10$_{EXTEM}$ *Reduced*

Suggests inadequate clot firmness due to either decreased platelets and/or fibrinogen

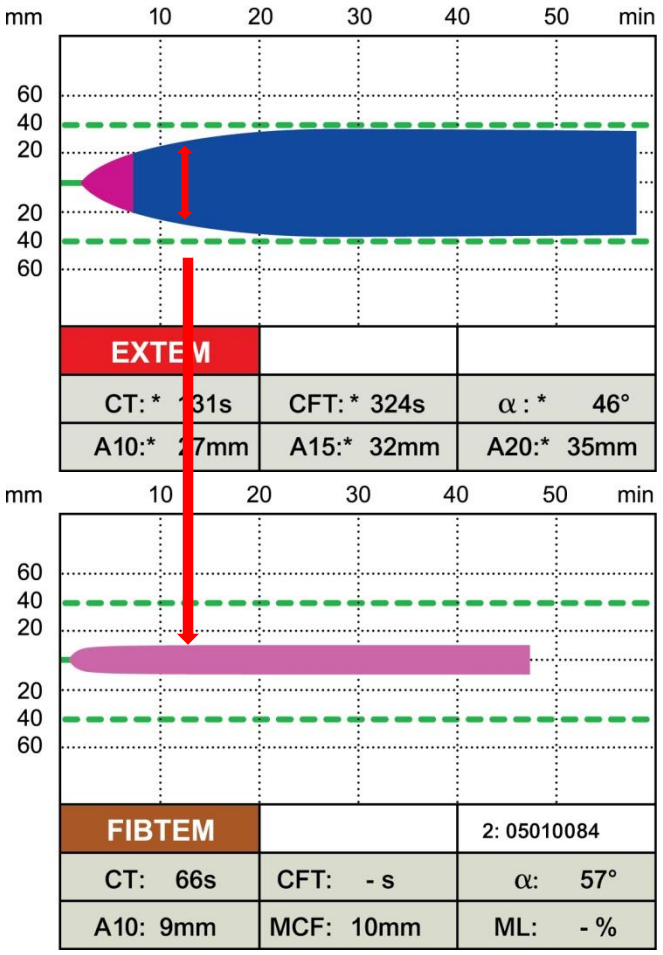
A5/10 = 27 mm (>40mm)

A5/10$_{FIBTEM}$ *Reduced*

A5/10 = 4 mm

Suggests inadequate fibrin contribution to clot firmness: low fibrinogen

In your bleeding patient, ROTEM demonstrates:



$A5/10_{EX}$ *Reduced*

Suggests inadequate clot firmness as a result of decreased platelets and/or fibrinogen

