Prise en charge de l'hémostase en chirurgie cardiaque, circonstances particulières : héparine / protamine / Rotem

Cours aux résident.e.s en anesthésie

Antoine G Rochon MD FRCPC

Montréal, le 18 septembre 2025

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

ANESTHÉSIOLOGIE • ICM

Université de Montréal

Conflits d’intérêts

– Aucun

Objectifs: à la fin de ce séminaire, le participant devrait pouvoir :

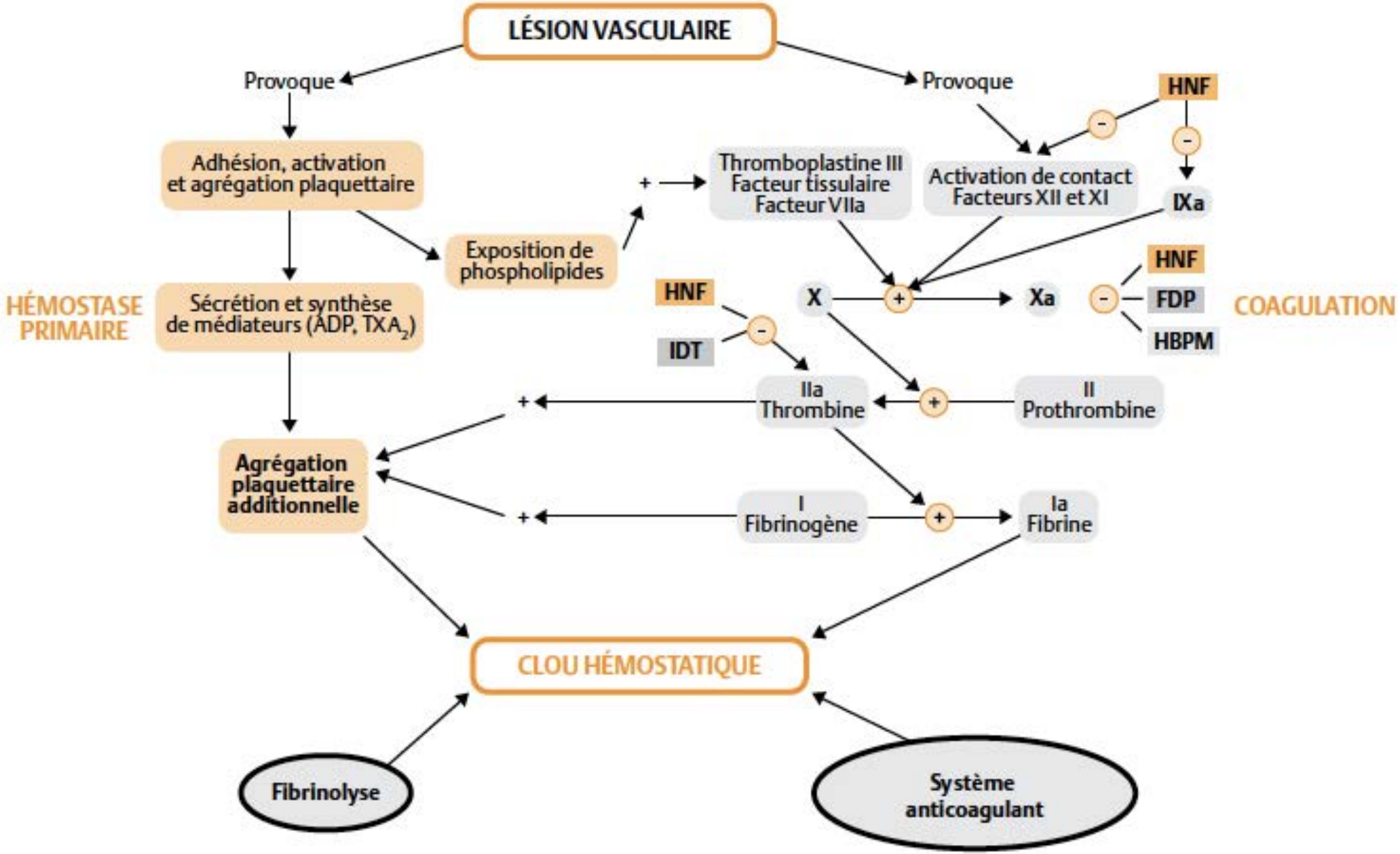
- Comprendre le fonctionnement de l'héparine et de la protamine.
- Reconnaître et prendre en charge un cas de résistance à l'héparine.
- Décrire comment fonctionnent les tests viscoélastiques.
- Identifier les avantages et les limites des tests viscoélastiques.
- Interpréter des temogrammes cliniques.

Gestion personnalisée du sang

	1er pilier Optimiser l'érythropoïèse	2e pilier Minimiser les pertes sanguines & le saignement	3e pilier Optimiser la réponse physiologique à l'anémie
Postopératoire	• Stimuler l'érythropoïèse	• Monitorer attentivement et prendre en charge le saignement postopératoire • Éviter toute reprise d'un saignement • Éviter toute hypothermie et traiter activement si celle-ci apparaît • Récupérer le sang autologue • Minimiser les pertes sanguines iatrogènes • Prendre en charge l'hémostase et l'anticoagulation • Administrer une prophylaxie du saignement digestif haut (?) • Éviter/traiter rapidement toute infection	• Maximiser la livraison d'oxygène • Minimiser la consommation d'oxygène • Éviter/traiter rapidement toute infection • Utiliser un seuil transfusionnel restrictif, en accord avec les recommandations internationales

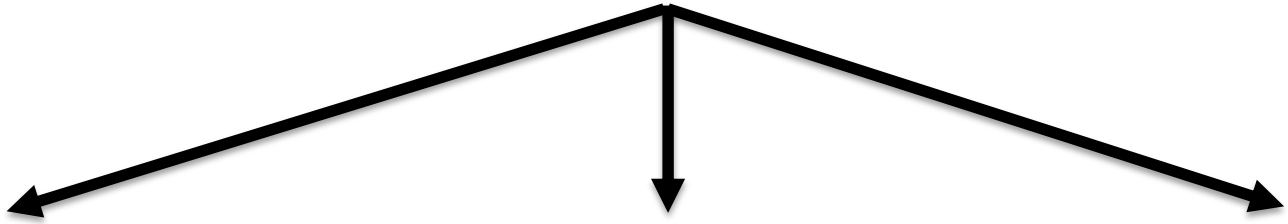
Hardy JF 2021.

Hémostase:



Rochon et als. *Précis de pharmacologie* 2e ed 2015:385-403.

Pathophysiologie des anomalies de l'hémostase associées à la CEC



HÉMODILUTION

- Amorce de CEC
- Volume de cardioplégie
- Utilisation prolongée du *cell saver*

ACTIVATION

- Activation de contact
- Activation du facteur tissulaire:
  - Monocytes
  - Incision
  - Sang dans péricarde
- Activation de la fibrinolyse

CONSOMMATION

- Via la thrombine
- Via la plasmine
- Via l'inflammation
- Mécanique:
  - Oxygénateur
  - Suction de cardiotomie
  - Filtre de CEC
  - pompe

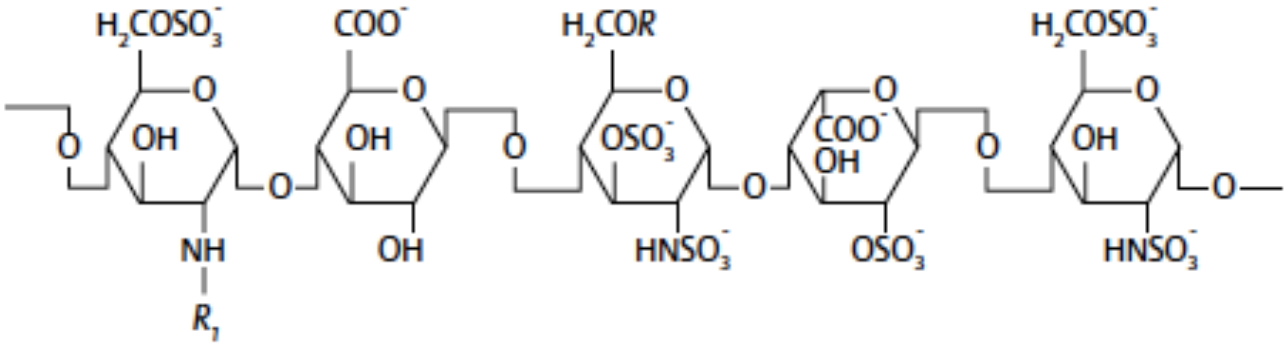
Despotis et als. Anesth. 1999;91:1122-1151.

Héparine:

- Découverte en 1916 par Jay MacLean et William H Howell.
- Glycosaminoglycan
- D’origine animale
- Agit vite / neutralisable

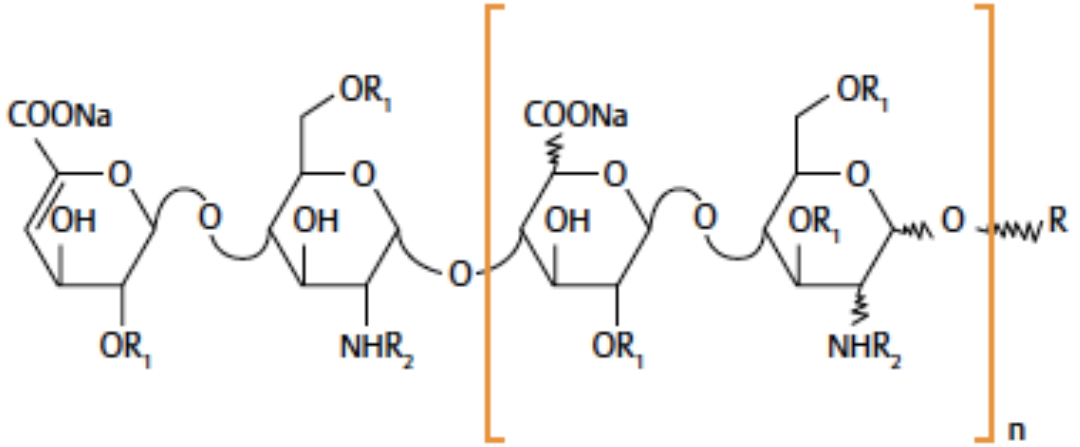
Héparine non fractionnée

- chaînes de 16 à 80 saccharides
- 3 à 30 kDa

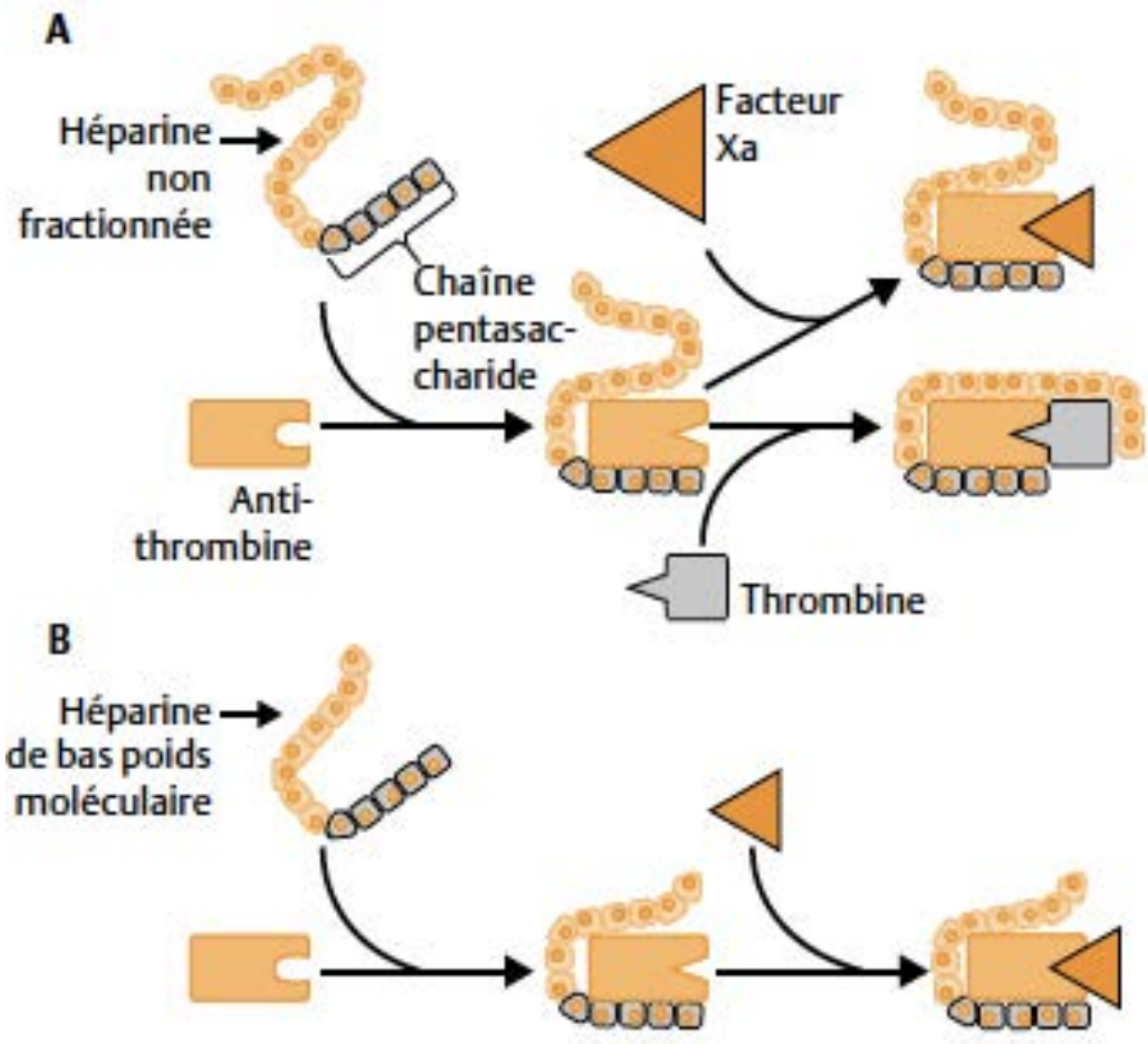


Héparine de bas poids moléculaire

- Chaînes de 13 à 22 saccharides
- 4 à 6 kDa



Rochon et als. *Précis de pharmacologie* 2e ed 2015:385-403.



Rochon et als. *Précis de pharmacologie* 2e ed 2015:385-403.

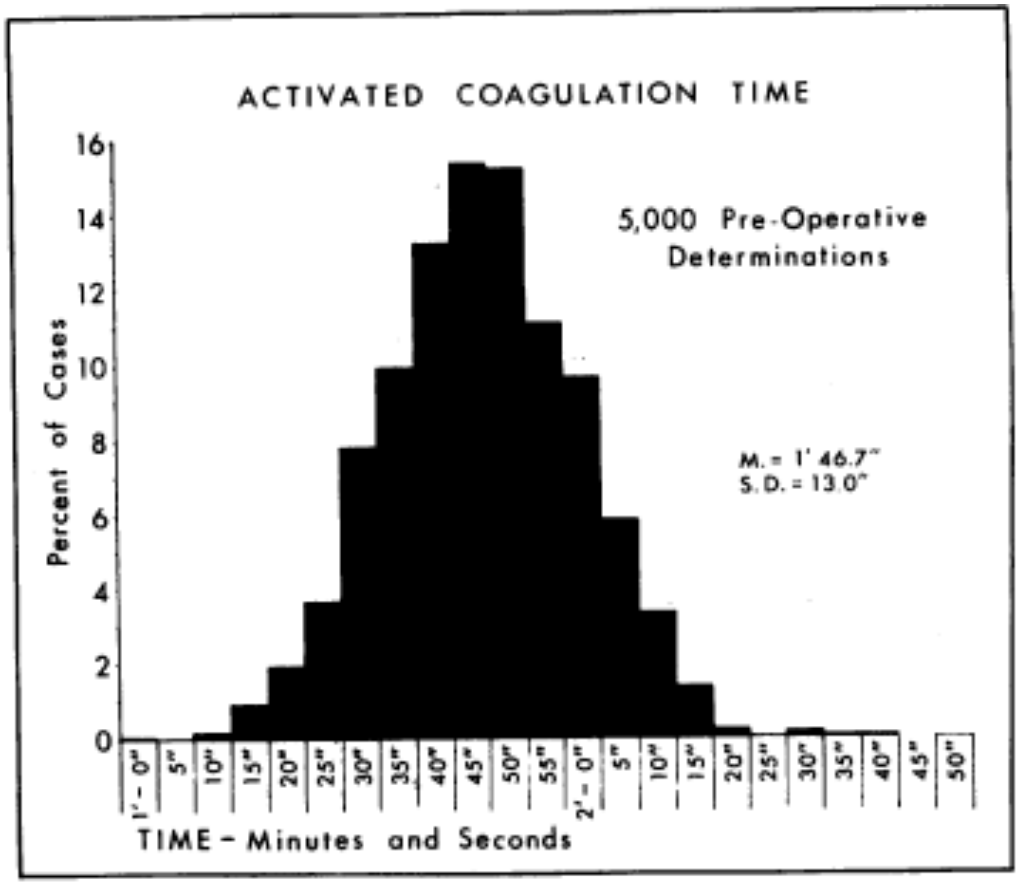
Monitoring de l’héparinémie:

The Activated Coagulation Time of Whole Blood as a Routine Pre-Operative Screening Test

Hattersley. Calif Med 1971;114(5):15-8.

