Performance of ROTEM and TEG

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Thromboelastography

Thromboelastography (**TEG**) is a method of testing the efficiency of blood coagulation. It is a test mainly used in surgery and anesthesiology, although few centers are capable of performing it. More common tests of blood coagulation include prothrombin time (PT,INR) and partial thromboplastin time (aPTT) which measure coagulation factor function, but TEG also can assess platelet function, clot strength, and fibrinolysis which these other tests cannot.[1]

Thromboelastometry (TEM), previously named rotational thromboelastography (ROTEG) or rotational thromboelastometry (ROTEM), is another version of TEG in which it is the sensor shaft, rather than the cup, that rotates.

Wikipedia

Thromboelastography

1951 : 1
2017 : 293

ROTEM

CLOTSCANNER

TEG

Cochrane Library

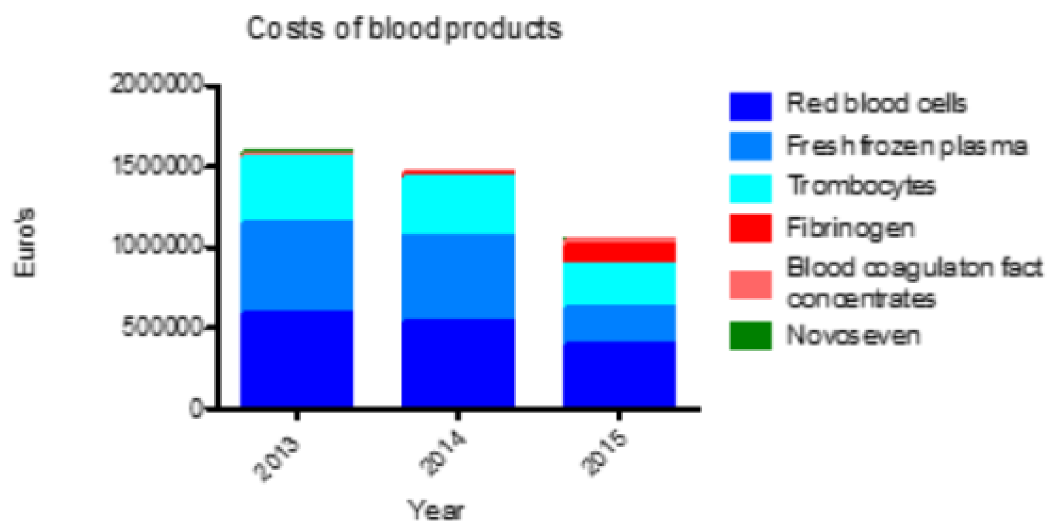
Trusted evidence.
Informed decisions.
Better health.

Thromboelastography (TEG) or thromboelastometry (ROTEM) to monitor haemostatic treatment versus usual care in adults or children with bleeding

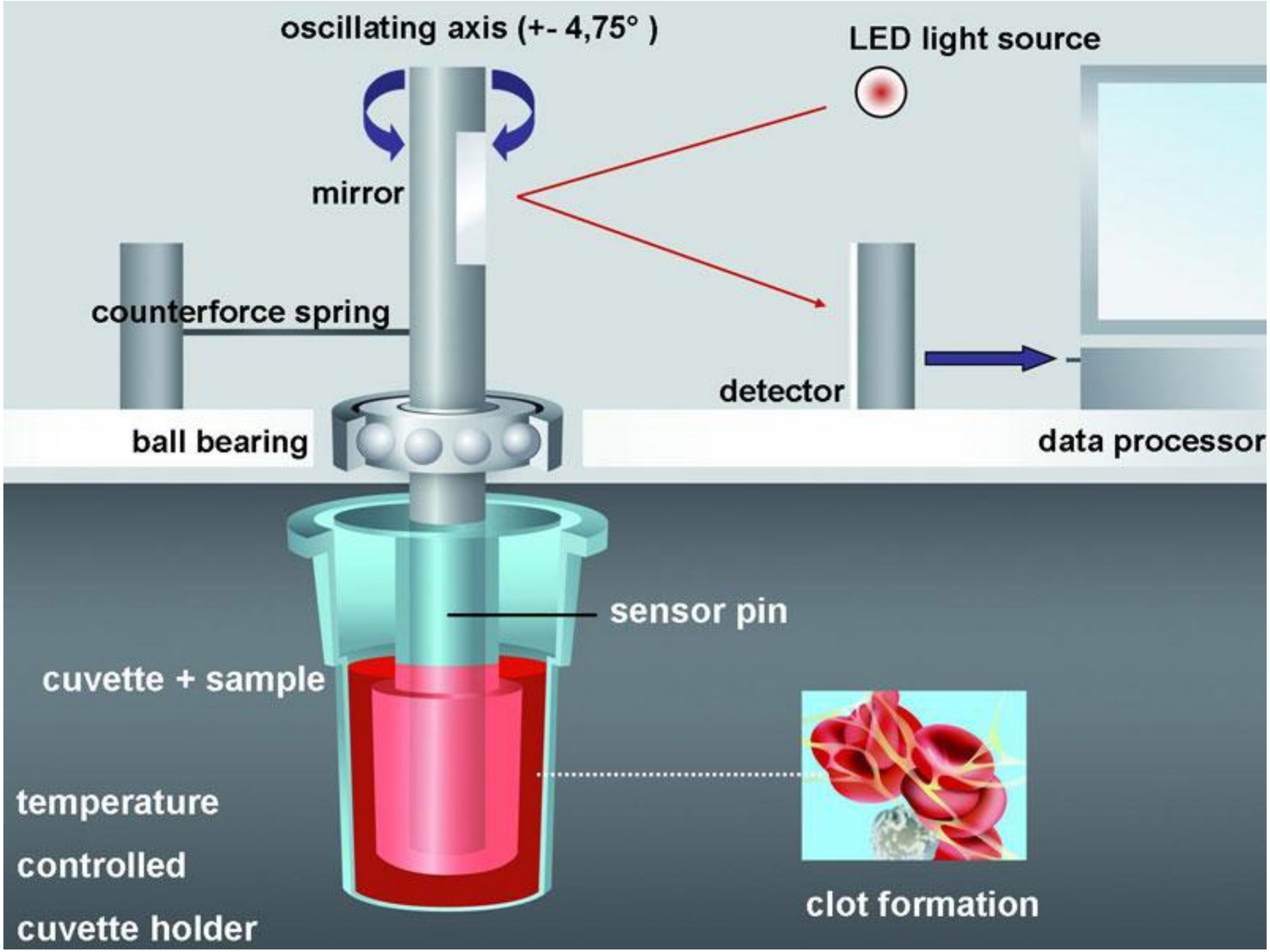
Anne Wikkelsø[1], Jørn Wetterslev[2], Ann Merete Møller[3], Arash Afshari[4]