A5/10 = 27

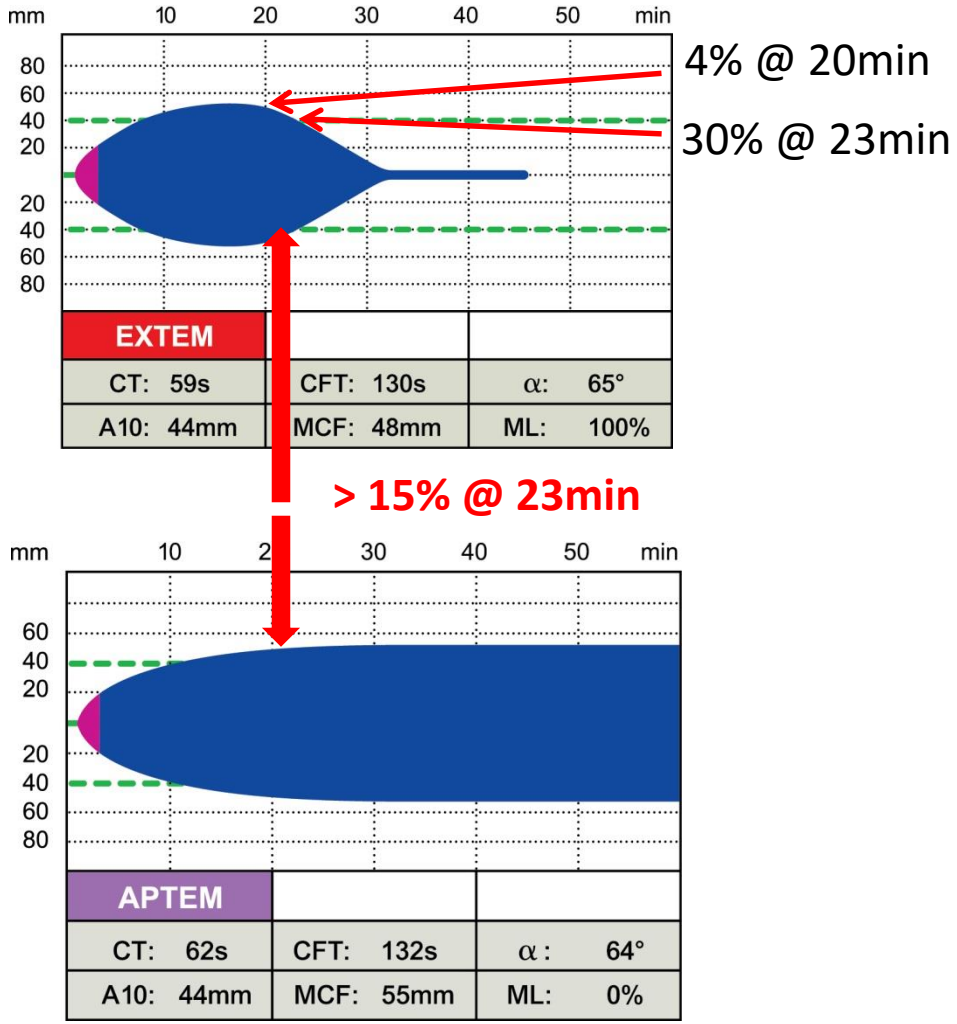
$A5/10_{FIB}$ *Normal*

A5/10 = 9mm

Suggests adequate fibrinogen

Platelets are the cause for low A5/10 on EXTEM

In your bleeding patient, ROTEM demonstrates:

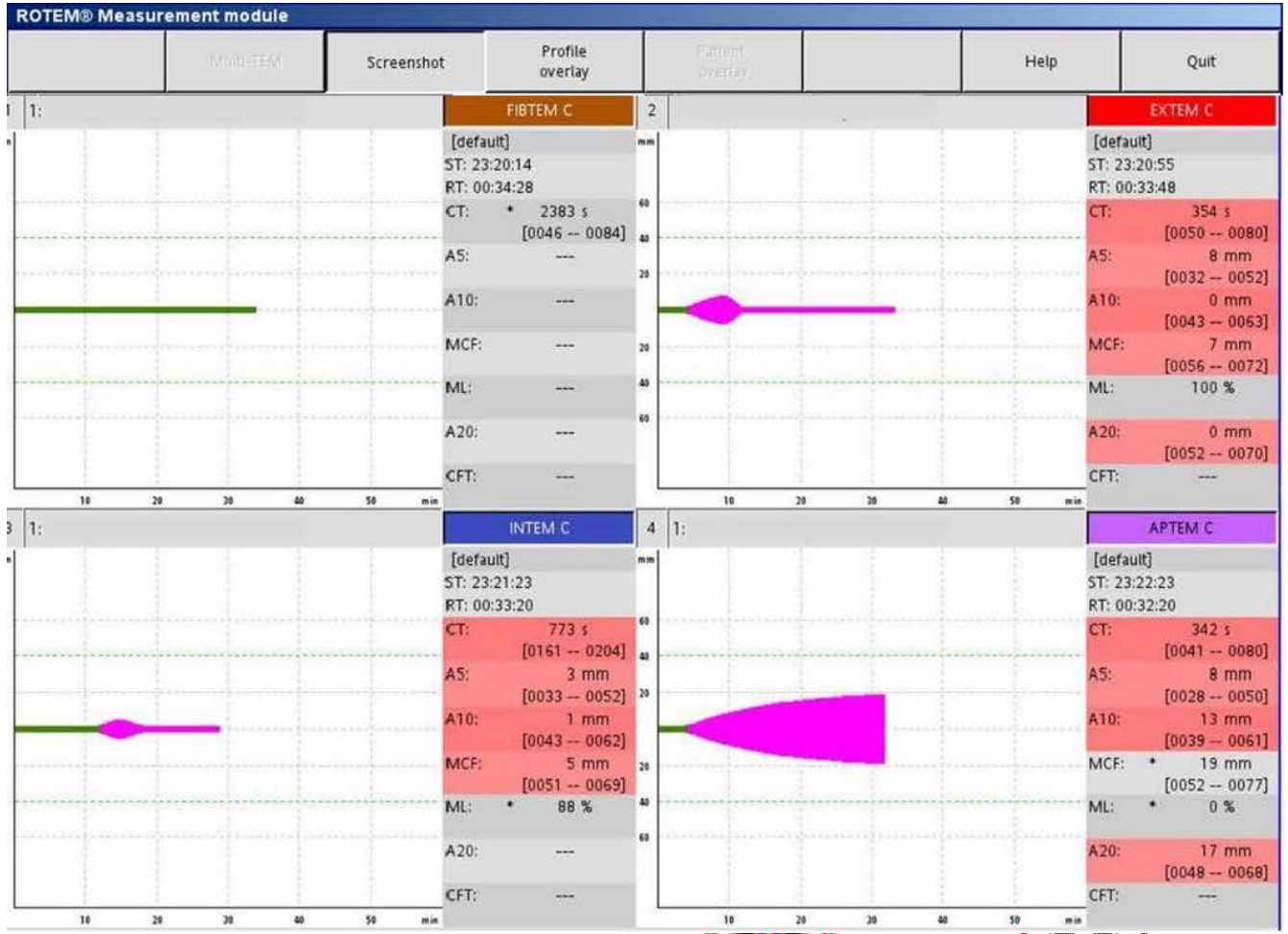


ML_{EX} = 30% @ 23MIN

Suggests hyperfibrinolysis

The APTEM is then run & lysis is corrected

Confirms hyperfibrinolysis and shows efficacy of antifibrinolytic therapy

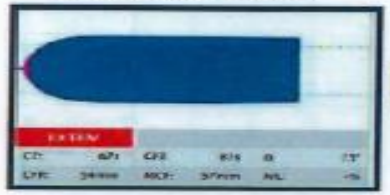


SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

NORMAL ROTEM



RESULTS
EXTEM CT < 90s
EXTEM A5 ≥ 40 mm
FIBTEM A5 ≥ 10 mm
EXTEM ML < 15 % (30 min)

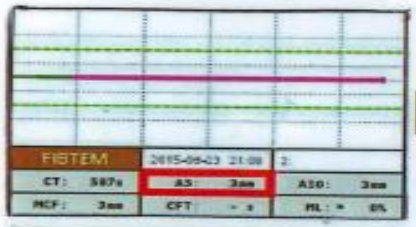
DIAGNOSIS
Normal

TREATMENT
Nil

Note: If ongoing bleeding – repeat ROTEM if no surgical cause found or after initial 4 units of packed red cells

ABNORMAL ROTEMs: (SEE BELOW)

Contact Critical Bleeding Haematologist via switchboard or refer to roster
Repeat ROTEM 10 min after every intervention to assess response



RESULTS
FIBTEM A5 ≤ 10 mm

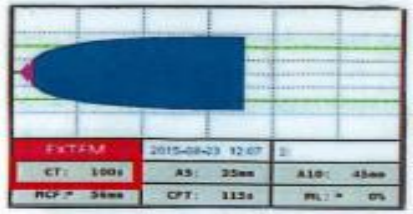
DIAGNOSIS
Low Fibrinogen

TREATMENT
Start FFP and give
1 Adult dose CRYO
when available

RESULTS
EXTEM A5 < 40 mm
AND
FIBTEM A5 > 10 mm

DIAGNOSIS
Low platelets

TREATMENT
Platelets 1 adult dose

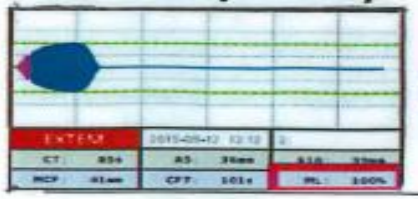


RESULTS
EXTEM CT ≥ 90s
AND
FIBTEM A5 > 10 mm

DIAGNOSIS
Low coagulation factors

TREATMENT
FFP 2-4 units
OR
PCC 10 Units/kg

30 min (Check)