The Activated Coagulation Time of Whole Blood as a Routine Pre-Operative Screening Test

Hattersley. Calif Med 1971;114(5):15-8.



Adequate Anticoagulation During Cardiopulmonary Bypass Determined by Activated Clotting Time and the Appearance of Fibrin Monomer

John A. Young, M.D., C. Thomas Kisker, M.D., and Donald B. Doty, M.D.

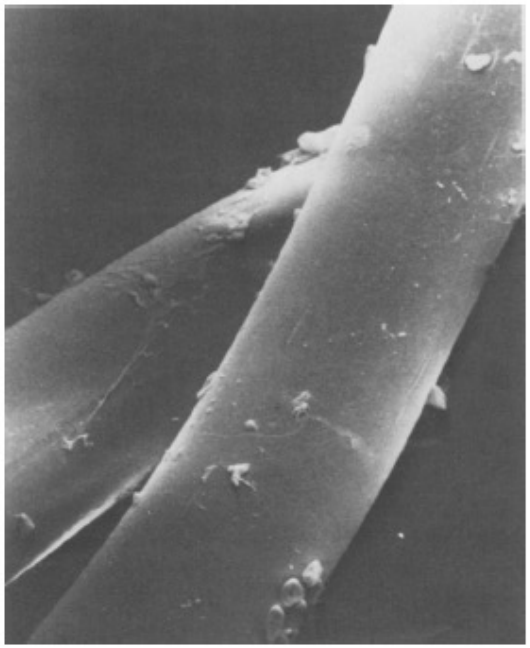
Ann Thorac Surg. 1978;26(3):231-40.

Adequate Anticoagulation During Cardiopulmonary Bypass Determined by Activated Clotting Time and the Appearance of Fibrin Monomer

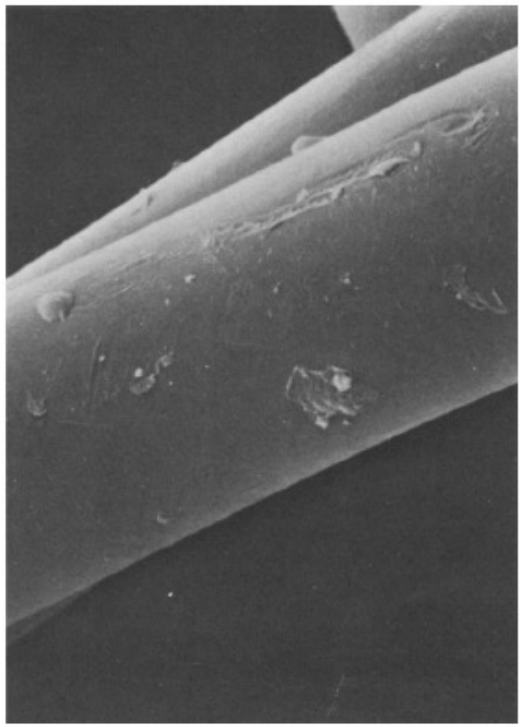
John A. Young, M.D., C. Thomas Kisker, M.D., and Donald B. Doty, M.D.

Ann Thorac Surg. 1978;26(3):231-40.

ACT < 400 sec



ACT > 450 sec



ACT > 700 sec

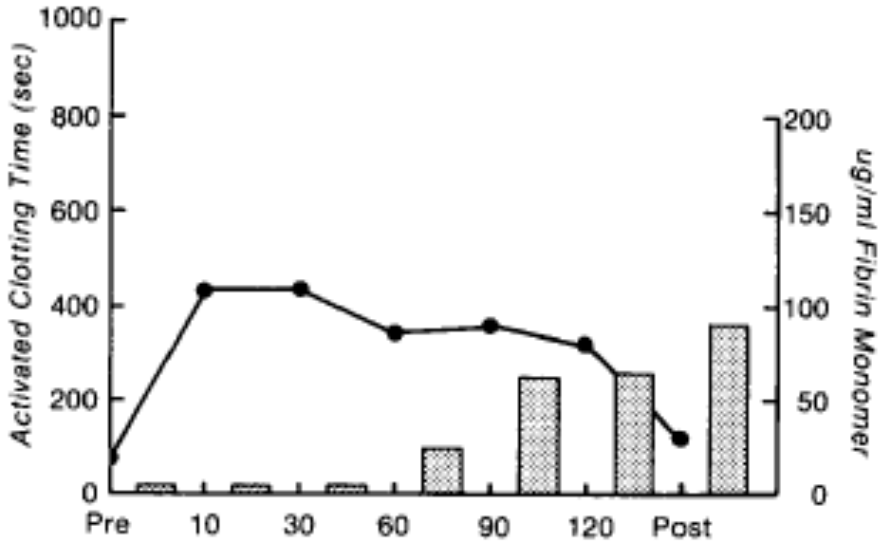


Fig 1. Whole-blood activated clotting time (ACT) and fibrin monomer levels at time intervals before, during, and after 120 minutes of cardiopulmonary bypass in 1 experiment. When ACT dropped below 400 seconds at 60 minutes of CPB, fibrin monomer was detected in plasma (bar graph), indicating that excessive coagulation was occurring.

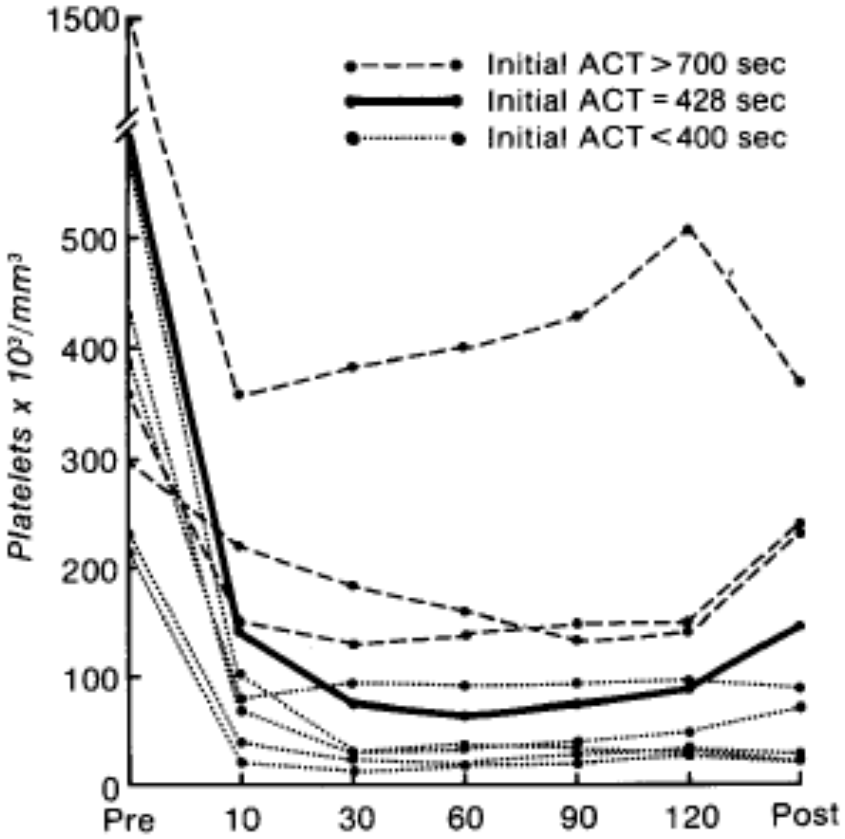


Fig 2. Platelet count in each experiment during 120 minutes of cardiopulmonary bypass, plotted according to initial whole-blood activated clotting time (ACT) on bypass. Platelet counts decreased to lower levels at an ACT of less than 400 seconds than when ACT was greater than 700 seconds. The experiment with an initial ACT equal to 428 seconds shows a course similar to that with ACT greater than 700 seconds.

Young Ann Thorac Surg. 1978;26(3):231-40.

Célite

- Terre de diatomée
- 80 – 90 silicone
- Utilisé comme pesticide “biologique”
- Utilisé dans le dentifrice, la litière de chat et dans la culture des bonsaï

Kaolin

- Argile, silicate d’aluminium
- Utilisé dans la confection de la porcelain,dans l’industrie du papier, comme antidiarrhéique

The activated clotting time in cardiac surgery: should Celite or kaolin be used?

Adrianus J. De Vries[a,*], Annemieke Oude Lansink-Hartgring[b], Freek-Jan Fernhout[c], Rolf C. G. Huet[a] and Edwin R. van den Heuvel[d]

Interact CardioVasc Thorac Surg2017;24:549-54

	Celite ($n=48$)	Kaolin ($n=49$)	P-value
Total heparin dose, IU	35 271 ± 12 406	35 997 ± 11 540	0.77
Heparin supplements, *n*	51	56	0.53
Haemoglobin, mmol/l	5.8 ± 0.7	5.7 ± 0.7	0.28
Platelets, x10^9/l	156 ± 51	151 ± 56	0.64
Prothrombin time, s	12.9 ± 1.3	12.9 ± 1.2	0.95
Activated partial thromboplastin time, s	30.2 ± 4.9	30.8 ± 3.1	0.50
Fibrinogen, g/l	2.1 ± 0.7	2.1 ± 0.6	0.96
Antithrombin III, %	55 ± 13	57 ± 10	0.57
D-dimer, ng/ml	2836 ± 2950	2236 ± 2656	0.29
F1.2 fragment, pM/l	1325 ± 981	1221 ± 894	0.59
Postoperative blood loss, ml	613 ± 473	569 ± 310	0.59
Red blood cells, *n* (%)	6 (13)	7 (14)	0.22
Fresh frozen plasma, *n* (%)	1 (2)	2 (4)	1.00
Platelets, *n* (%)	1 (2)	1 (2)	1.00
Intensive care stay, days	1.4 ± 1.2	2.0 ± 4.5	0.36

The Society of Thoracic Surgeons, The Society of Cardiovascular Anesthesiologists, and The American Society of ExtraCorporeal Technology: Clinical Practice Guidelines*—Anticoagulation During Cardiopulmonary Bypass

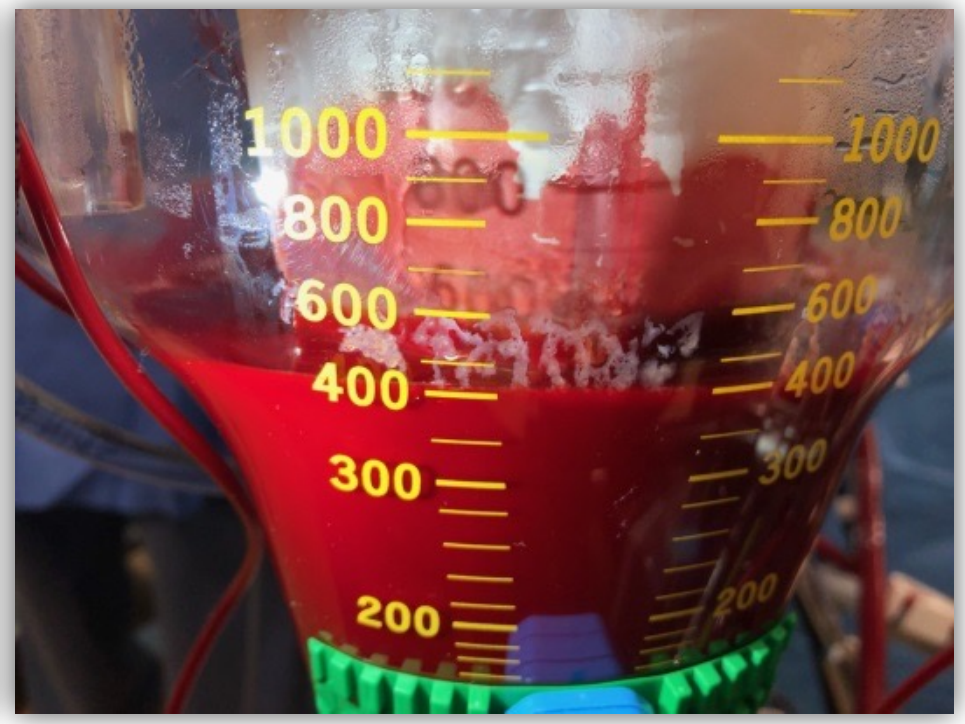
Linda Shore-Lesserson, MD, Robert A. Baker, PhD, CCP, Victor A. Ferraris, MD, PhD, Philip E. Greilich, MD, David Fitzgerald, MPH, CCP, Philip Roman, MD, MPH, and John W. Hammon, MD

Ann Thorac Surg 2018;105:650-62.

“ Il est raisonnable de maintenir l’ACT au dessus de 480 secondes ”

Problématiques 2015 à 2019

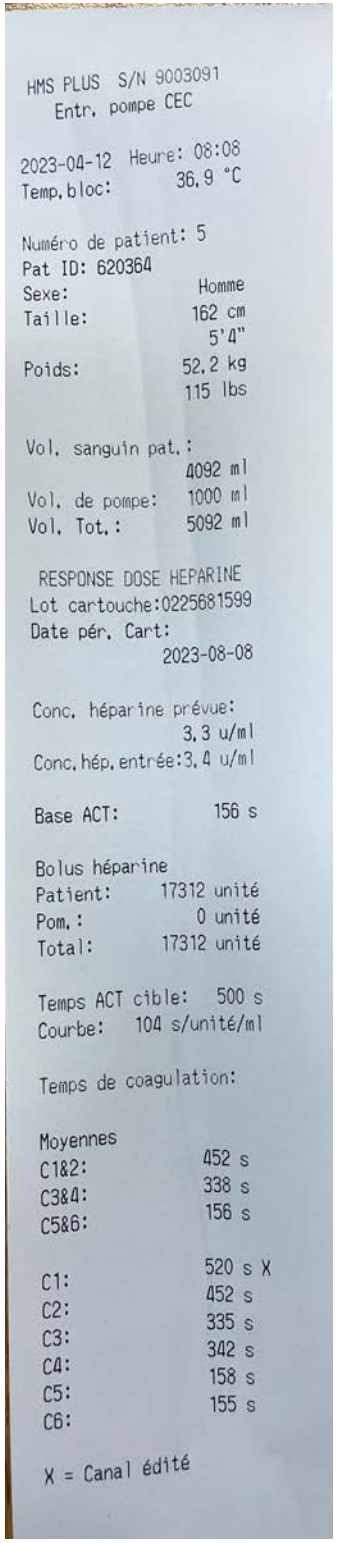
- Présence de caillots dans des réservoirs de la CEC et deux évènements thrombotiques



ACT Plus

HEPCON HMS


Custodiol
DEL NIDO
1000ml/sac
Heparin Dose Response Levels / Werte für Heparindosisreaktion / Niveles de respuesta a dosis de heparina /
Niveaux de la dose/réponse à l'héparine / Livelli di risposta alla dose di eparina
2.84 U/mL
2.84 U/mL
1.70 U/mL
1.70 U/mL
0.0 U/mL
0.0 U/mL
M956368A001 Rev A