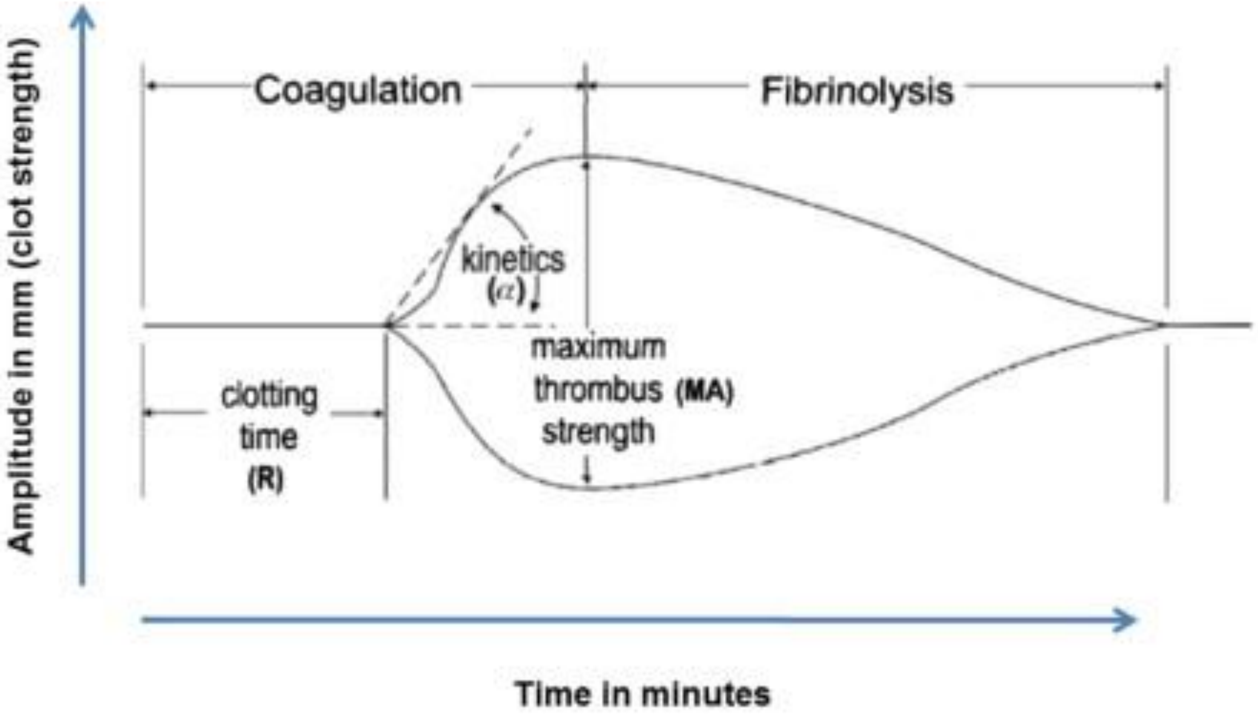
There is growing evidence that application of TEG- or ROTEM-guided transfusion strategies may reduce the need for blood products, and improve morbidity in patients with bleeding. However, these results are primarily based on trials of elective cardiac surgery involving cardiopulmonary bypass, and the 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.