RESULTS
EXTEM ML ≥ 15%

DIAGONSIS
Hyperfibrinolysis

TREATMENT
Tranexamic Acid 1g IV

Version 3 Effective date: Dec 2017

Summary

- What is it…?
- Do I need it?
- How do I get it?
- What else do I need?
- Prove its easy to interpret…..
  - +/- cases (time..!)

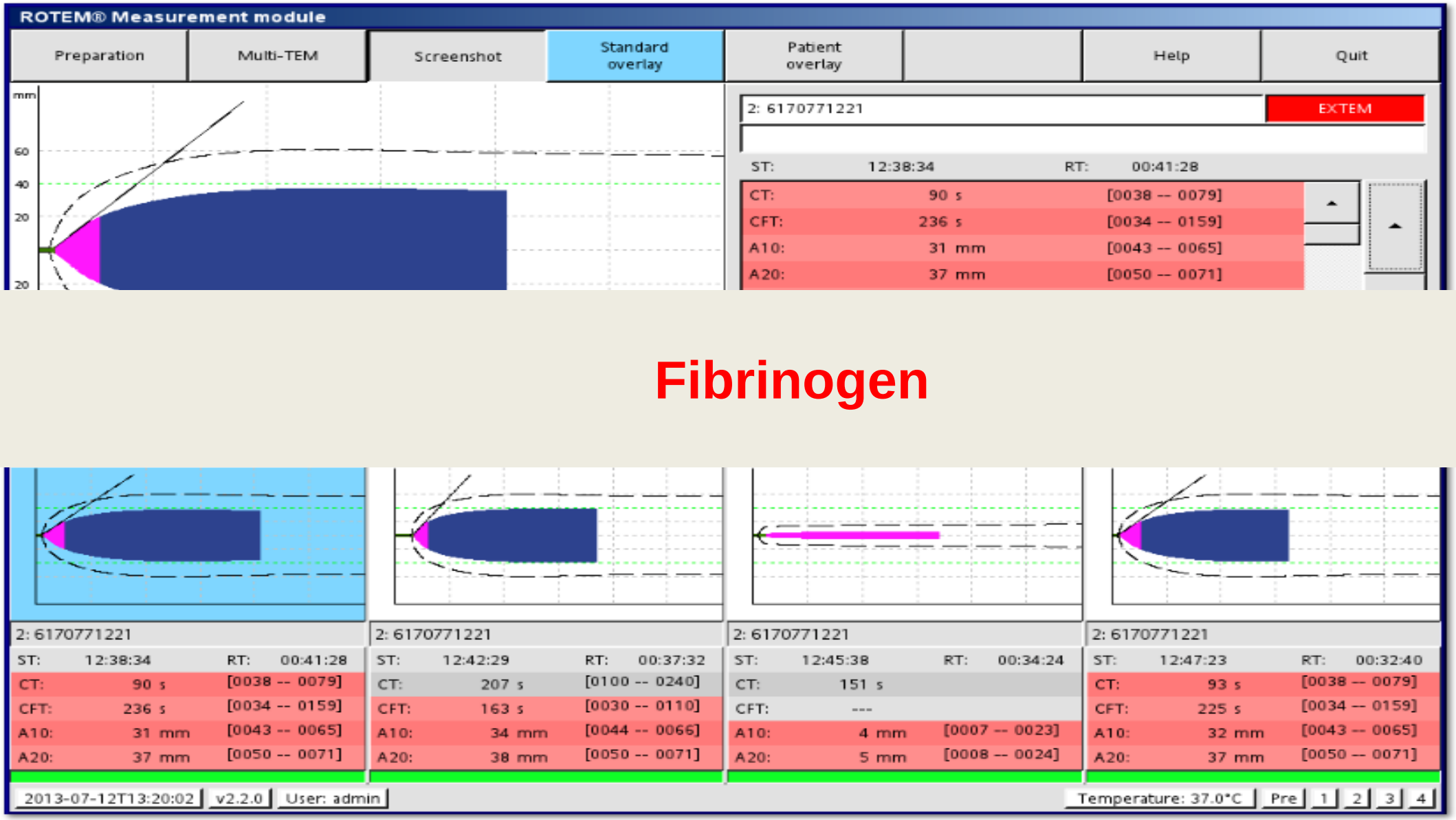
SA Ambulance Service

Government of South Australia
SA Health

medSTAR Emergency Medical Retrieval