HMS PLUS S/N 9003091
Entr. pompe CEC

2023-04-12 Heure: 08:08
Temp. bloc: 36,9 °C

Numéro de patient: 5
Pat ID: 620364
Sexe: Homme
Taille: 162 cm
5'4"
Poids: 52,2 kg
115 lbs

Vol. sanguin pat.:
4092 ml
Vol. de pompe: 1000 ml
Vol. Tot.: 5092 ml

RESPONSE DOSE HEPARINE
Lot cartouche:0225681599
Date pér. Cart:
2023-08-08

Conc. héparine prévue:
3,3 u/ml
Conc. hép. entrée:3,4 u/ml

Base ACT: 156 s

Bolus héparine
Patient: 17312 unité
Pom.: 0 unité
Total: 17312 unité

Temps ACT cible: 500 s
Courbe: 104 s/unité/ml

Temps de coagulation:

Moyennes
C1&2: 452 s
C3&4: 338 s
C5&6: 156 s

C1: 520 s X
C2: 452 s
C3: 335 s
C4: 342 s
C5: 158 s
C6: 155 s

X = Canal édité

HMS PLUS S/N 9003091
Entr. pompe CEC

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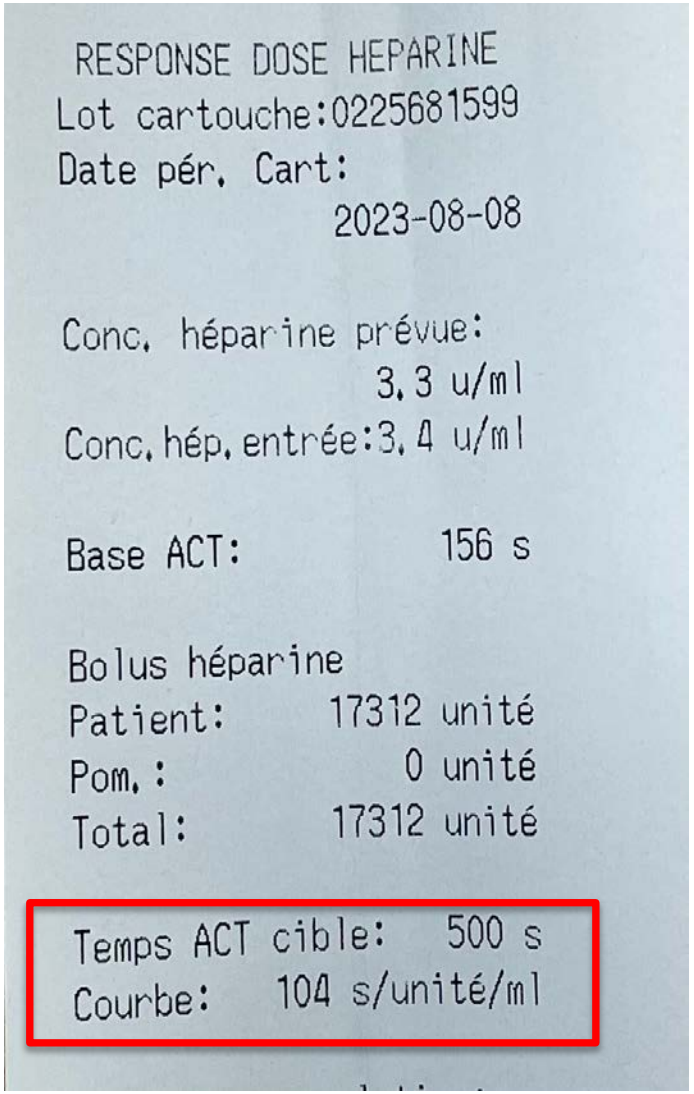

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Temps ACT cible: 500 s
Courbe: 104 s/unité/ml

Anticoagulation Management and Heparin Resistance During Cardiopulmonary Bypass: A Survey of Society of Cardiovascular Anesthesiologists Members

Roman M. Sniecinski, MD, MSc,* Elliott Bennett-Guerrero, MD,† and Linda Shore-Lesserson, MD‡

Automne 2017, 2972 sondages , 550 réponses (18,5%)

Anesthesiology Dec 2018; epub

GESTION DE L'HÉPARINE	2017		1993
Dosage empirique (IU/kg)	74,9%		95%
Calcul dose réponse (Hepcon)	24,5%		
ACT cible uniquement	84,7%		99%
ACT cible & [héparine]	13,1%		
Héparine ajoutée au circuit de CEC?	oui 84%	non 13%	
Héparine additionnelle pour maintenir l'ACT?	88,4%		
Héparine additionnelle pour maintenir [hep]	6,7%		
ACT cible non atteint = concentrés AT3	54,2%		
ACT cible non attaint = PFC	38,4%		
ACT cible non atteint = initier CEC quand même	0,9%		

Sniecinski Anesthesiology Dec 2018; epub

Quel niveau d'AT3 est nécessaire?

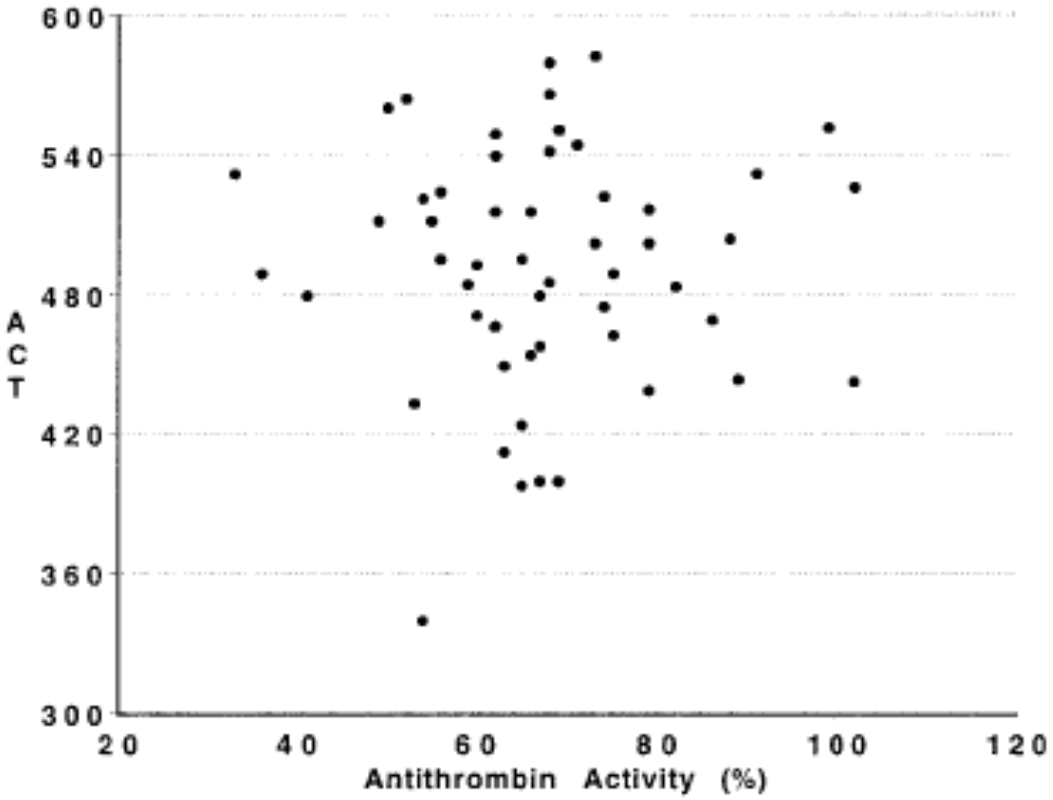


Figure 1. Scattergraph showing the apparent lack of correlation between kaolin ACT duration and AT activity after administration of greater than 600 U/kg heparin in 53 patients ($r = 0.01$).

- Relation non linéaire
- Seuls les patients avec AT3 < 80% n'ont pas atteints un ACT > 420
- Certains patients avec AT3 < 60% ont eu ACT thérapeutique

Lemmer et als. J Thorac Cardiovasc Surg 2002;123:213-7.

Résistance à l'héparine:

Thrombate III
antithrombin III (human)

- Pool d'au moins 1 000 donneurs
- Pasteurisé
- 500 – 2000 IU par vial

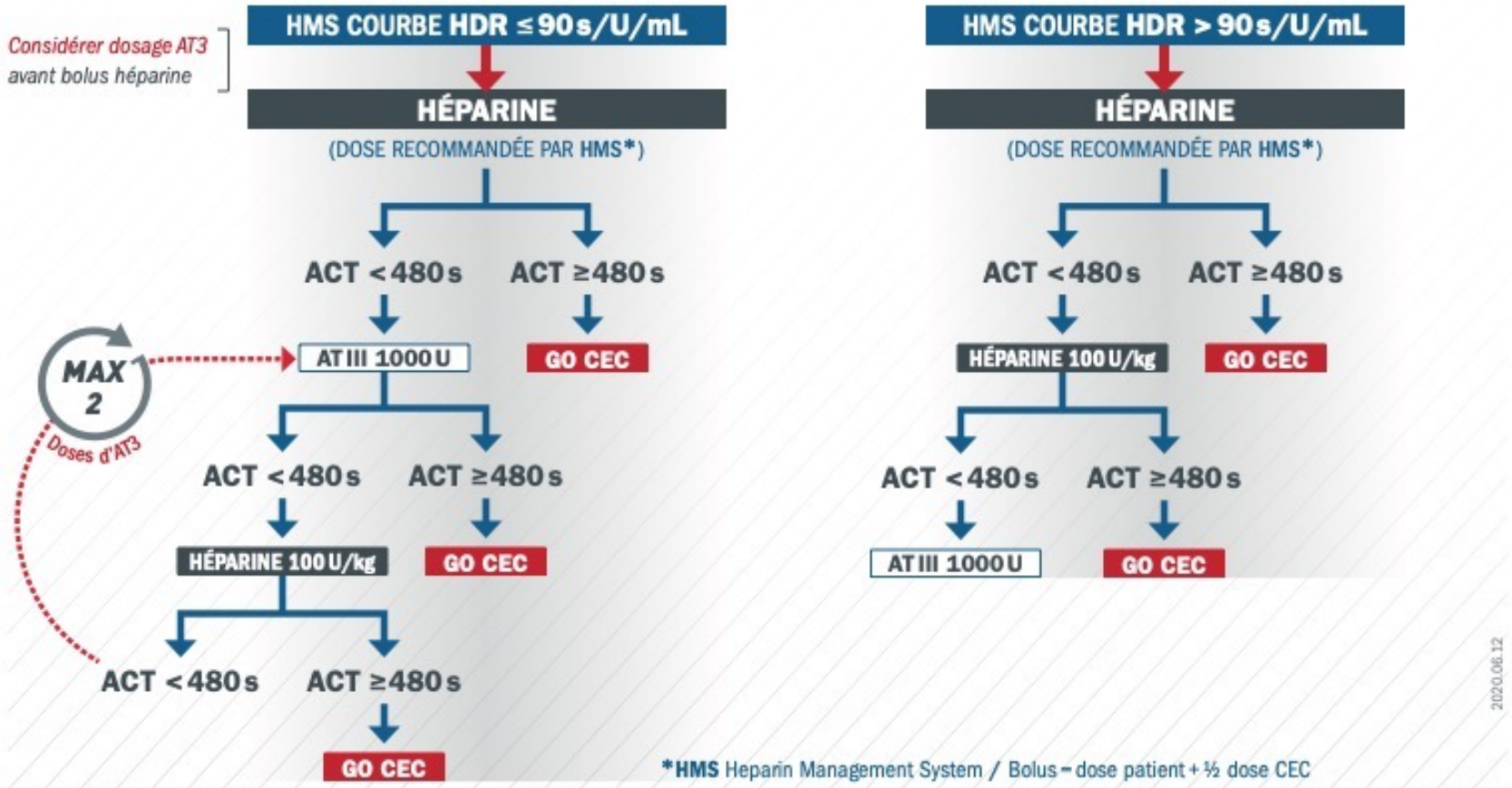
ALGORITHME DE TRAITEMENT DE LA **RÉSISTANCE À L'HÉPARINE POUR LA CEC**

PATIENTS À RISQUE

- Déficience héréditaire en antithrombine III (AT3)
- Baisse de production AT3 (dysfonction hépatique)
- Consommation accrue AT3 (héparine préop, états inflammatoires, hypercoagulabilité, BIA)

ACTIVITÉ NORMALE en antithrombine III (AT3) 80-120 %

• UN RÉSULTAT HMS HDR ≤90 s/U/mL EST SUSPECT D'UNE RÉSISTANCE À L'HÉPARINE •



2020.06.12

*HMS Heparin Management System / Bolus = dose patient + ½ dose CEC

¬ SI AT3 NON DISPONIBLE, substituer par 4 plasmas frais congelés (PFC) (PFC = 1 U/mL AT3)

Résistance à l'héparine:

ACT est non spécifique et sensible à plusieurs facteurs

Indicence 3 – 20 % des patients

AT3 < 80% = plus haut taux de résistance à l'héparine

Concentrés d'AT3 ou PFC sont OK, mais 2U PFC pas assez

Concentrés AT3 efficaces pour augmenter l'ACT et ↓ la transfusion de PFC, mais pas de bénéfice démontré sur les *outcomes* cliniques.

Protamine:

- Mélange de peptides polycationiques basiques obtenu du sperme de saumon.
- Inactive l'héparine circulante seulement.
- Est éliminée en 10 minutes en absence d'héparine
- Réaction acido-basique et formation d'un sel (complexe héparine/protamine)
- Complexes sont éliminés par système réticuloendothélial avec une demi-vie de 7 minutes
- Protamine en excès à des propriété anticoagulante et peut inhiber l'agrégation plaquettaire.

Protamine: quelle dose?

Journal of Cardiothoracic and Vascular Anesthesia 34 (2020) 2369–2374

Contents lists available at ScienceDirect

Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: www.jcvaonline.com

Original Article

In Vivo Protamine Titration Using Activated Coagulation Time to Neutralize Heparin Anticoagulation in Cardiac Surgery: Proof of Concept

Antoine G. Rochon, MD[*,1], Sylvain Bélisle, MD[*], Pierre Couture, MD[*], Annik Fortier, Msc[†], Jean-Sébastien Lebon, MD[*], Alain Deschamps, MD, PhD[*,†]

[*]Department of Anesthesia, Montreal Heart Institute, Montreal, Quebec, Canada
[†]Department of Montreal Health Innovations Coordinating Center, Montreal Heart Institute, Université de Montréal, Montreal, Quebec, Canada

0,8 x dose total reçue

Ratio 1mg : 100U de [héparine résiduelle fin CEC]

Table 2
Evolution of ACT in Relation to Protamine Infusion

	Pre-protamine	3 min	6 min	9 min	12 min	15 min	18 min	21 min
Control group	552 [441-618]	257 [144-348]	139 [129-146.5]	143 [132.5-163.5]	157 [146-177.5]	158.5 [146.5-187.5]	175 [156-203]	148 [136.5-163.5]
Test group	538 [473-663]	277 [156-339]	148.5 [135-162]	150 [136-172]	149 [135-160]	140 [132-162]	134 [123-149]	132.5 [122-144]
p value	0.4342	0.4656	0.0183	0.1963	0.0414	<0.0001	<0.0001	<0.0001

NOTE. 3 to 21 minutes = activated clotting time values 3 to 21 minutes after the beginning of protamine infusion.
Abbreviations: ACT, activated clotting time.

Protamine: démonstration

Thromboélastométrie:

Thromboélasto-graphie/métrie

Zeitschrift f. d. gesamte experimentelle Medizin, Bd. 117, S. 189—203 (1951).

1951

Aus der Medizinischen Universitätsklinik Heidelberg
(Direktor: Prof. Dr. med. R. Siebeck).

Die Thrombelastographie.

Eine Methode zur physikalischen Analyse des Blutgerinnungsvorganges.

Von

Hellmut Hartert.