Consumption of blood products

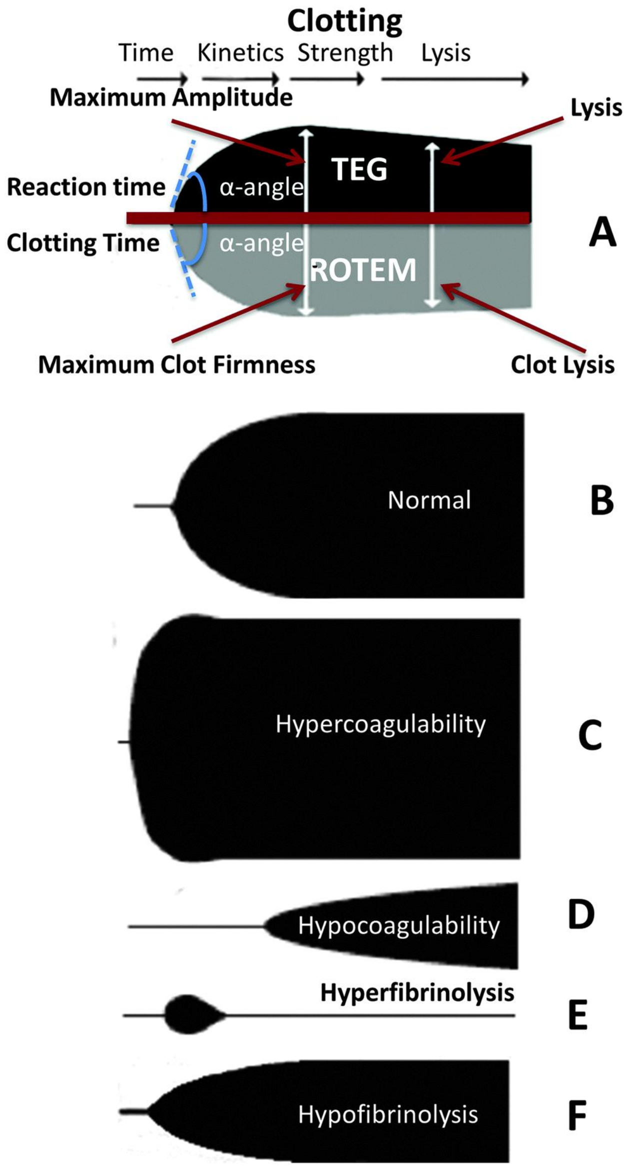


AND 19 % reduction in re-thoracotomies

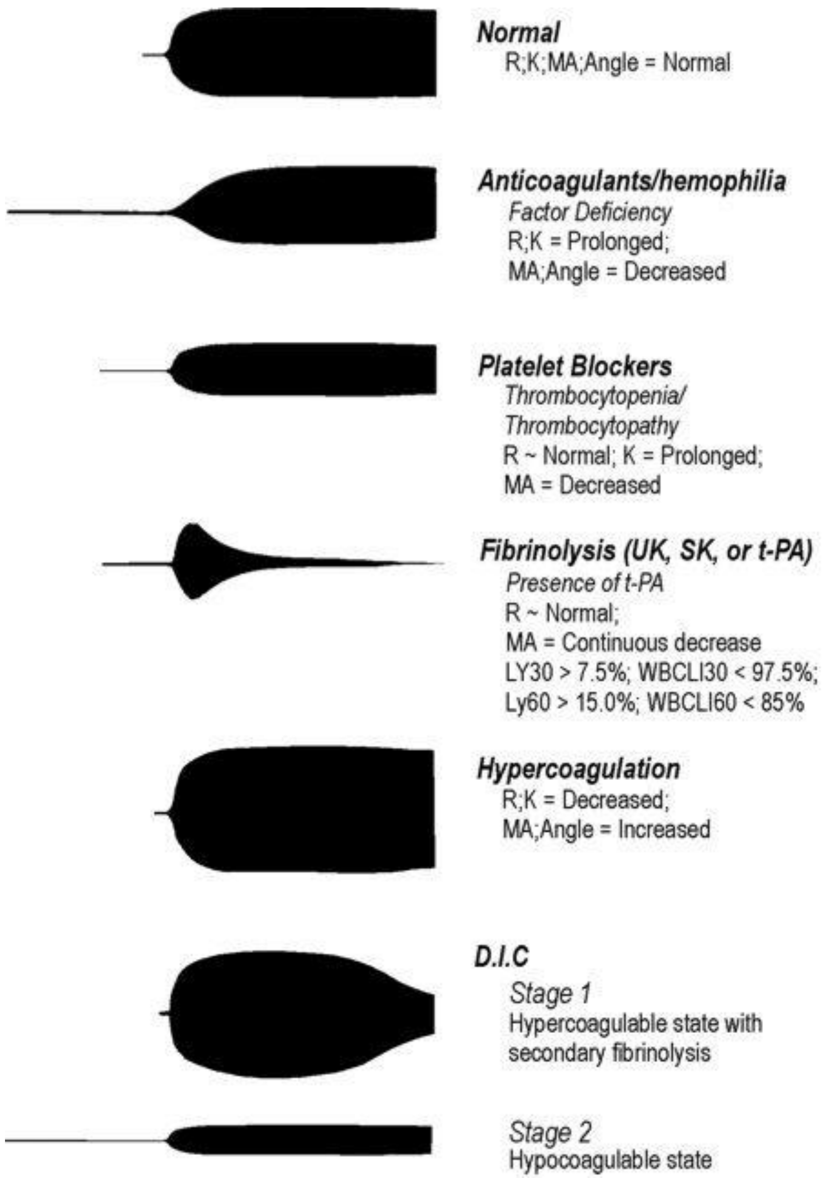

oscillating axis (+- 4,75°)
LED light source
mirror
counterforce spring
detector
ball bearing
data processor
sensor pin
cuvette + sample
temperature
controlled
cuvette holder
clot formation



Key: **R** (minutes) = Reaction time, time from start of test to initial clot formation. **K** (minutes) = Kinetics of clot i.e. time taken to achieve a certain level of clot strength (amplitude of 20 mm). **Alpha angle** (degrees) = measure of the speed at which fibrin build up and cross-linking occurs, assessing clot formation. **MA** (mm) = measure of the ultimate strength of the fibrin clot. **LY30** (%) = percentage decrease in amplitude at 30 minutes after MA, a measure of the degree of fibrinolysis.



Clotting
Time
Kinetics
Strength
Lysis
Maximum Amplitude
Lysis
Reaction time
TEG
α-angle
Clotting Time
α-angle
ROTEM
A
Maximum Clot Firmness
Clot Lysis
Normal
B
Hypercoagulability
C
Hypocoagulability
D
Hyperfibrinolysis
E
Hypofibrinolysis
F



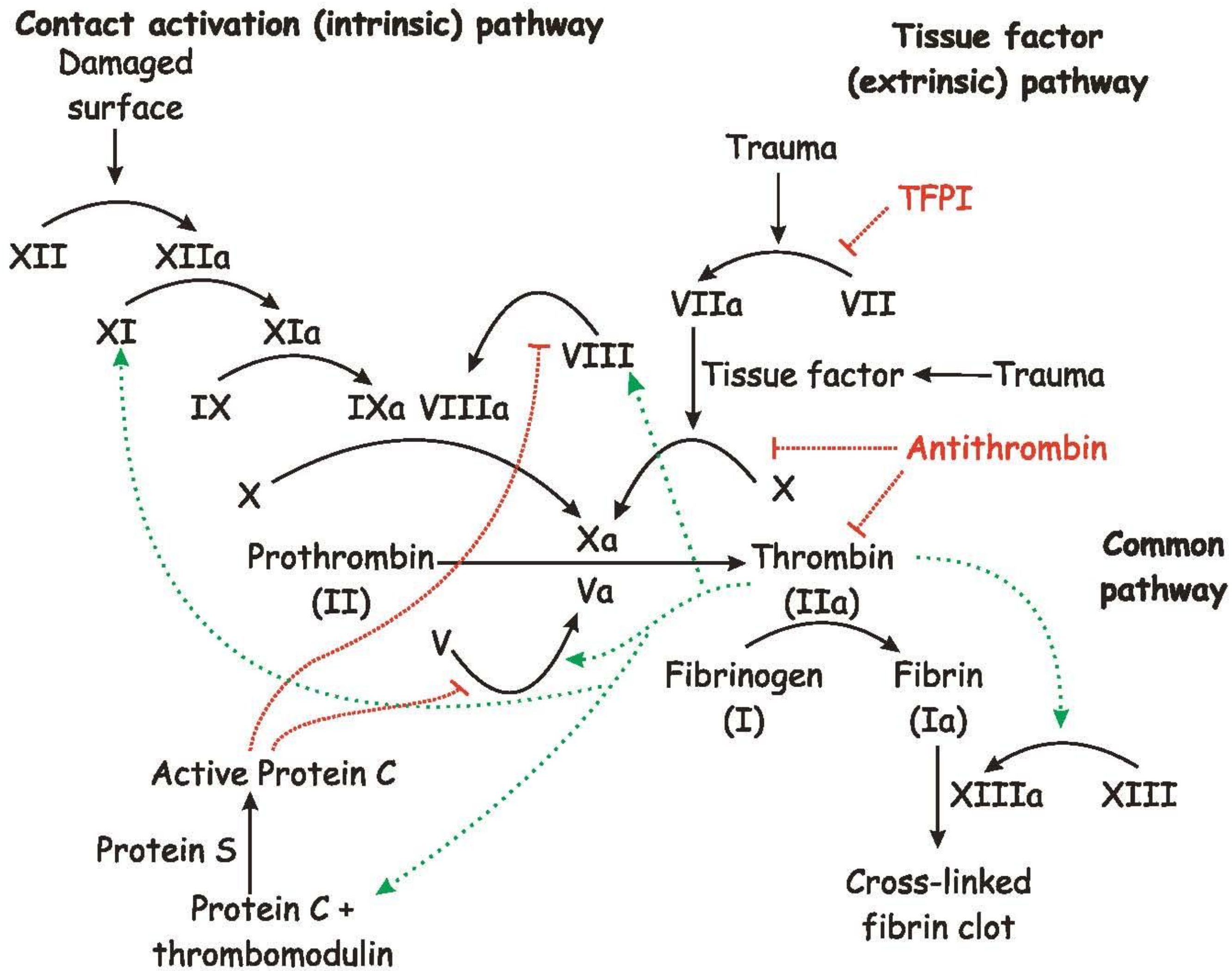
Normal
R;K;MA;Angle = Normal
Anticoagulants/hemophilia
Factor Deficiency
R;K = Prolonged;
MA;Angle = Decreased
Platelet Blockers
Thrombocytopenia/
Thrombocytopathy
R ~ Normal; K = Prolonged;
MA = Decreased
Fibrinolysis (UK, SK, or t-PA)
Presence of t-PA
R ~ Normal;
MA = Continuous decrease
LY30 > 7.5%; WBCLI30 < 97.5%;
Ly60 > 15.0%; WBCLI60 < 85%
Hypercoagulation
R;K = Decreased;
MA;Angle = Increased
D.I.C
Stage 1
Hypercoagulable state with
secondary fibrinolysis
Stage 2
Hypocoagulable state