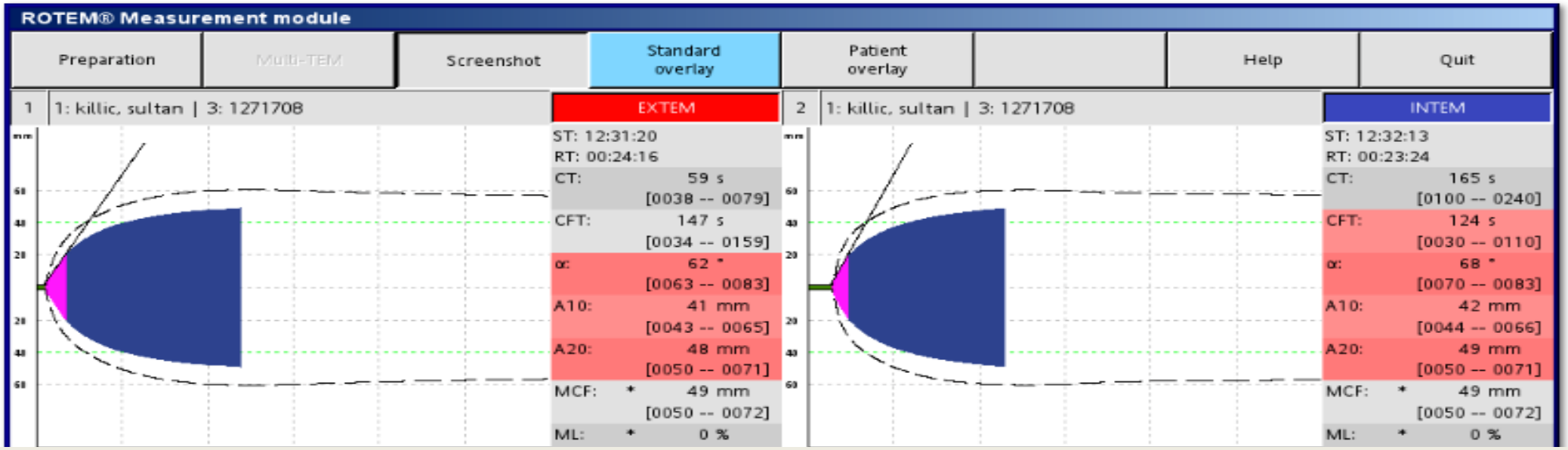
Cases

Bleeding post Surgery

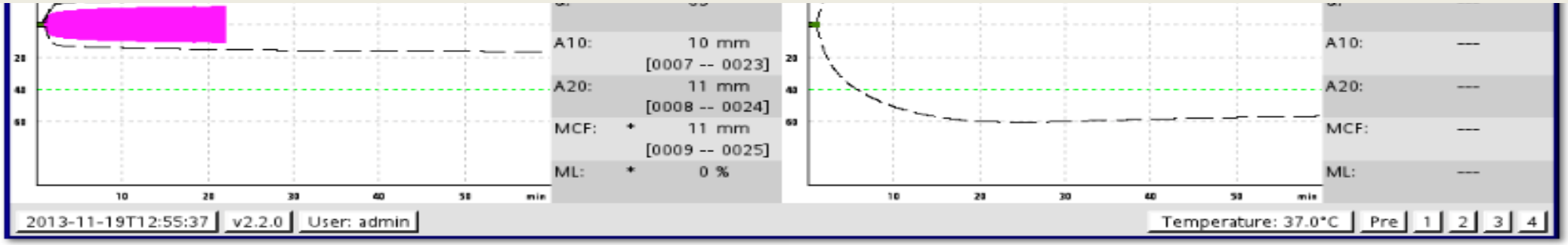


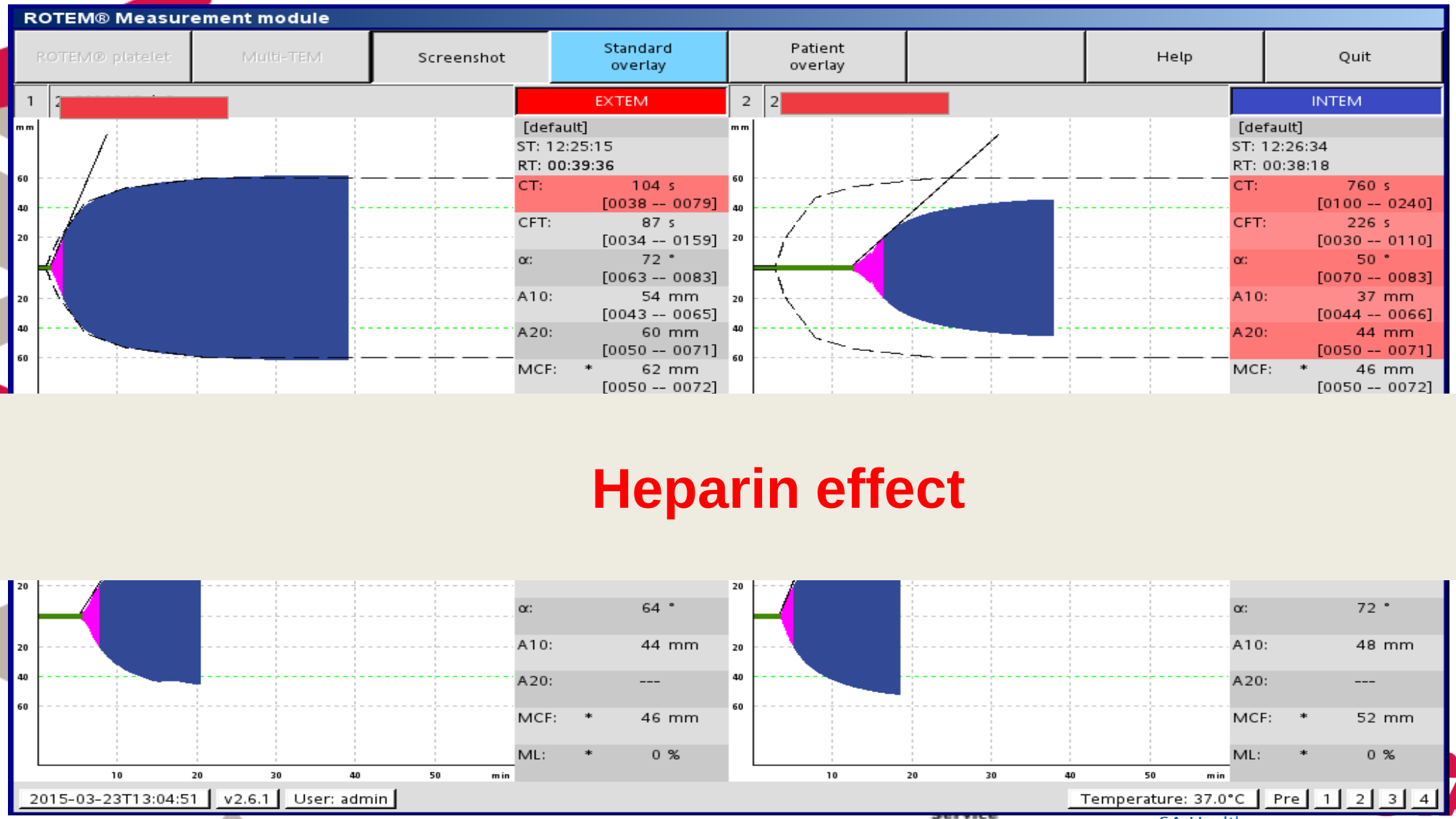
Fibrinogen

Bleeding