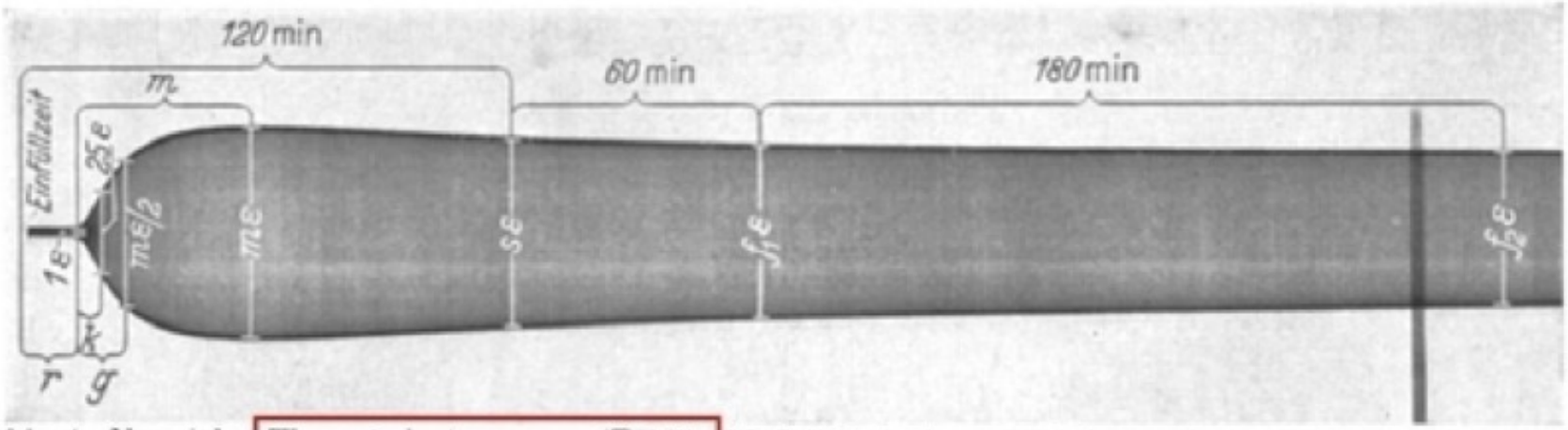
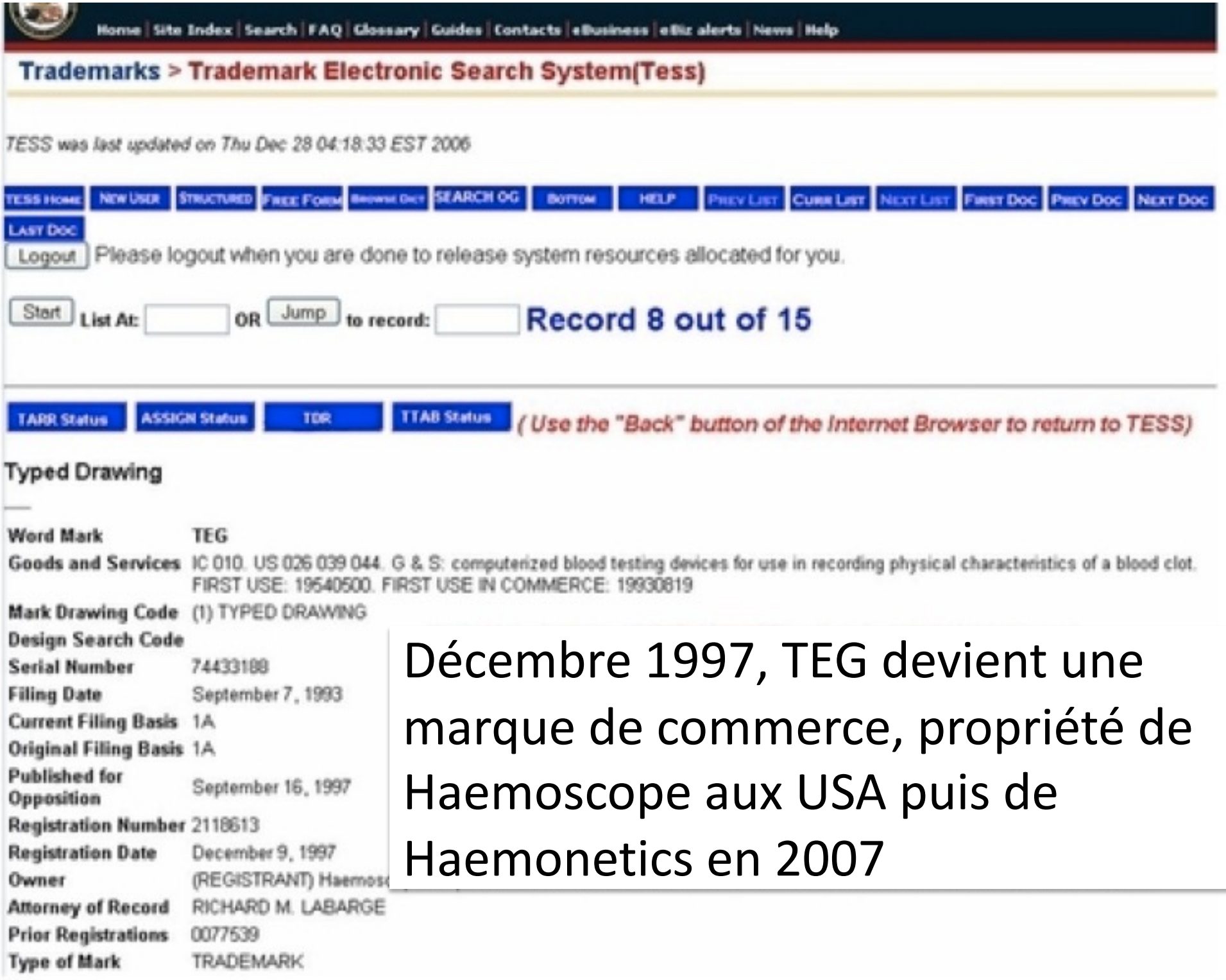


Abb. 4. Normales Thrombelastogramm (TEG). Maßstab 1 : 3. r Reaktionszeit; k absolute Gerinnselbildungsgeschwindigkeit; g stellt den entsprechenden Relativwert dar; me maximale Thrombuselastizität.

TEG = Thrombelastogram



Décembre 1997, TEG devient une marque de commerce, propriété de Haemoscope aux USA puis de Haemonetics en 2007

Thromboélasto-graphie/métrie

thromboelastometry
ROTEM®
The bleeding management system

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J!Research > Publications > New

The roTEG coagulation analyser - a new thrombelastographic system for whole blood coagulation analysis

Research Area:	Methodology and general Articles	**Year:**	1996
Type of Publication:	In Proceedings		
Authors:	_ Mößmer G. Hipp R. Calatzis An.		
Editor:	A Proceedings of the 16th international Congress of Clinical Chemistry		

[Back]

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Thromboélasto-graphie/métrie

Lawsuit:

Haemoscope Corp. v. Pentapharm AG,
No. 02 C 4261 (N.D. Ill. Dec. 6, 2002).