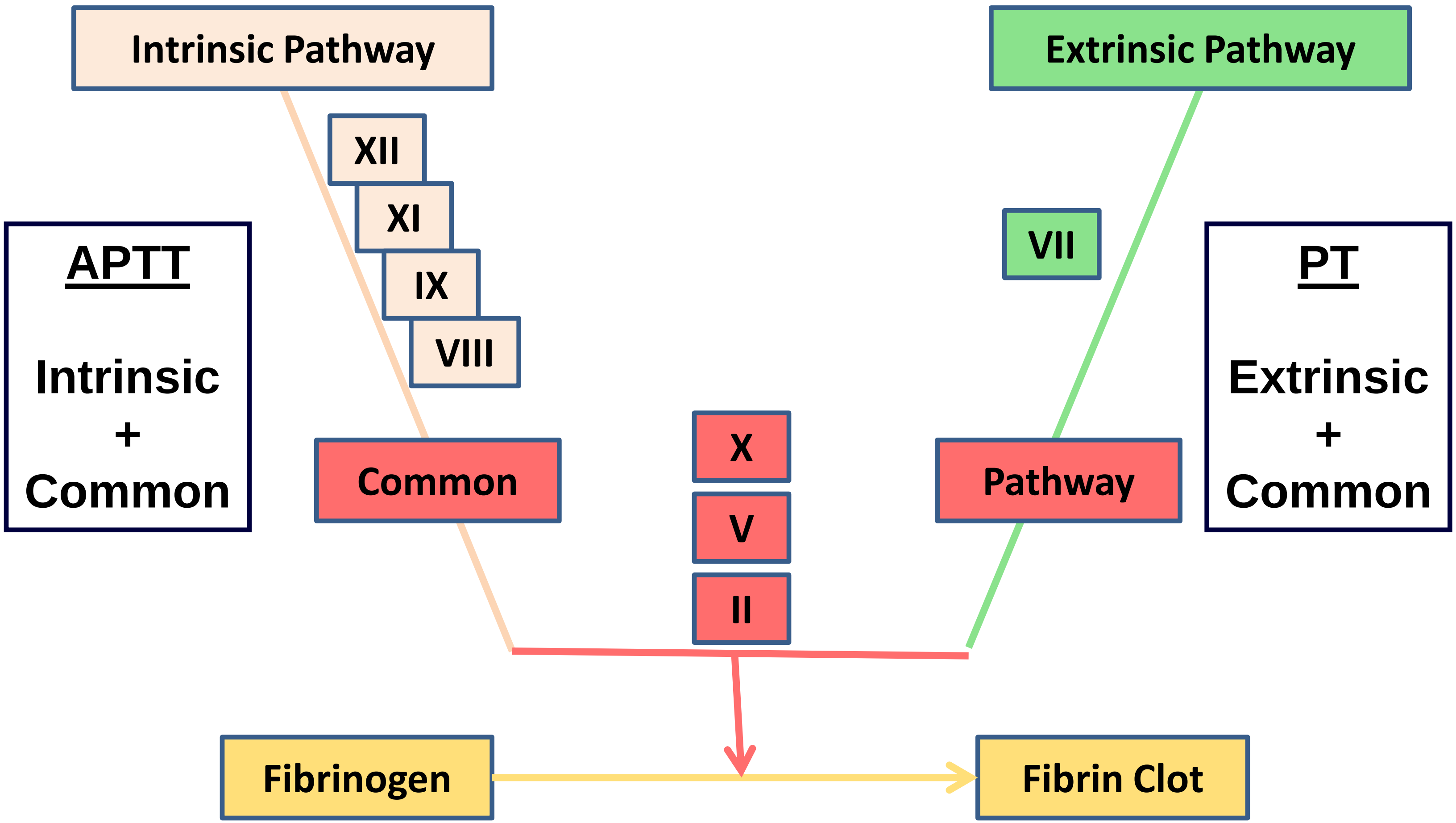
ROTEM tests

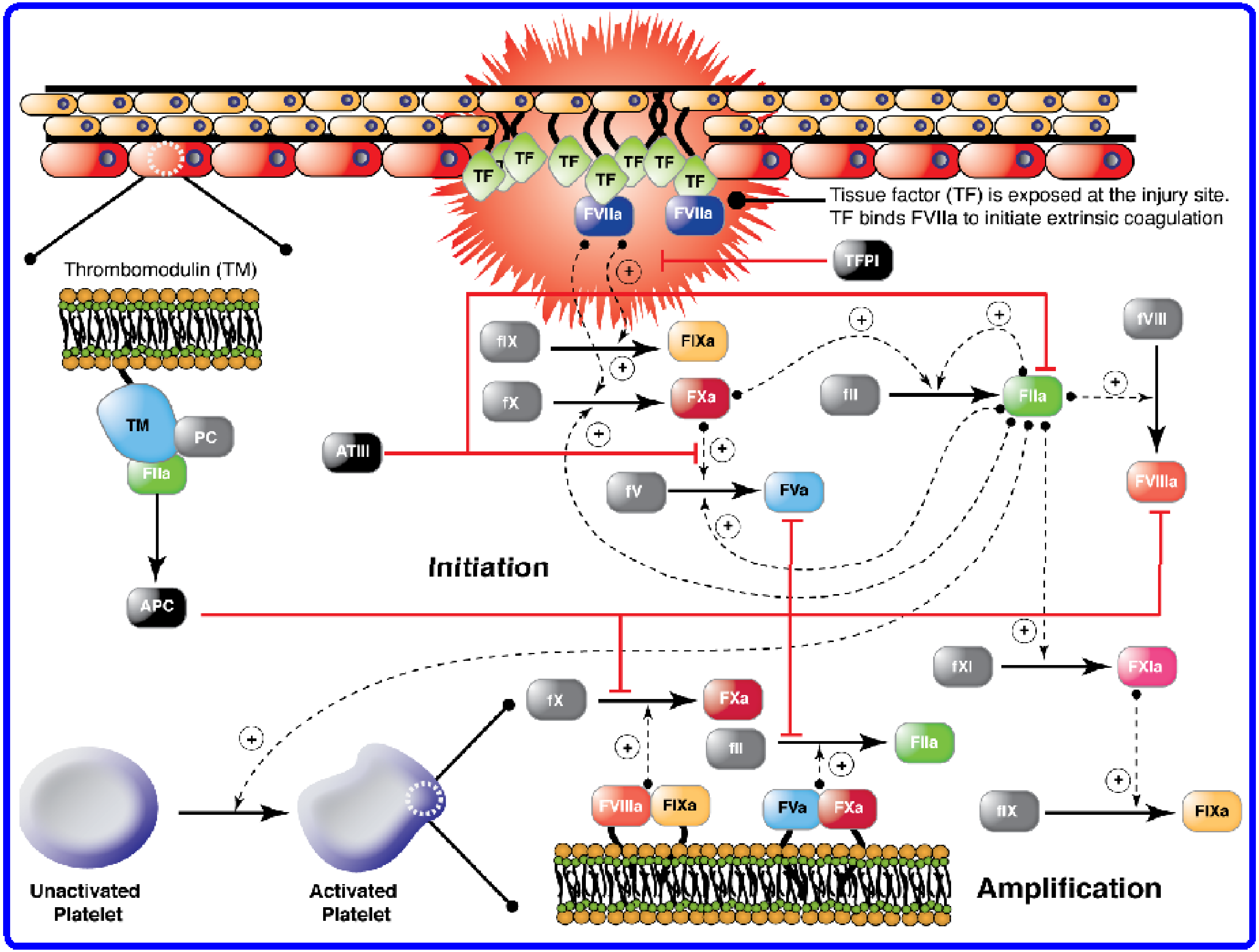
Intem	Mildly activates the contact phase of hemostasis, high heparin sensitivity, screening test
Extem	Mildly activates hemostasis via the physiological activator tissue factor, moderate heparin sensitivity, screening test
Fibtem	EXTEM based assay for measuring fibrinogen. Cytochalasin D inhibits platelet contribution of clot formation
Heptem	Neutralisation of heparin --> measures coagulation without heparin (comparable with Intem)
Aptem	inhibits fibrinolysis --> detection of hyper fibrinolysis (comparable with Extem)