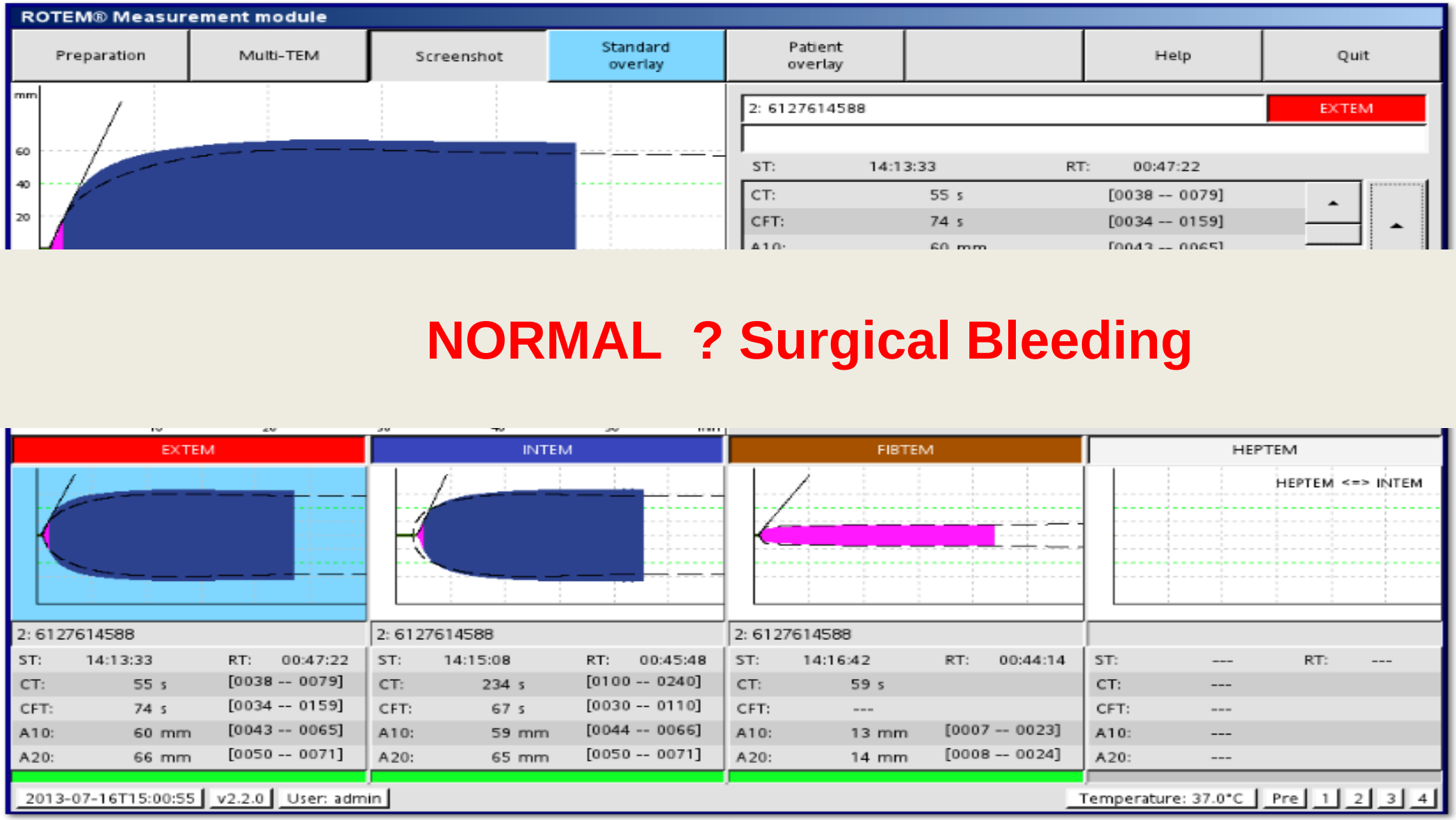
Platelets





Heparin effect

Bleeding post-op in ICU



NORMAL ? Surgical Bleeding

Online Cases

- https://www.obsgynaecritcare.org/rotem-flip-cards-test-interpretation-skills/