ROTEG →

Thromboélastographie ➔ Thromboélastométrie

ROTEM ® = Thromboélastométrie rotatoire

Thromboélasto-graphie/métrie

TEG®

ROTEM®

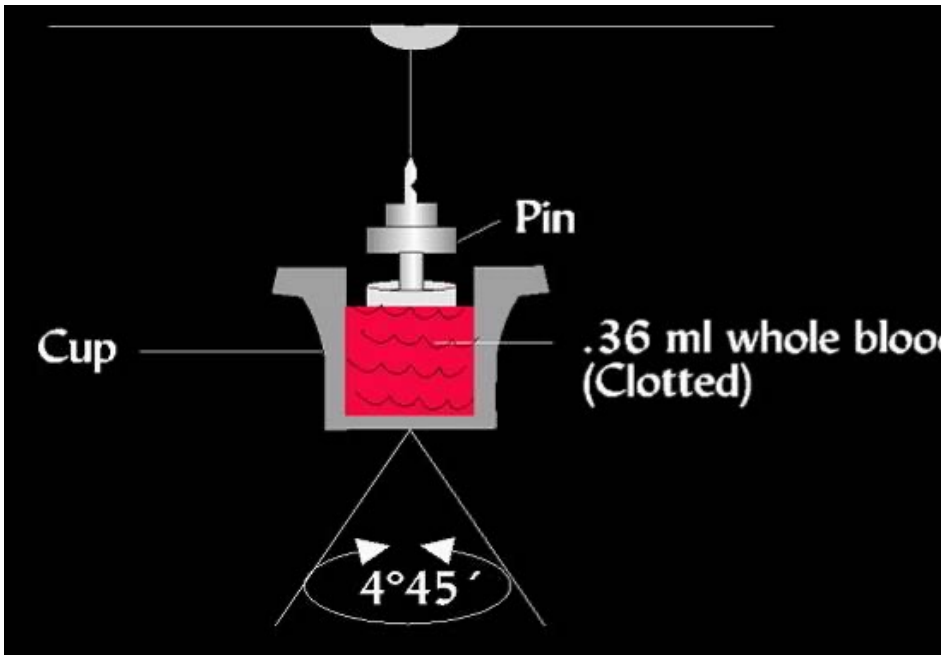
Thromboelasto-graphie/metrie

TEG® 6s

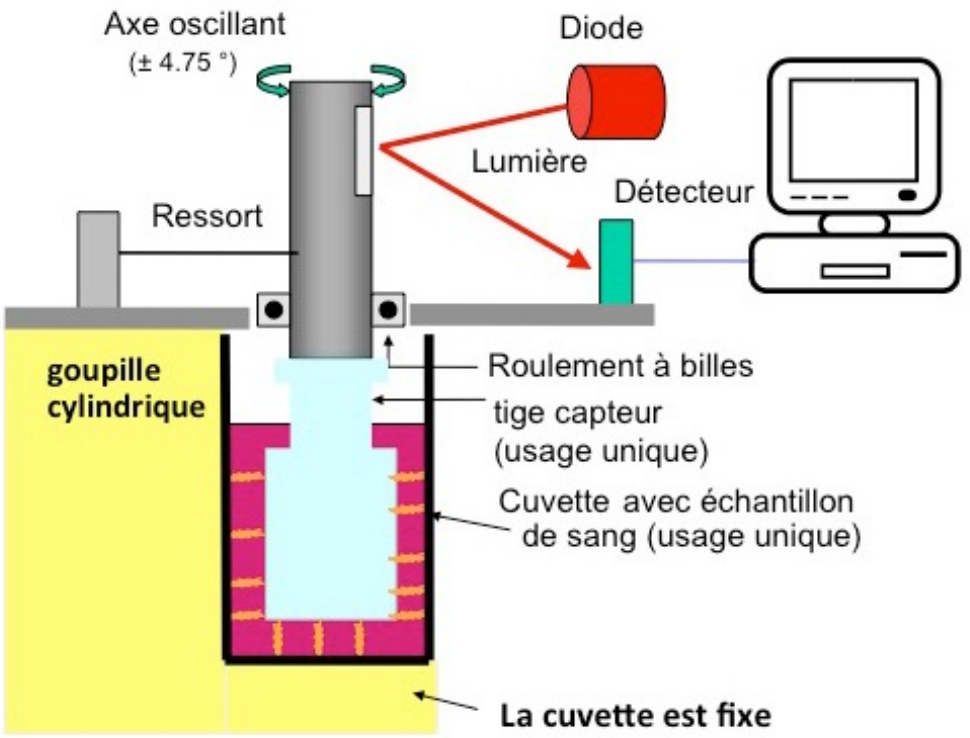
ROTEM® *sigma*

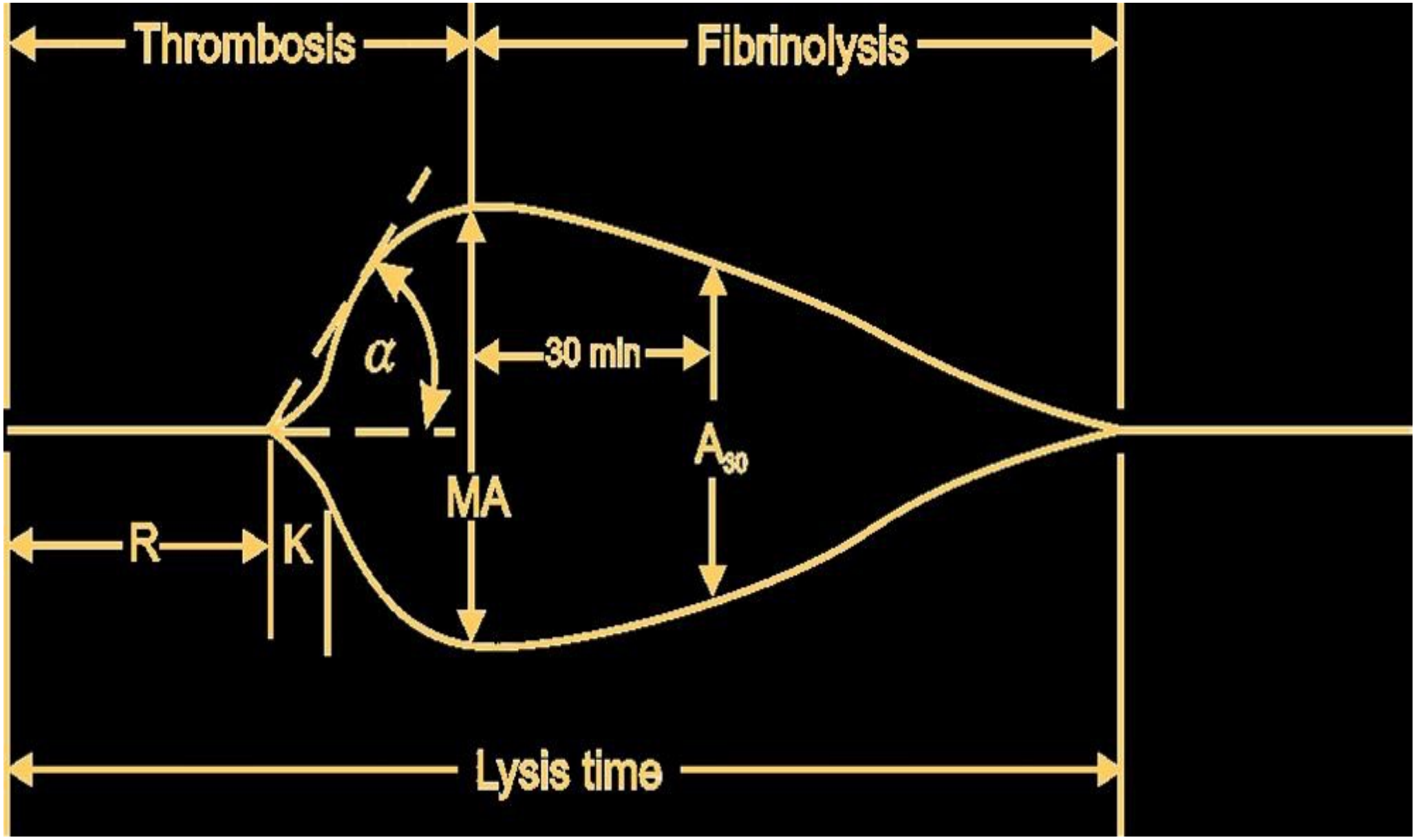
Thromboélasto-graphie/métrie

TEG®



ROTEM®



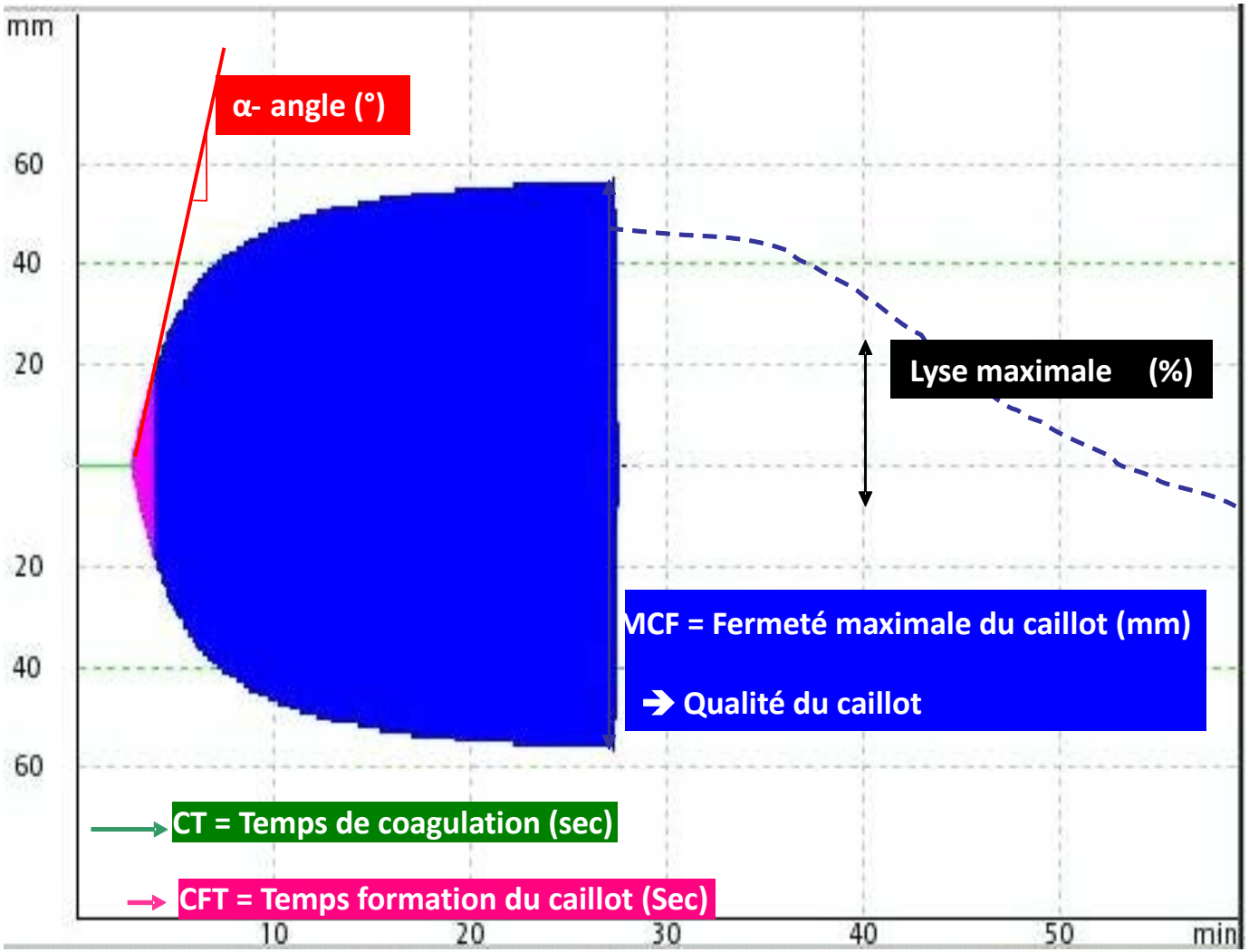


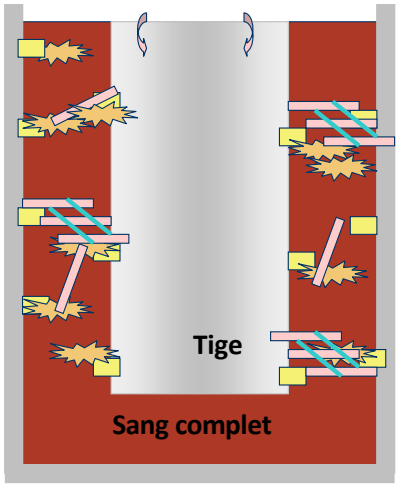
- Profile hémostatique:

R time → **α Angle** → **MA** → **LY**

Filaments fibrine → cinétique → Force du caillot → Fibrinolyse

ROTEM ® : Paramètres





Cuvette

- Courbe typique
- Valeurs numériques
- Résultats anormaux identifiés
- fermeté du caillot = Qualité

Thromboélasto-graphie/métrie

Paramètres ROTEM®	Paramètres TEG®
CT – Clotting Time (secondes)	R – Reaction Time (minutes)
CFT – Clot Formation Time (secondes)	K – Coagulation Time (minutes)
α Angle Alpha (°)	α Angle Alpha (°)
A (x) – Amplitude (mm) à un point temporel X: 5/10/15/20/25/30 (minutes)	Pas de paramètre équivalent
MCF – Maximum Clot Firmness (mm)	MA – Maximum Amplitude (mm)

Thromboelasto-graphie/metrie

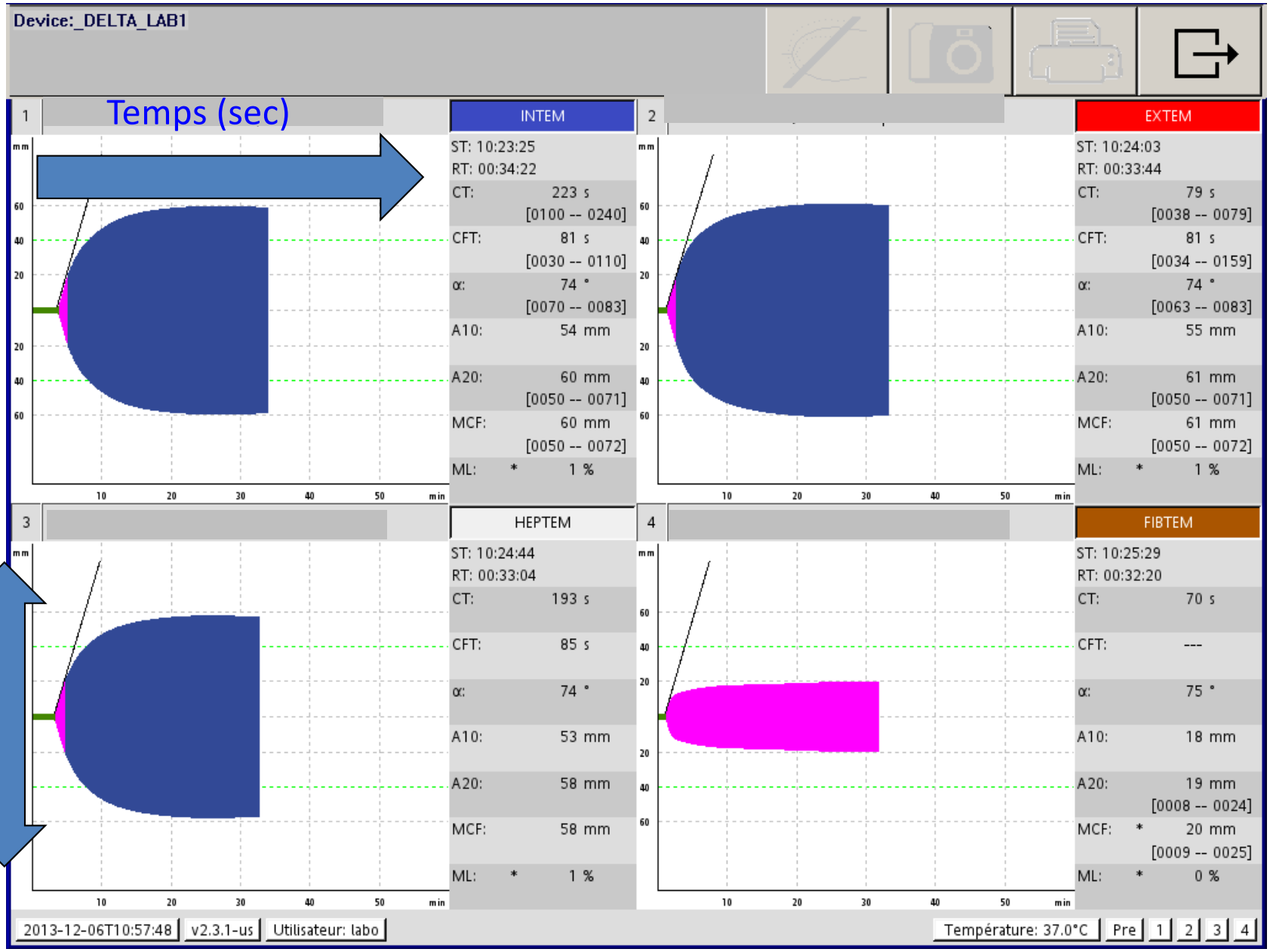
ROTEM® vs TEG®

ROTEM®

- **IN-tem (intrinsèque)**
- **HEP-tem (héparinase)**
- **Extem (extrinsèque)**
- **FIBtem (Fibrinogène)**
- **Aptem (Hyperfibrinolyse)**
- **Rotem® *plaquettes***

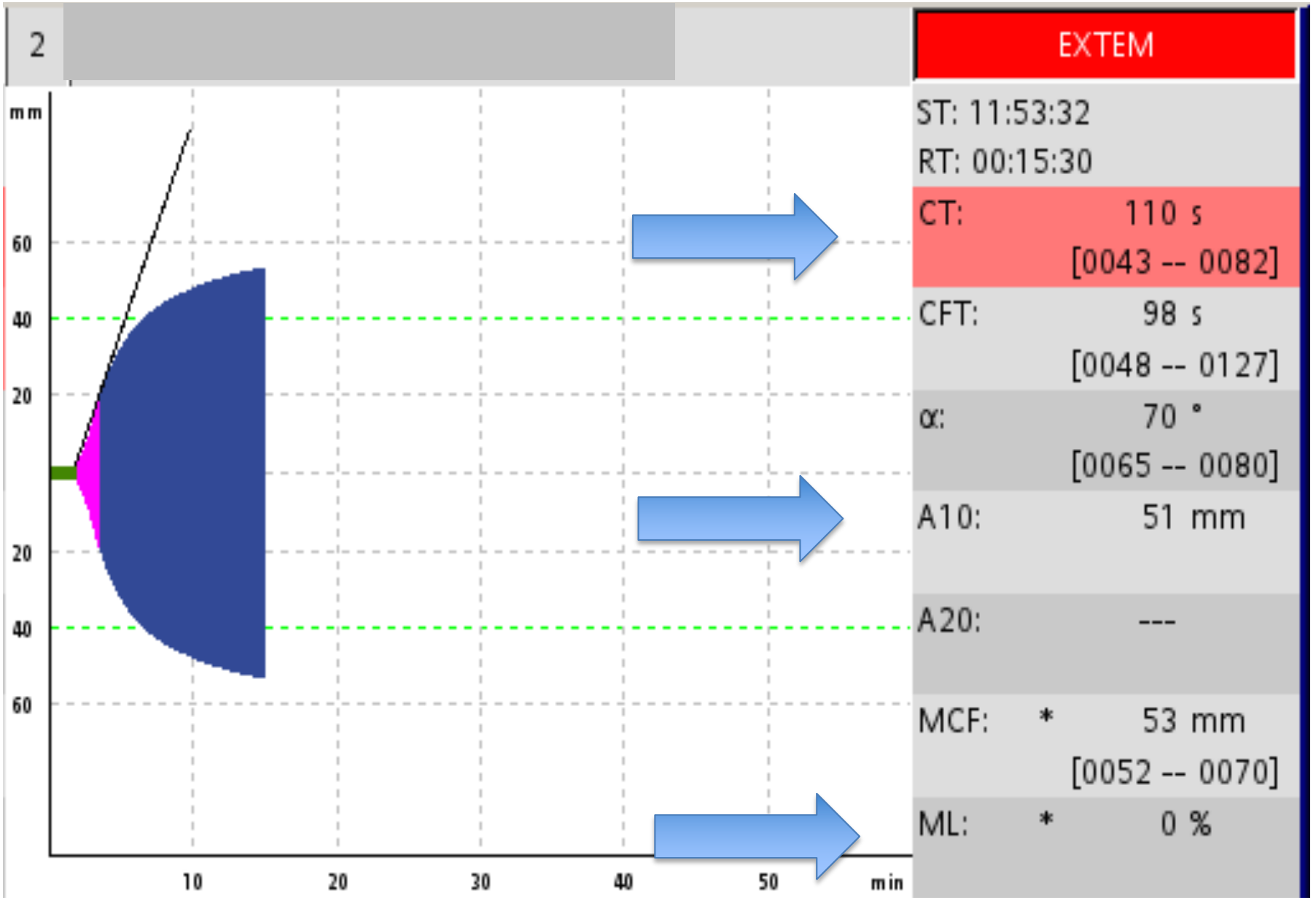
TEG®

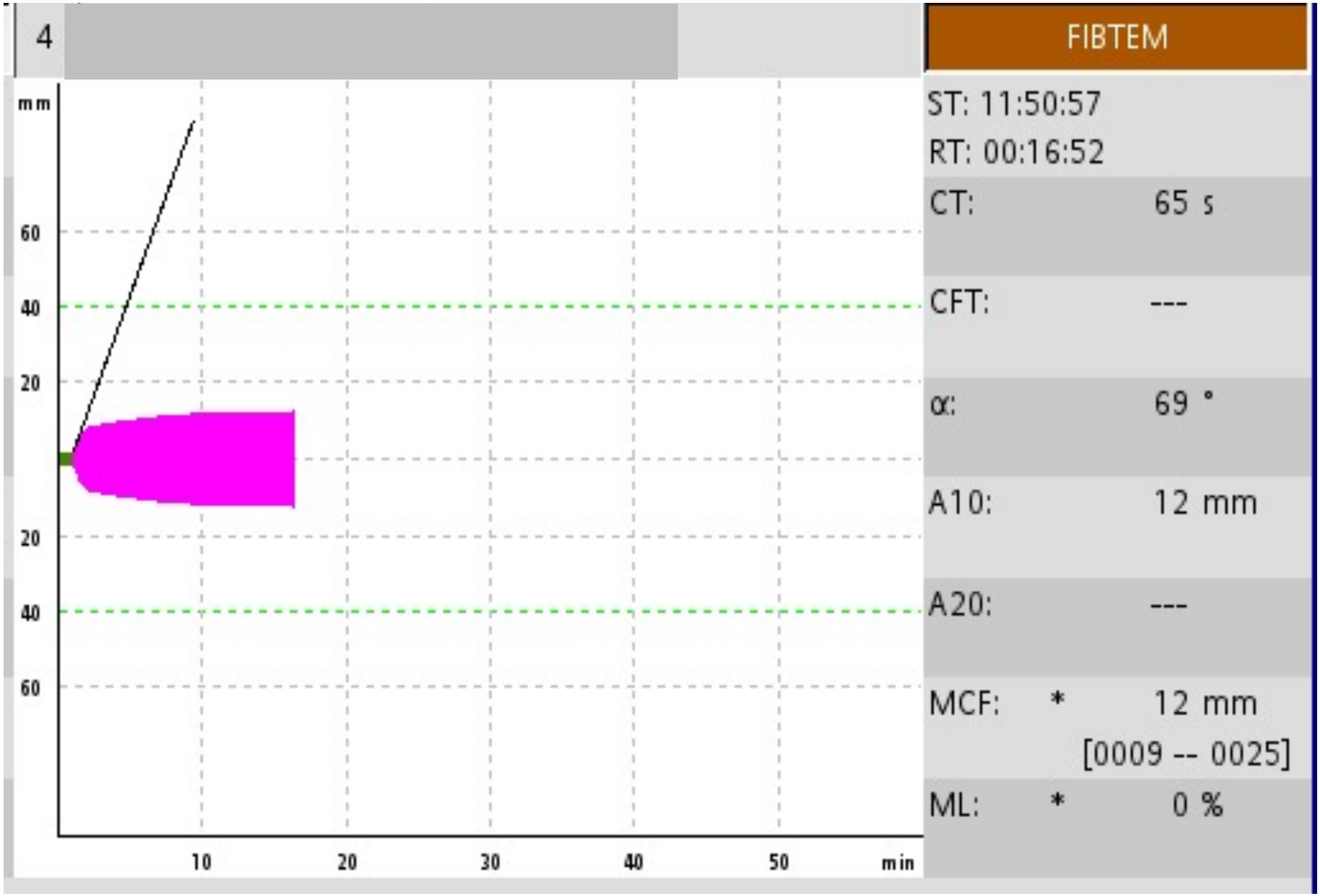
- Koalin (intrinsèque)
- Cupule héparinase
- Rapid TEG ®
- Fonctionnalité du fibrinogène
- Platelet Mapping