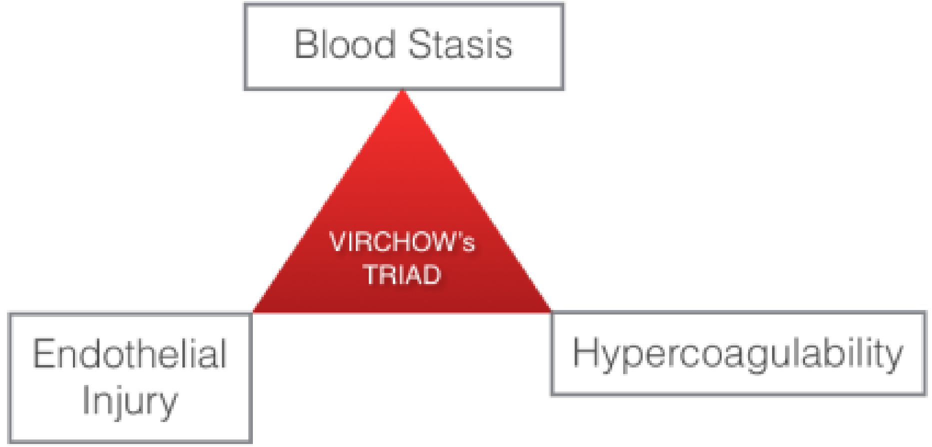
TEG tests

Kaolin TEG	An intrinsic pathway activated assay.
Kaolin TEG with Heparinase	Eliminates the effect of heparin in the test sample.
RapidTEG	An intrinsic and extrinsic pathway activated assay speeds the coagulation process to more rapidly assess coagulation properties.
TEG Functional Fibrinogen	An extrinsic pathway activated assay uses a potent GPIIb/IIIa platelet inhibitor to restrict platelet function to isolate fibrin contribution to clot strength.
TEG Platelet Mapping	Includes a thrombin generated tracing and platelet receptor specific tracing(s) (ADP/AA). Identifies the level of platelet inhibition and Aggregation.

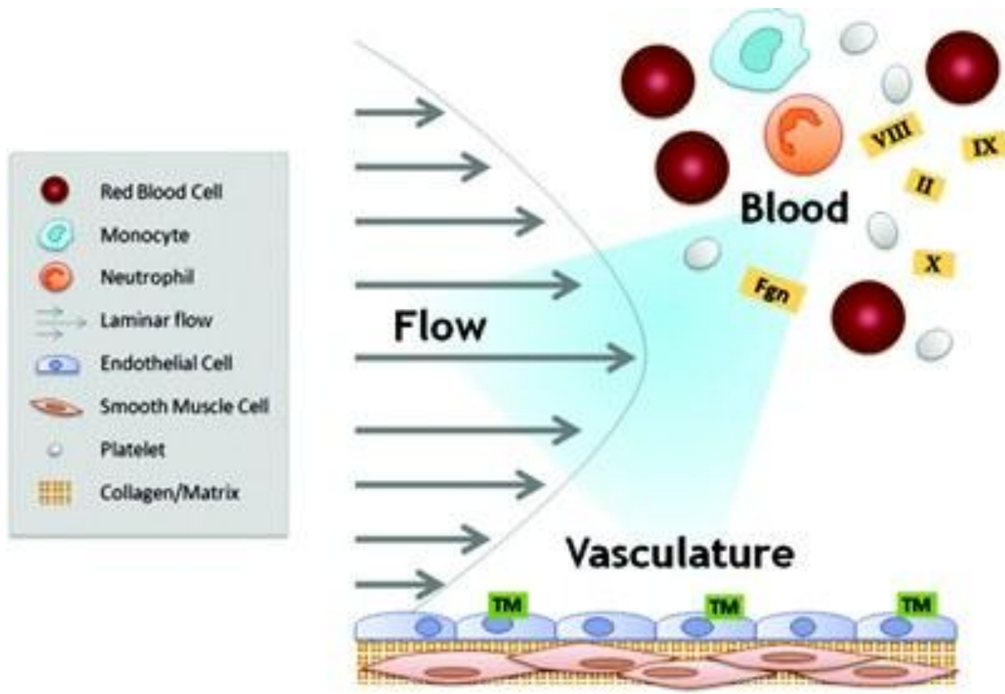

Contact activation (intrinsic) pathway
Damaged surface
XII
XIIa
XI
XIa
IX
IXa VIIIa
VIII
X
Xa
Va
V
Prothrombin (II)
Thrombin (IIa)
Tissue factor (extrinsic) pathway
Trauma
TFPI
VIIa
VII
Tissue factor
Trauma
Antithrombin
X
Common pathway
Fibrinogen (I)
Fibrin (Ia)
XIIIa
XIII
Cross-linked fibrin clot
Active Protein C
Protein S
Protein C + thrombomodulin


Intrinsic Pathway
Extrinsic Pathway
XII
XI
IX
VIII
VII
APTT
Intrinsic
+
Common
PT
Extrinsic
+
Common
Common
X
V
II
Pathway
Fibrinogen
Fibrin Clot

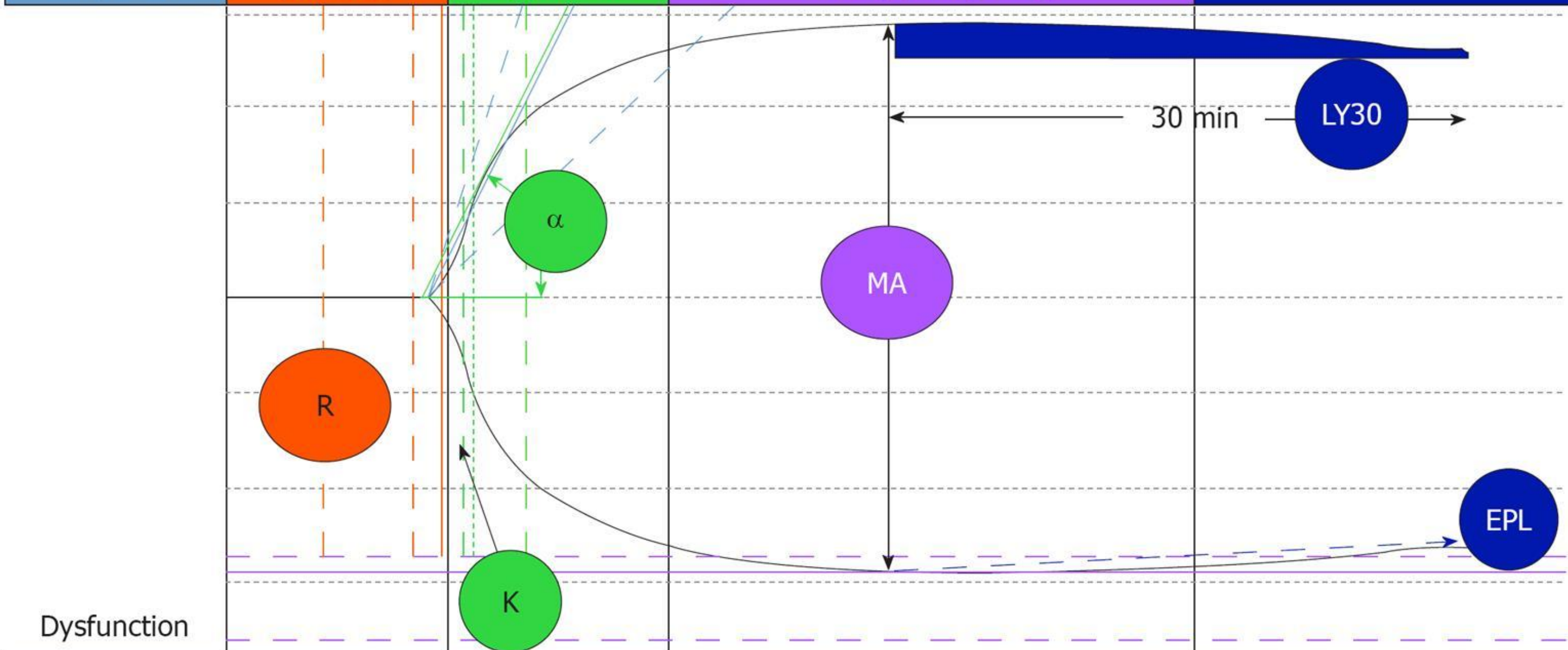

TF
FVIIa
Tissue factor (TF) is exposed at the injury site.
TF binds FVIIa to initiate extrinsic coagulation
TFPI
Thrombomodulin (TM)
TM
PC
FIIa
APC
ATIII
fIX
FIXa
fX
FXa
fII
FIIa
fVIII
FVIIIa
fV
FVa
Initiation
fXI
FXIa
Unactivated Platelet
Activated Platelet
Amplification
+



VIRCHOW'S TRIADE

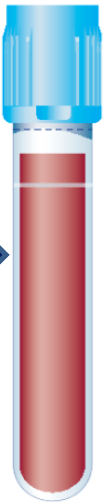


Parameter	Clot time	Clot rate	Maximum clot strength	Clot stability
Hemostatic activity	IIa generation fibrin formation	Fibrin X-linking fibrin←→platelet	Platelet-fibrin(ogen) interactions	Reduction in clot strength
Hemostatic component	Coagulation pathways	Fibrinogen, iIa, platelets	Platelets (80%) Fibrin[ogen (20%)]	Fibrinolysis
Hypo-coagulable	↑ R (min)	↑ K (min) ↓ α (deg)	↓ MA	LY30 > 7.5% EPL > 15%
Hyper-coagulable	↓ R (min)	↓ K (min) ↑ α (deg)	↑ MA	n/a



Performance Assessment ROTEM / TEG

Real life application



Performance Assessment

Performance Assessment ROTEM / TEG

Limitations in External Quality Assessment

ROTEM :	CT	MCF
TEG :	R	MA

Quality Assurance and Quality Control of Thromboelastography and Rotational Thromboelastometry: The UK NEQAS for Blood Coagulation Experience

Dianne P. Kitchen, F.I.B.M.S.,[1] Steve Kitchen, Ph.D.,[1] Ian Jennings, Ph.D.,[1]
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Table 3 Rotation Thromboelastometer Results

Sample and Test Performed	Parameter	Median	CV	Range of Results
1: Spiked heparin sample				
ITEM $n = 10$	CT sec	369	13	304–454
	MCF mm	35.5	12.3	28–41
HEPTEM $n = 8$	CT sec	157	24.8	138–267
	MCF mm	37	9.5	34–44
2: Normal sample				
ITEM $n = 9$	CT sec	147	10.4	126–161
	MCF mm	39	8.8	36–46
EXTEM $n = 9$	CT sec	48	*121.1 (18.7)	39–334
	MCF mm	41	8.3	36–47

Performance Assessment ROTEM

NORMAL PLASMA

EXTEM (CT) sec	N	Mean	Range	CV (%)
All	85	55.8	38 – 117	16.2
Delta: Single-use	32	52.3	39 – 117	19.8
Delta: Liquid	39	58.2	38 – 86	12.2
Sigma	14	56.8	42 – 72	7.6

EXTEM (CT) sec	N	Mean	Range	CV (%)
All	80	49.1	37 - 80	13.0
Delta: Single-use	22	42.9	37 - 50	10.7
Delta: Liquid	41	50.2	45 - 78	7.3
Sigma	17	56.4	42 - 80	18.3