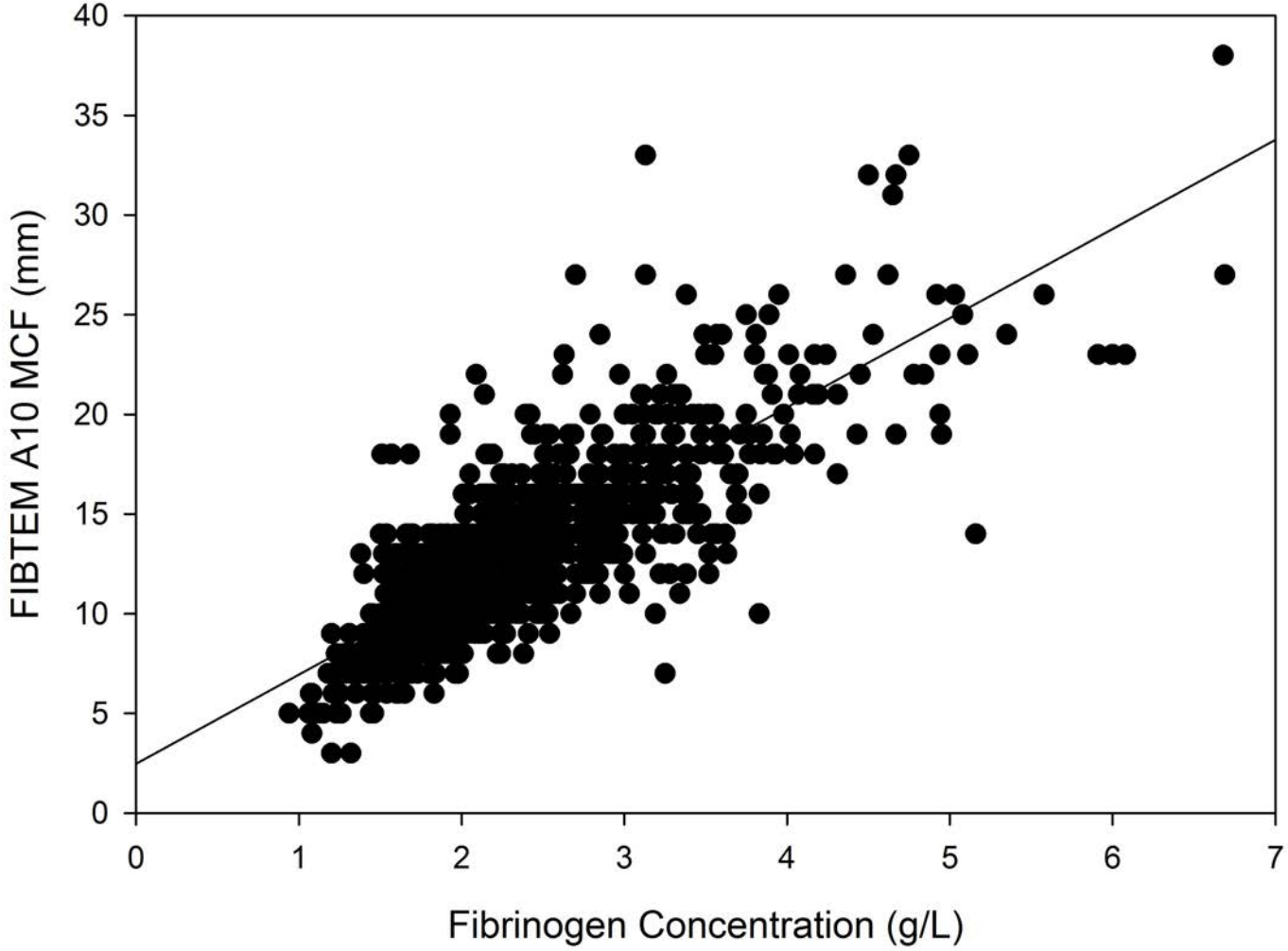
6 TESTS: INTEM / EXTEM
HEPTEM / FIBTEM
APTEM / NATEM

2 types de résultats :
Temps : en secondes
Amplitude : en millimètres

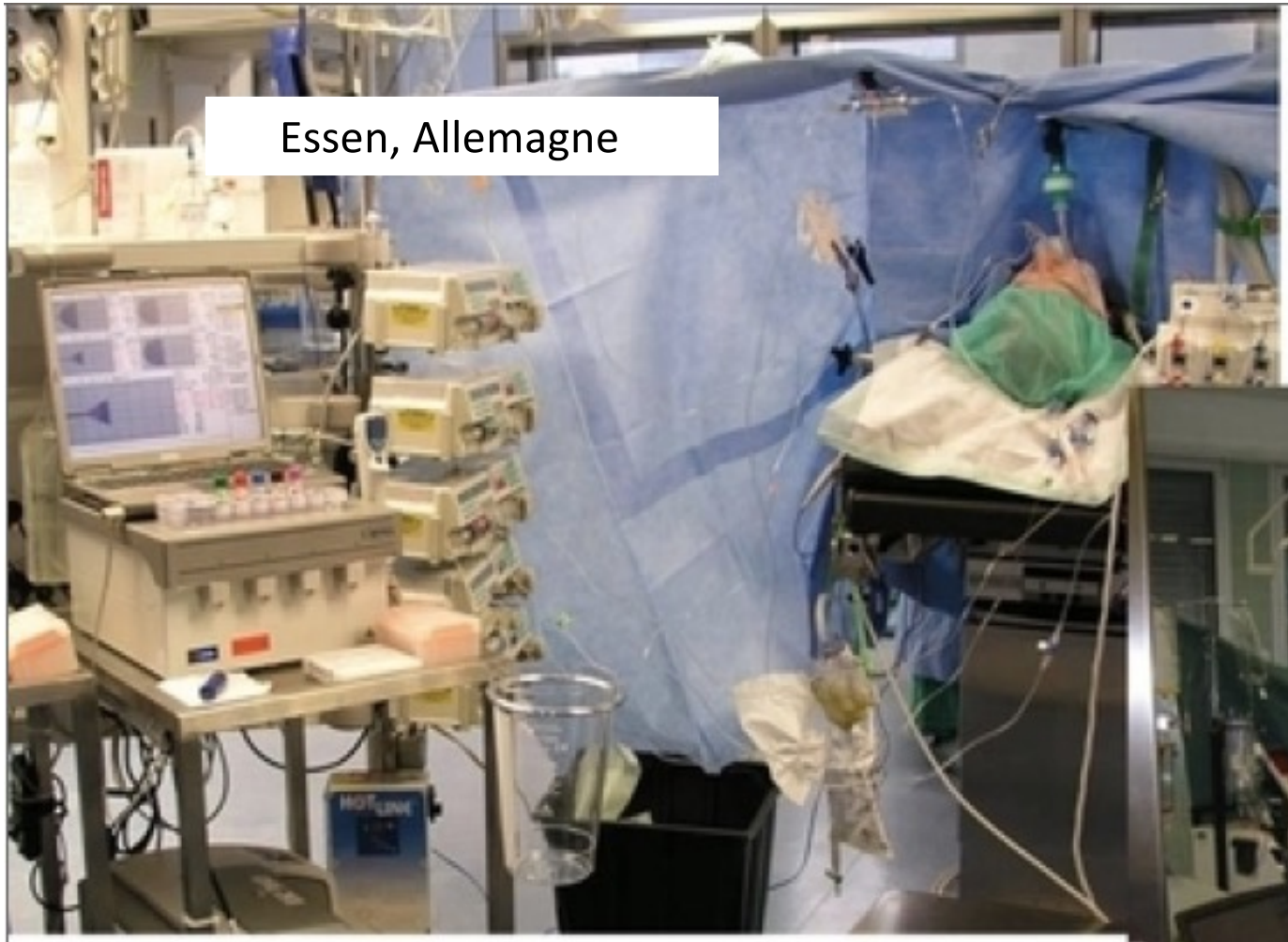

2
EXTEM
mm
60
40
20
20
40
60
10
20
30
40
50
min
ST: 11:53:32
RT: 00:15:30
CT: 110 s
[0043 -- 0082]
CFT: 98 s
[0048 -- 0127]
α: 70 °
[0065 -- 0080]
A10: 51 mm
A20: ---
MCF: * 53 mm
[0052 -- 0070]
ML: * 0 %


4
FIBTEM
mm
60
40
20
20
40
60
10
20
30
40
50
min
ST: 11:50:57
RT: 00:16:52
CT: 65 s
CFT: ---
α: 69 °
A10: 12 mm
A20: ---
MCF: * 12 mm
[0009 -- 0025]
ML: * 0 %

FIBTEM et corrélation avec [fibrinogène]



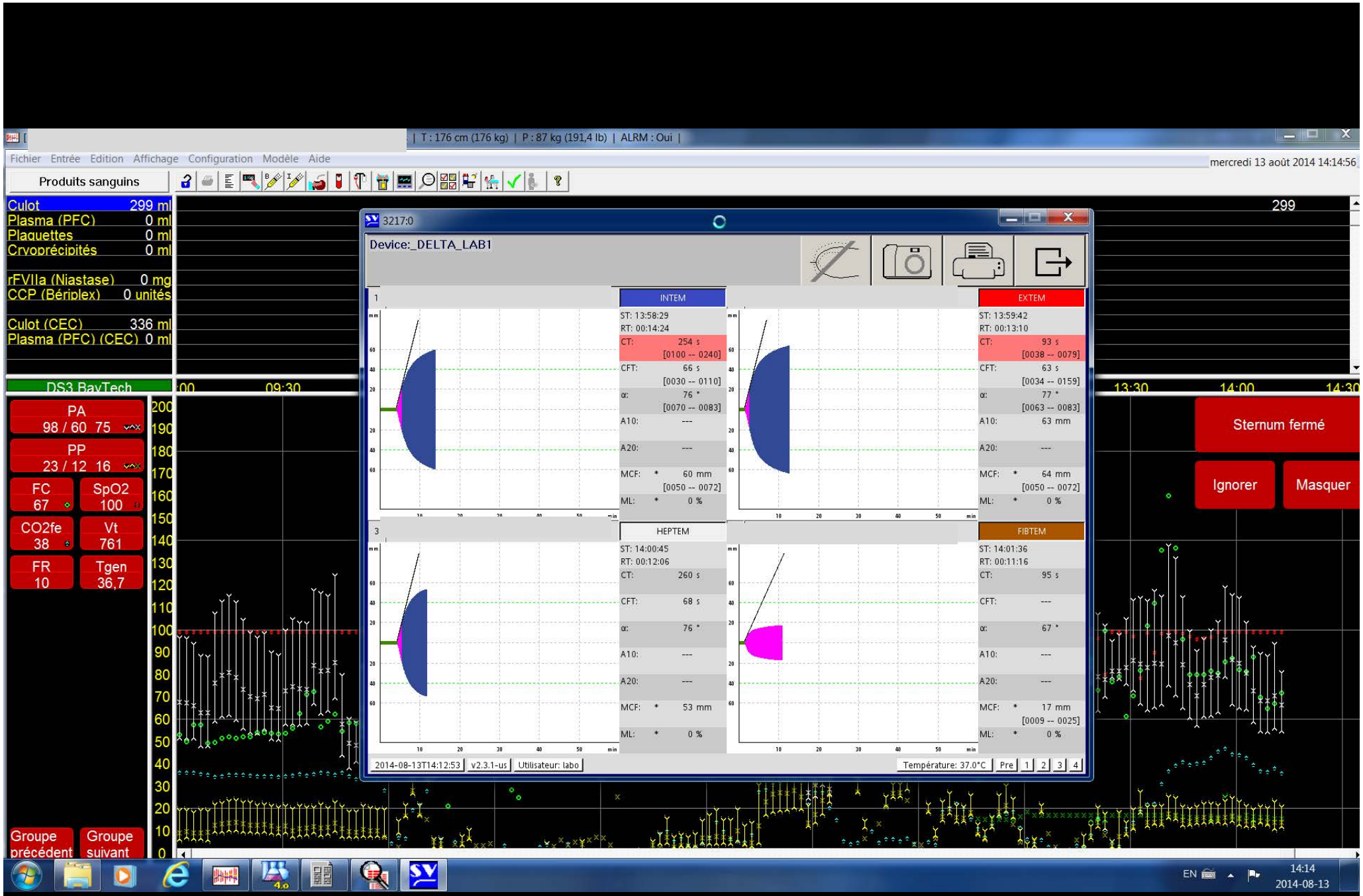
Mace, JCVA, 2015


Essen, Allemagne


Insbruck, Autriche

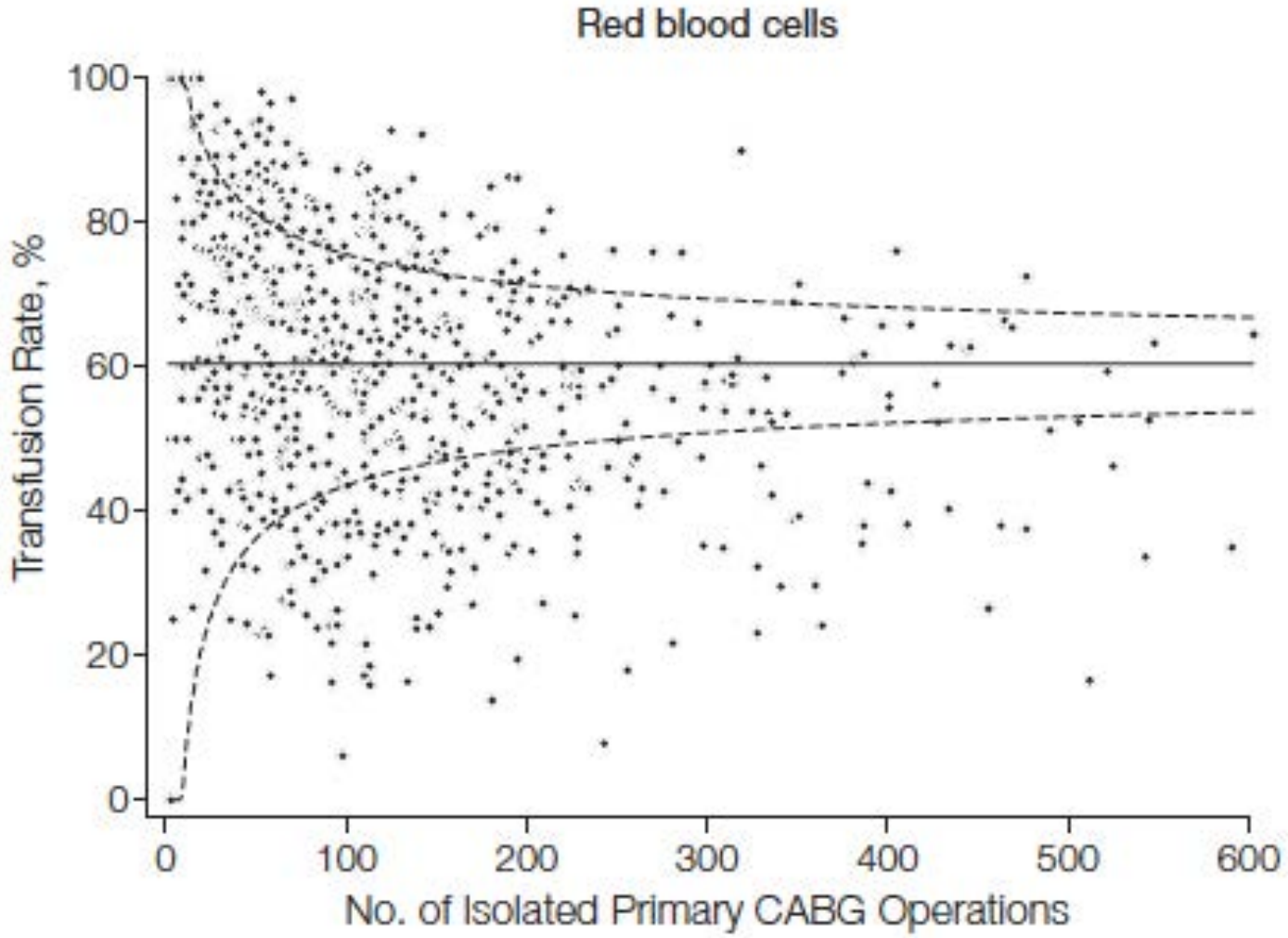

THE FIBRINOLYTIC SYSTEM
An Overall Exploratory Test System to Study a Complex Problem
DIAGNOSTICA STAGO
ROTEM
ROTEM
ROTEM