Performance Assessment ROTEM

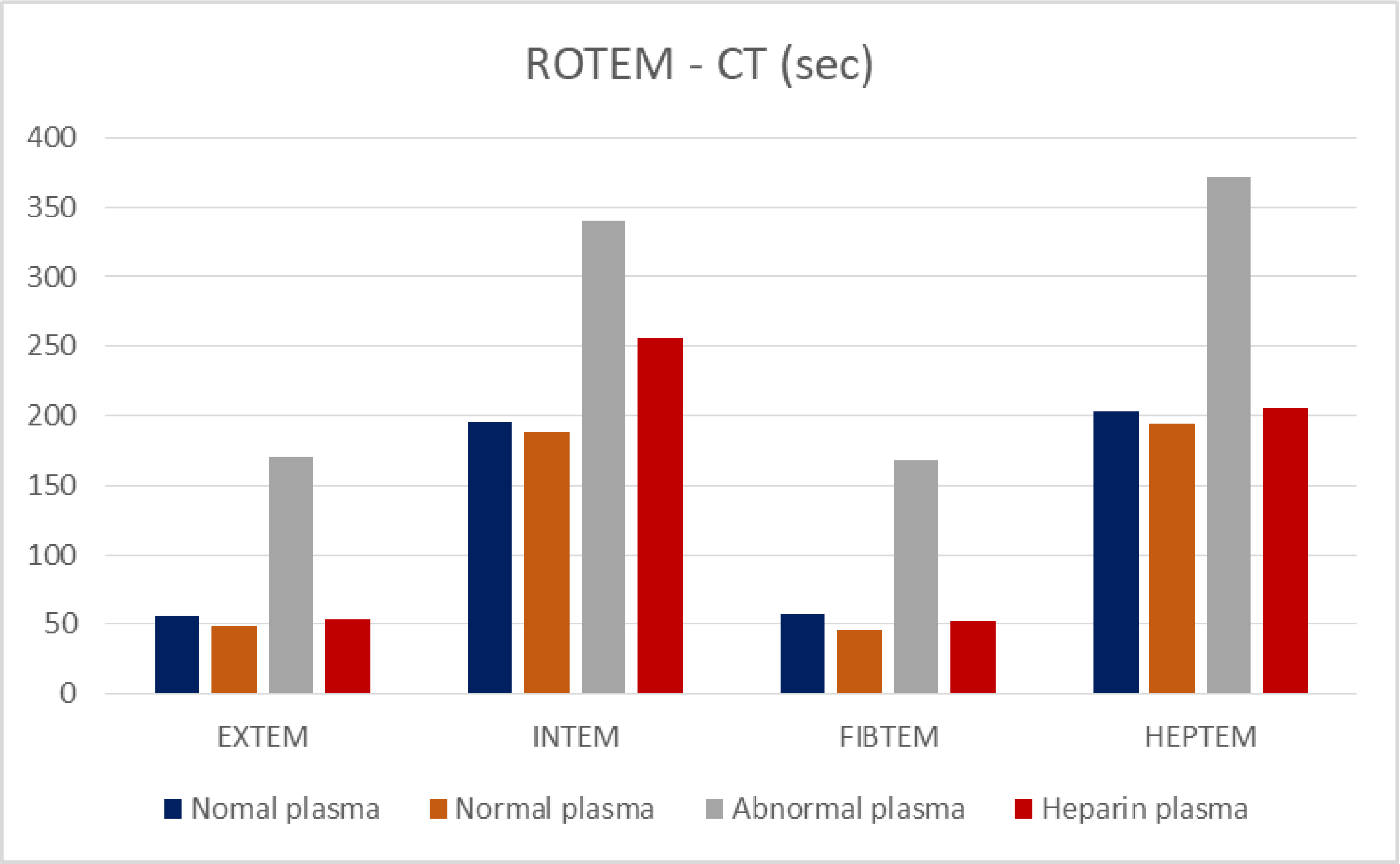
UNFRACTIONATED HEPARIN PLASMA

EXTEM (CT) sec	N	Mean	Range	CV (%)
All	80	54.1	40 – 146	8.6
Delta: Single-use	22	52.6	47 - 60	6.4
Delta: Liquid	41	54.2	45 - 146	7.8
Sigma	17	61.3	40 - 103	27.3

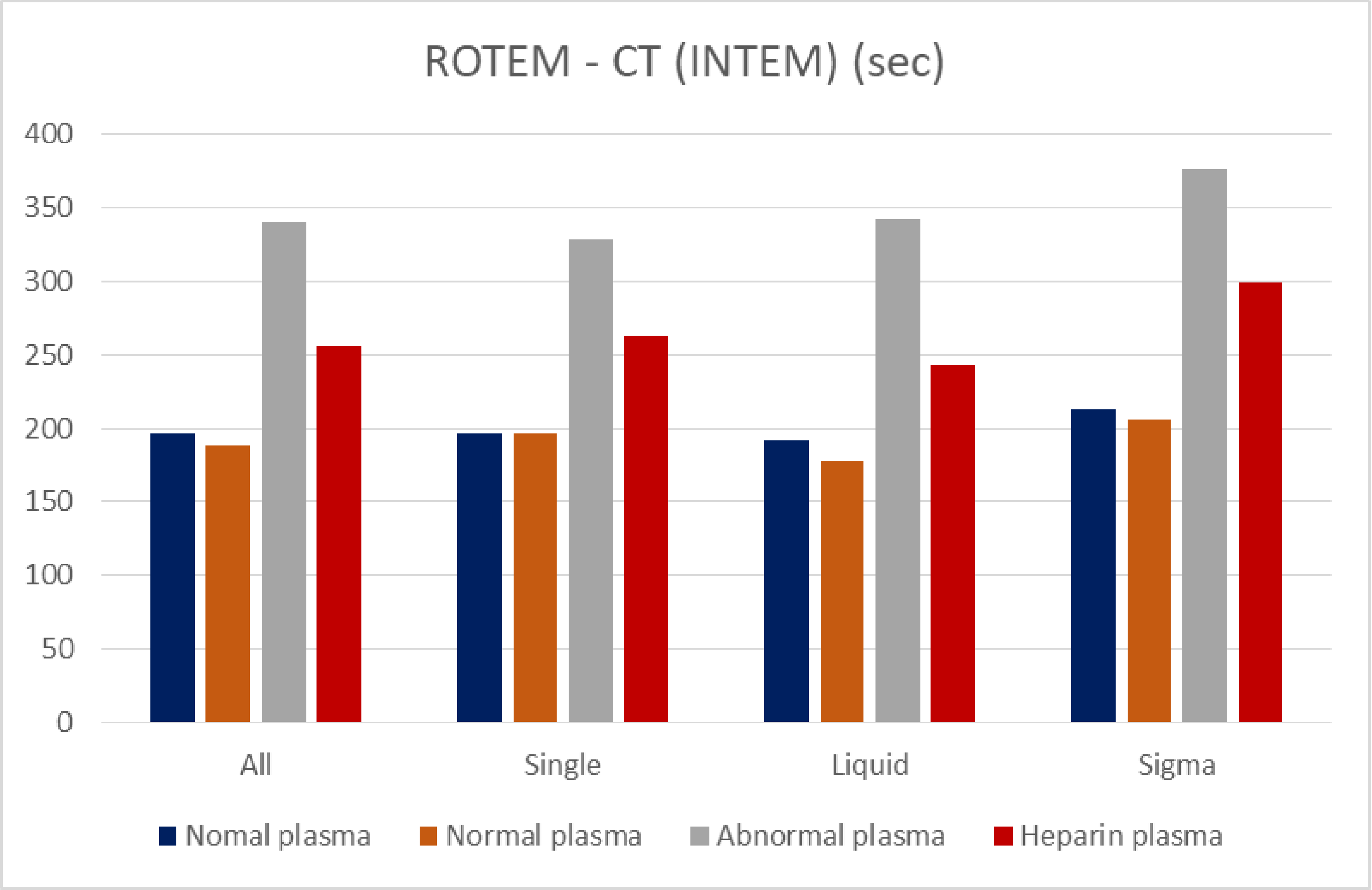
LOW COAGULATION FACTOR PLASMA

EXTEM (CT) sec	N	Mean	Range	CV (%)
All	86	170.8	86 – 790	29.5
Delta: Single-use	31	139.7	86 – 656	41.4
Delta: Liquid	41	180.4	118 – 220	11.0
Sigma	14	239.0	145 - 790	41.7

Performance Assessment ROTEM



Performance Assessment ROTEM



Performance Assessment ROTEM

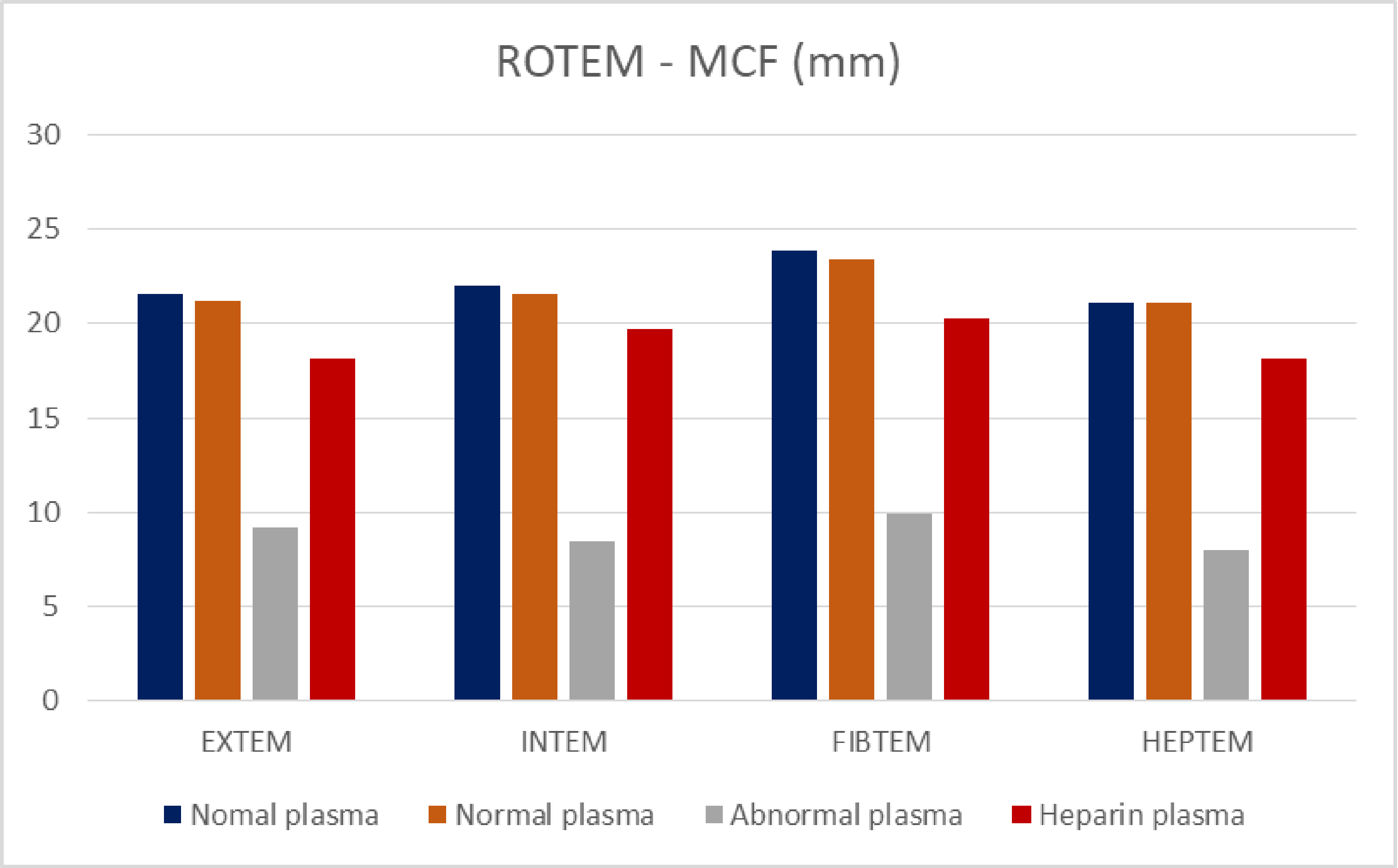
NORMAL PLASMA

CT CV (%)	EXTEM	INTEM	FIBTEM	HEPTEM
All	16.2	6.5	14.0	9.9
Delta: Single-use	19.8	3.0	13.9	9.4
Delta: Liquid	12.2	6.5	15.5	10.1
Sigma	7.6	17.1	12.8	-

LOW COAGULATION FACTOR PLASMA

CT CV (%)	EXTEM	INTEM	FIBTEM	HEPTEM
All	29.5	10.0	16.0	12.8
Delta: Single-use	41.4	6.8	19.7	10.8
Delta: Liquid	11.0	9.0	12.3	11.0
Sigma	41.7	22.9	34.9	-

Performance Assessment ROTEM



Performance Assessment ROTEM

NORMAL PLASMA

MCF CV (%)	EXTEM	INTEM	FIBTEM	HEPTEM
All	8.7	10.1	7.4	12.6
Delta: Single-use	10.3	8.2	9.4	6.2
Delta: Liquid	6.2	5.7	5.4	9.6
Sigma	9.1	12.8	5.0	-

LOW COAGULATION FACTOR PLASMA

MCF CV (%)	EXTEM	INTEM	FIBTEM	HEPTEM
All	15.8	15.8	13.1	20.0
Delta: Single-use	14.6	10.5	13.3	23.0
Delta: Liquid	12.0	12.6	11.0	10.8
Sigma	18.8	20.0	10.7	-

Quality Assurance and Quality Control of Thromboelastography and Rotational Thromboelastometry: The UK NEQAS for Blood Coagulation Experience

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Table 1 Thromboelastrograph Results

Sample and Test Performed	Parameter	Median	CV	Range of Results
1: Spiked heparin sample				
Plain cup $n = 12$		No clot formed	–	–
Heparinased cup $n = 12$	R min	5.1	17.2	3.9–5.9
	MA mm	42.4	10.3	37.9–53.8
2: Normal sample				
Plain cup $n = 12$	R min	5.55	14.5	4.8–6.6
	MA mm	44.2	7.6	41.7–53.4
8: Normal sample				
Plain cup $n = 18$	R min	12.9	19.9	7.8–20.8
	MA mm	31.6	11.3	28.0–42.5
Heparinased cup $n = 14$	R min	13.9	38.6	8.8–33.8
	MA mm	29.1	7.7	28–34.4

Performance Assessment TEG

NORMAL PLASMA

R (min)	N	Mean	Range	CV (%)
Plain cup	20	15.6	10.1 – 34.9	32.3
Heparinased cup	13	24.3	15.5 – 37.2	36.6

UNFRACTIONATED HEPARIN PLASMA

R (min)	N	Mean	Range	CV (%)
Plain cup	17	332	25.4 - 800	122
Heparinased cup	17	25.2	16.2 – 47.2	31.9

LOW COAGULATION FACTOR PLASMA

R (min)	N	Mean	Range	CV (%)
Plain cup	17	57.5	7.9 - 120	72.9
Heparinased cup	8	120.0	30.8 - 120	-

Performance Assessment TEG

NORMAL PLASMA

MA (mm)	N	Mean	Range	CV (%)
Plain cup	20	28.6	25.3 – 46.5	7.9
Heparinased cup	12	24.4	14.9 – 29.5	15.1

UNFRACTIONATED HEPARIN PLASMA

MA (mm)	N	Mean	Range	CV (%)
Plain cup	5	-	-	-
Heparinased cup	17	23.6	19.5 – 31.2	14.0

LOW COAGULATION FACTOR PLASMA

MA (mm)	N	Mean	Range	CV (%)
Plain cup	8	14.0	11.3 – 70.0	-
Heparinased cup	2	44.5	10.4 – 78.6	-

Concluding Remarks

- For external quality assessment for ROTEM and TEG we have to compromise with the use of plasma. This makes the evaluation of only a limited number of parameters possible.
- EQA for TEG is more difficult because of the sensitivity for abnormalities.
- Although the sometimes relative high between-monitor CV most participants are able to properly discriminate between normal and abnormal samples.