ICM, Québec


T : 176 cm (176 kg) | P : 87 kg (191,4 lb) | ALRM : Oui |
Fichier Entrée Edition Affichage Configuration Modèle Aide
mercredi 13 août 2014 14:14:56
Produits sanguins
Culot 299 ml
Plasma (PFC) 0 ml
Plaquettes 0 ml
Cryoprécipités 0 ml
rFVIIa (Niastase) 0 mg
CCP (Bériplex) 0 unités
Culot (CEC) 336 ml
Plasma (PFC) (CEC) 0 ml
DS3 BayTech
PA 98 / 60 75
PP 23 / 12 16
FC 67
SpO2 100
CO2fe 38
Vt 761
FR 10
Tgen 36,7
Groupe précédent
Groupe suivant
3217:0
Device:_DELTA_LAB1
INTEM
ST: 13:58:29
RT: 00:14:24
CT: 254 s [0100 -- 0240]
CFT: 66 s [0030 -- 0110]
α: 76 ° [0070 -- 0083]
A10: ---
A20: ---
MCF: * 60 mm [0050 -- 0072]
ML: * 0 %
EXTEM
ST: 13:59:42
RT: 00:13:10
CT: 93 s [0038 -- 0079]
CFT: 63 s [0034 -- 0159]
α: 77 ° [0063 -- 0083]
A10: 63 mm
A20: ---
MCF: * 64 mm [0050 -- 0072]
ML: * 0 %
HEPTEM
ST: 14:00:45
RT: 00:12:06
CT: 260 s
CFT: 68 s
α: 76 °
A10: ---
A20: ---
MCF: * 53 mm
ML: * 0 %
FIBTEM
ST: 14:01:36
RT: 00:11:16
CT: 95 s
CFT: ---
α: 67 °
A10: ---
A20: ---
MCF: * 17 mm [0009 -- 0025]
ML: * 0 %
2014-08-13T14:12:53
v2.3.1-us
Utilisateur: labo
Température: 37.0°C
Pre 1 2 3 4
Sternum fermé
Ignorer
Masquer
EN
14:14
2014-08-13

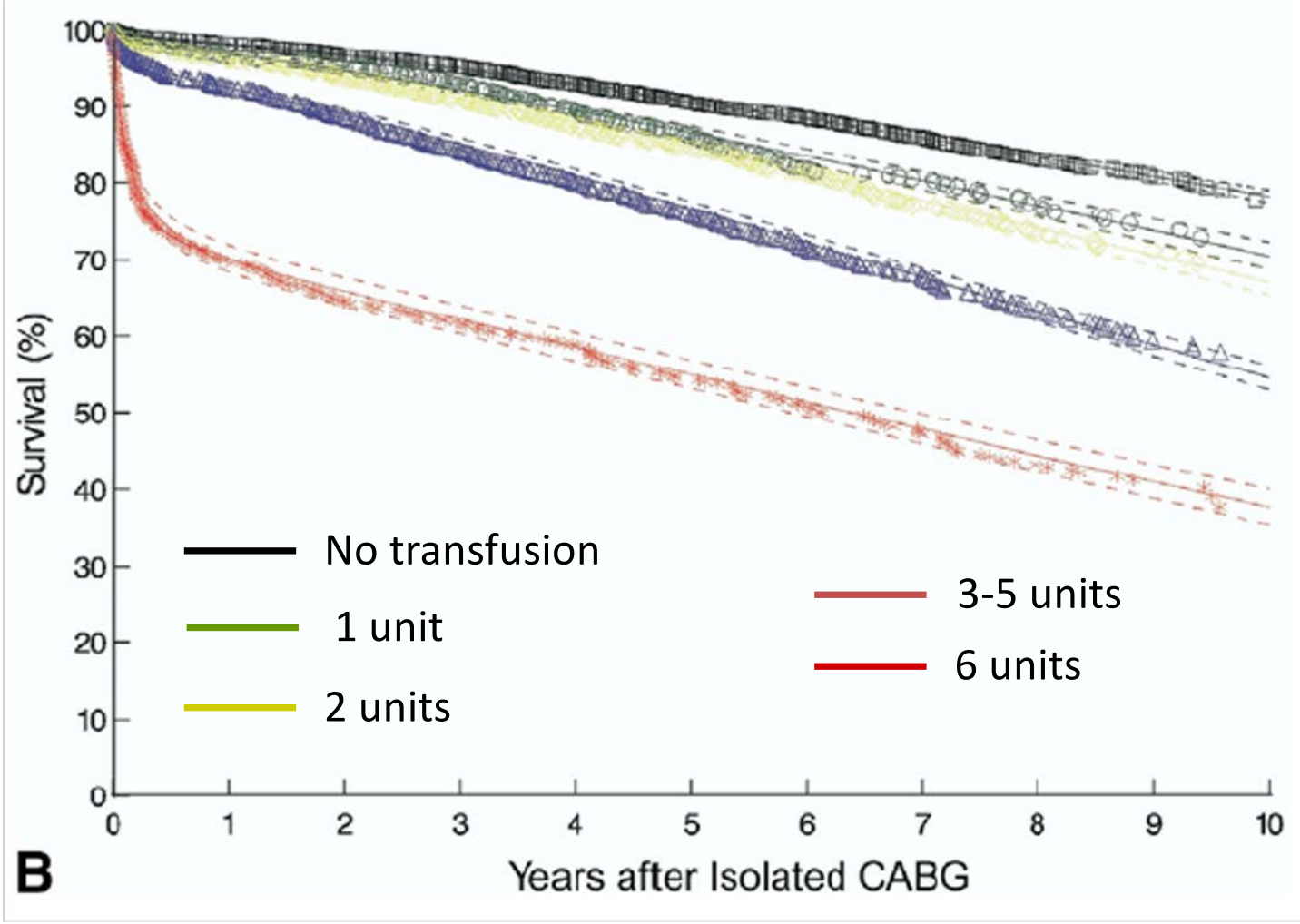
Pourquoi le Rotem?

Transfusion rate – 798 sites - 2008



Bennett-Guerrero. et al. JAMA 2010;304:1568 –75

Pontages, transfusions et survie



Koch CG. et al. Ann Thorac Surg. 2006;81:1650 –7

Transfusion & mortality in cardiac surgery

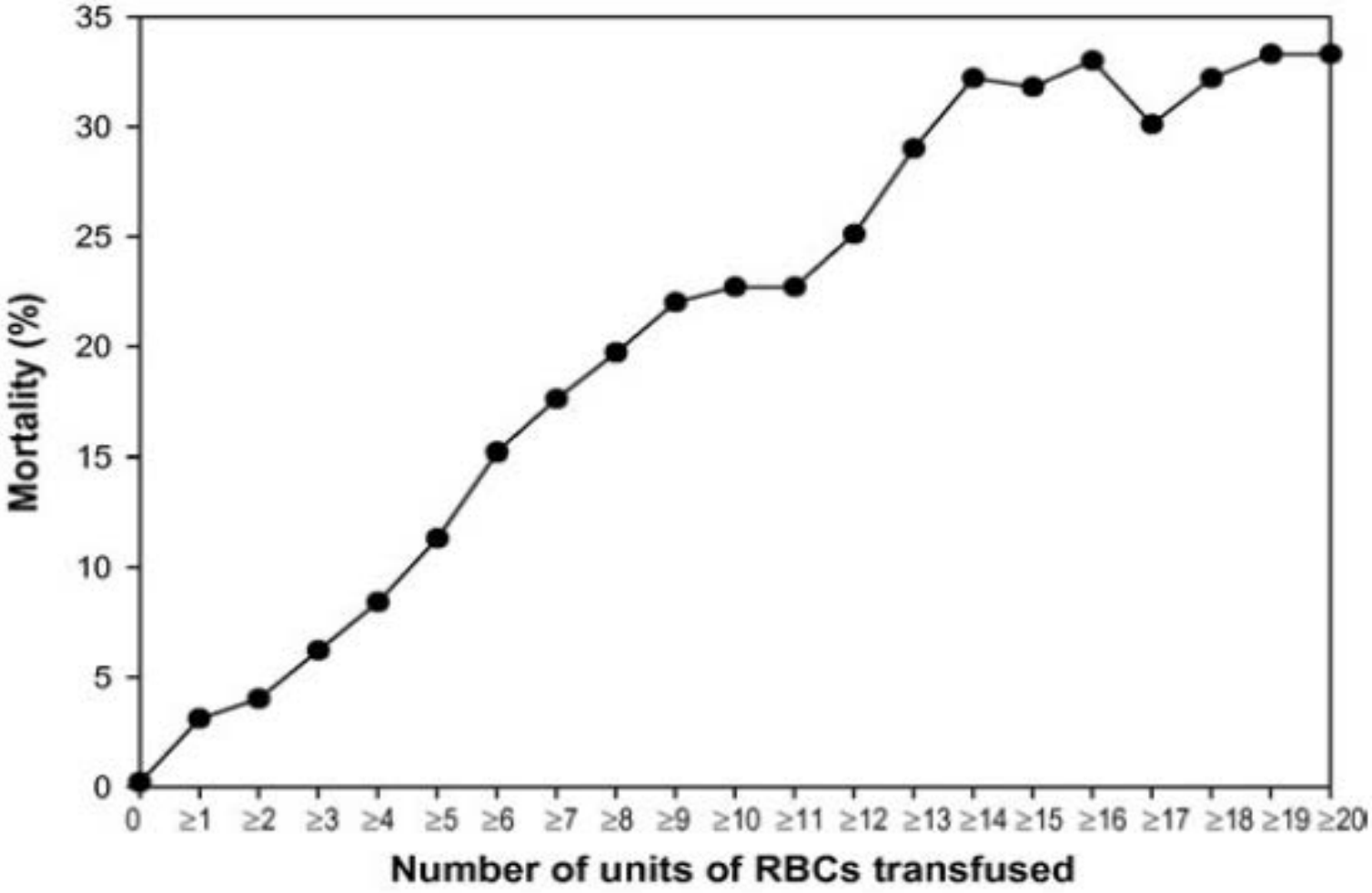
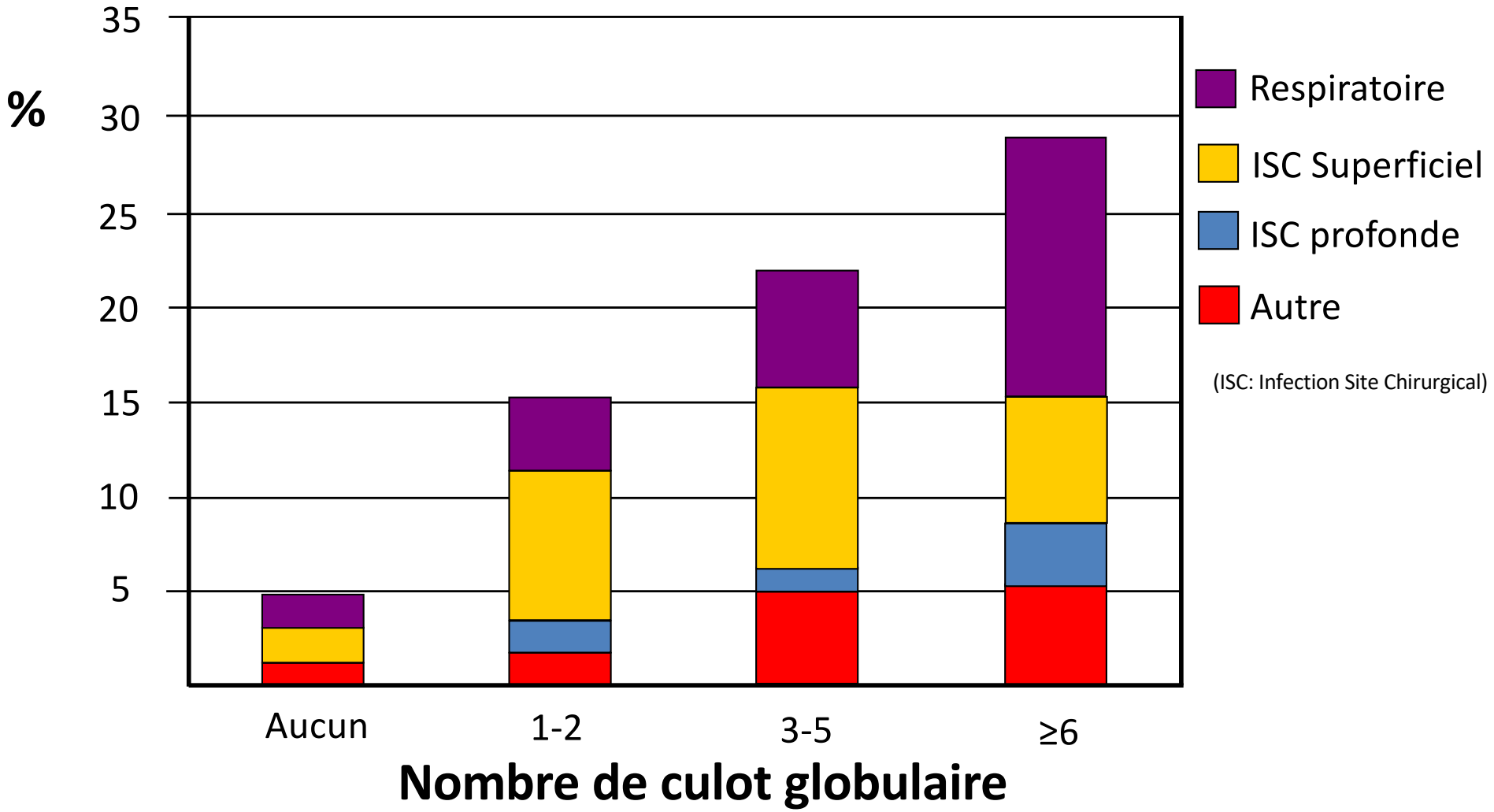


Fig. 1. The unadjusted relationship between perioperative RBC transfusion and mortality.

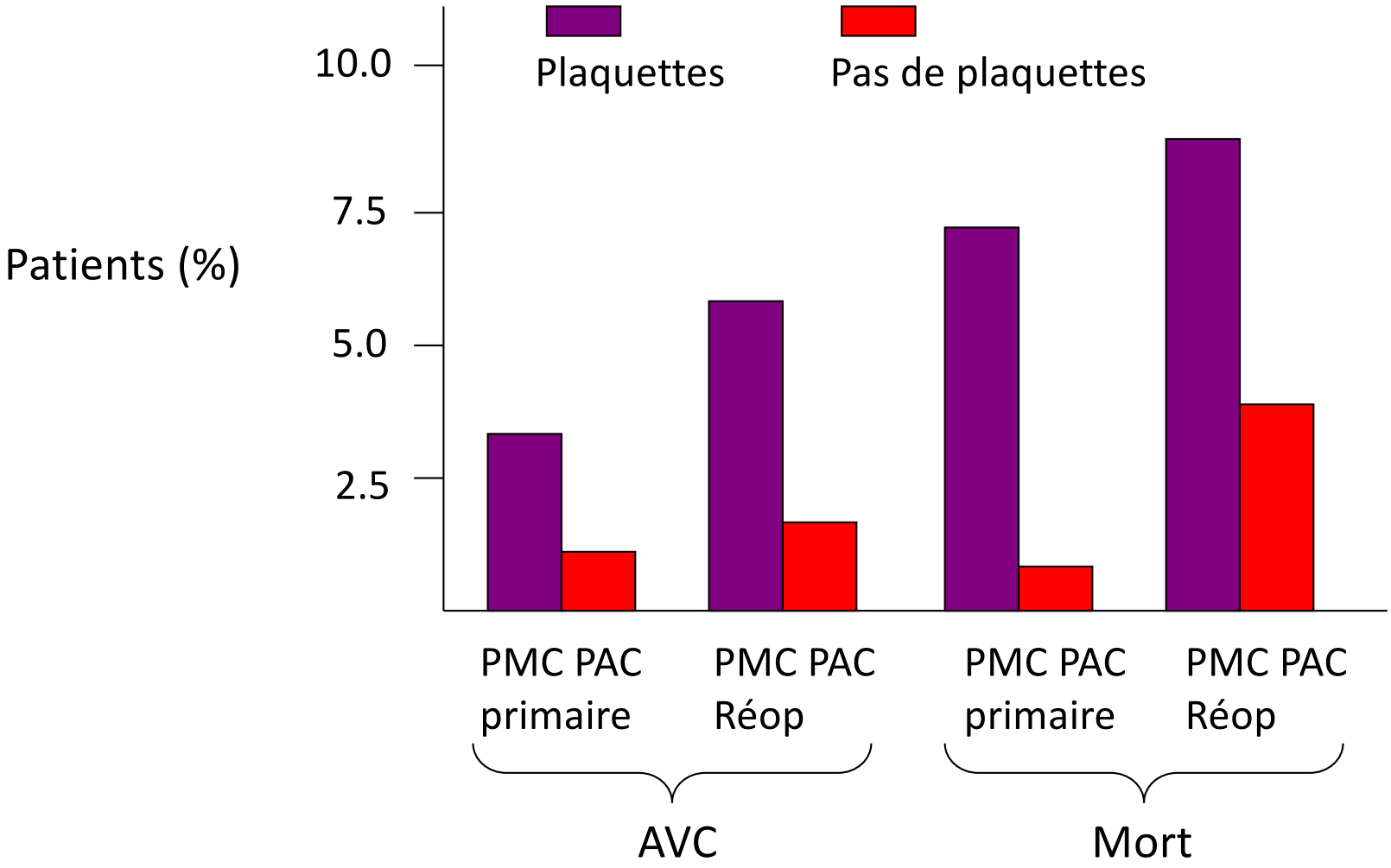
Karkouti et al. Transfusion 2004;44:1453-1462.

Pontages: Transfusion & Infection



Chelemer SB. et al. *Ann Thorac Surg*. 2002 Jan;73(1):138-42

Transfusion plaquettaire



Spiess BD et al. *Transfusion* 2004;44: 1143 - 8

Crit Care Med 2008 Vol. 36, No. 4

Transfusion of fresh frozen plasma in critically ill surgical patients is associated with an increased risk of infection

Babak Sarani, MD, FACS; W. Jonathan Dunkman, BA; Laura Dean; Seema Sonnad, PhD; Jeffrey I. Rohrbach, RN, MSN; Vicente H. Gracias, MD, FACS

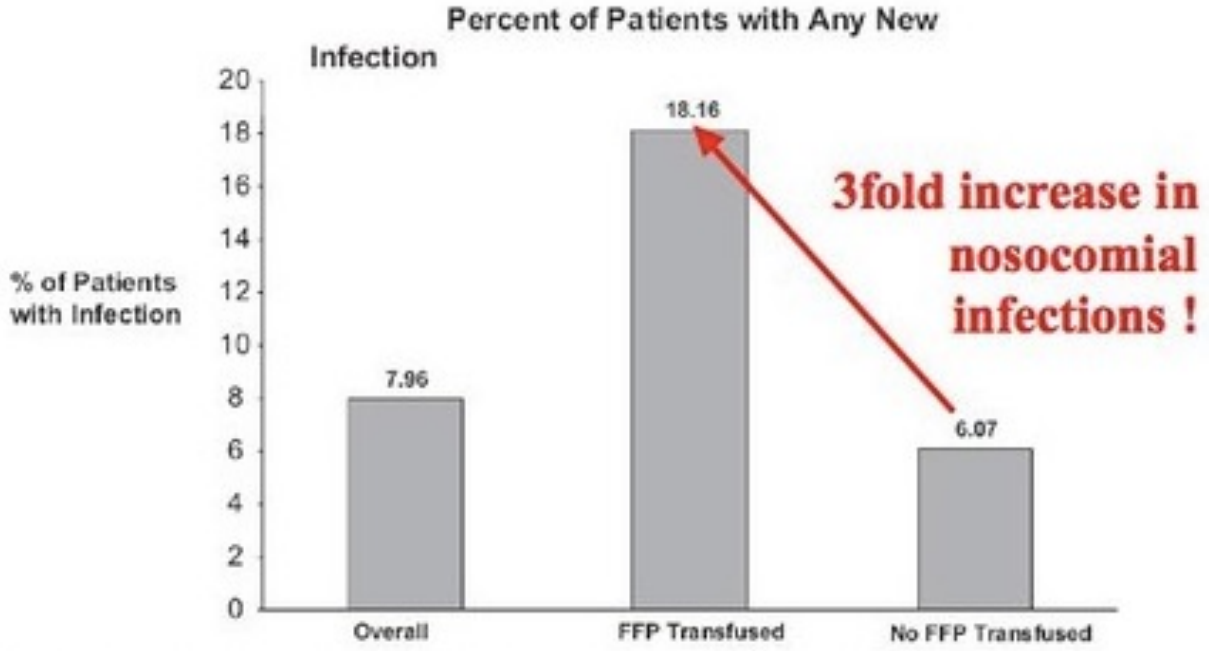


Figure 1. Patients who received fresh frozen plasma (*FFP*) were significantly more likely to develop an infection than those who did not receive FFP in a univariate model ($p < .01$).

Transfusion of Red Blood Cells, Fresh Frozen Plasma, or Platelets Is Associated With Mortality and Infection After Cardiac Surgery in a Dose-Dependent Manner

Yue Ming, MMed,* Jing Liu, MMed,† Fengjiang Zhang, MD, PhD,* Changwei Chen, MMed,†
Li Zhou, MD, PhD,† Lei Du, MD, PhD,† and Min Yan, MD, PhD*

Ming et al. A&A 2020

- Étude retrospective 2011 – 2017
- 8238 patients
- Tous les patients de chirurgie cardiaque
- Transfusés vs non-transfusés
- Infection & mortalité

Transfusion of Red Blood Cells, Fresh Frozen Plasma, or Platelets Is Associated With Mortality and Infection After Cardiac Surgery in a Dose-Dependent Manner

Yue Ming, MMed,* Jing Liu, MMed,† Fengjiang Zhang, MD, PhD,* Changwei Chen, MMed,† Li Zhou, MD, PhD,† Lei Du, MD, PhD,† and Min Yan, MD, PhD*

Ming et al. A&A 2020

- 8238 patients : 59,9% transfusés (4937)
- Mortalité: 2,0% vs 0,18% $P < 0,01$
- Infections: 13,3% vs 4,8% $P < 0,01$

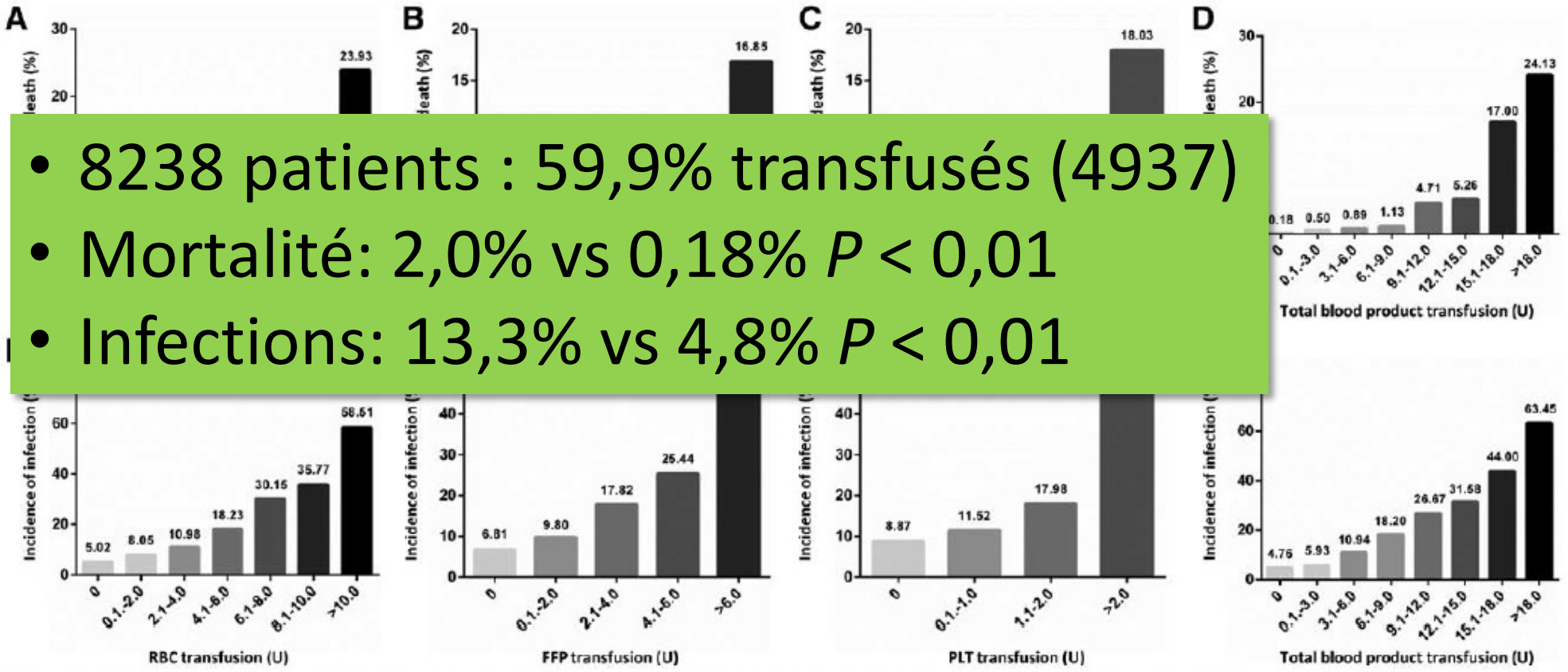


Figure 3. Incidence of all-cause mortality and infection in patients receiving increasing units of red blood cells, fresh frozen plasma, platelets, or any blood product. FFP indicates fresh frozen plasma; PLT, platelets; RBC, red blood cells.

Pourquoi le ROTEM:

- La pratique transfusionnelle en chirurgie cardiaque demeure variable avec des taux transfusionnels élevés.
- La transfusion de produits sanguins est associée à des évènements indésirables significatifs.
- L'implantation et l'adoption de la gestion personnalisée du sang avec ses trois piliers est prometteuse.
- Les protocoles transfusionnels basés sur les moniteurs de proximités dont les tests viscoélastiques sont nécessaires pour mieux transfuser.

Délais des tests standards de coagulation en STAT :

- 35 ± 37 minutes (USA)

  Chandler et al. Transfusion 2010

- 34 ± 15 minutes (Suisse)

  Jeger et al. J Trauma 2009

- 50 ± 20 minutes (ICM)

Ces délais ne tiennent pas compte de l'échantillonage ni du transport

Journal of Cardiothoracic and Vascular Anesthesia, Vol 28, No 2 (April), 2014: pp 210–216

Rapid and Correct Prediction of Thrombocytopenia and Hypofibrinogenemia With Rotational Thromboelastometry in Cardiac Surgery

Rik H.G. Olde Engberink, MD,* Gerhardus J.A.J.M. Kuiper, MD,† Rick J.H. Wetzels, MSc,§ Patty J. Nelemans, MD, PhD,‡ Marcus D. Lance, MD,† Erik A.M. Beckers, MD, PhD,* and Yvonne M.C. Henskens, PhD§

*From the Departments of *Internal Medicine, †Anesthesiology, and ‡Epidemiology and Statistics and §Central Diagnostic Laboratory, Maastricht University Medical Center, Maastricht, The Netherlands.*

ROTEM tests : 12 min

STAT FSC : 13 min

STAT Fibrinogène : 37 min

Tests de l’hémostase

Tests Standards

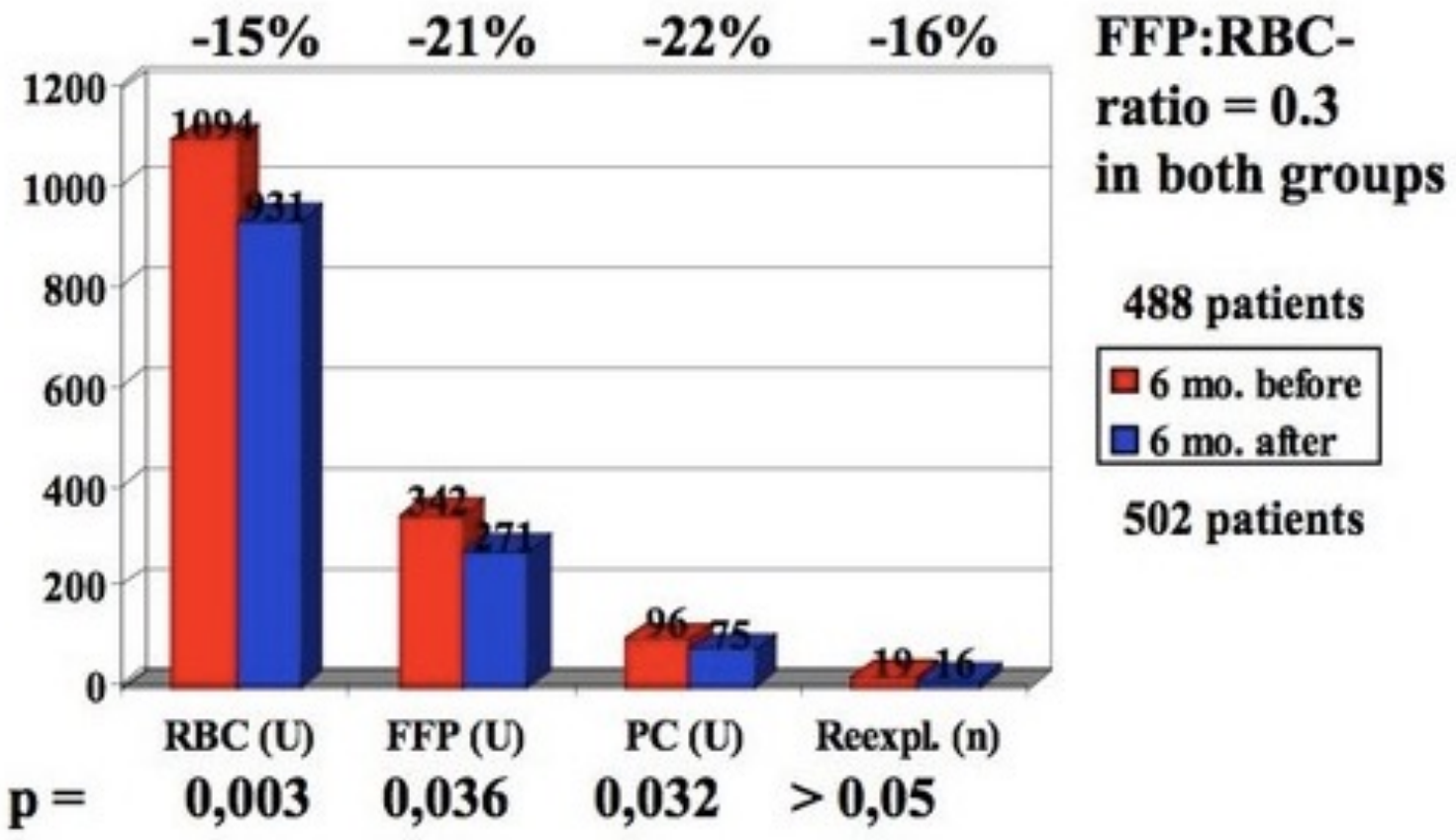
ROTEM®

Que dit la litérature?

An audit of red cell and blood product use after the institution of thromboelastometry in a cardiac intensive care unit

L. Anderson,* I. Quasim,* R. Soutar,† M. Steven,* A. Macfie* and W. Korte‡ *Department of Anaesthesia, †Department of Haematology, Western Infirmary, Glasgow, UK, and ‡Institute for Clinical Chemistry and Haematology, Kantonsspital, St Gallen, Switzerland

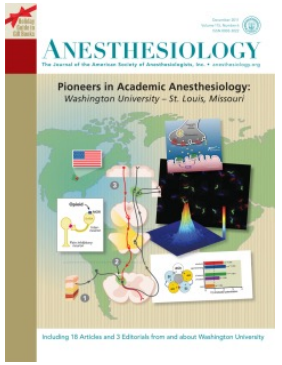
Transf Med 2006;16:31–39



Anesthesiology 2011; 115:1179–91

PERIOPERATIVE MEDICINE

Coagulation Management in Cardiovascular Surgery



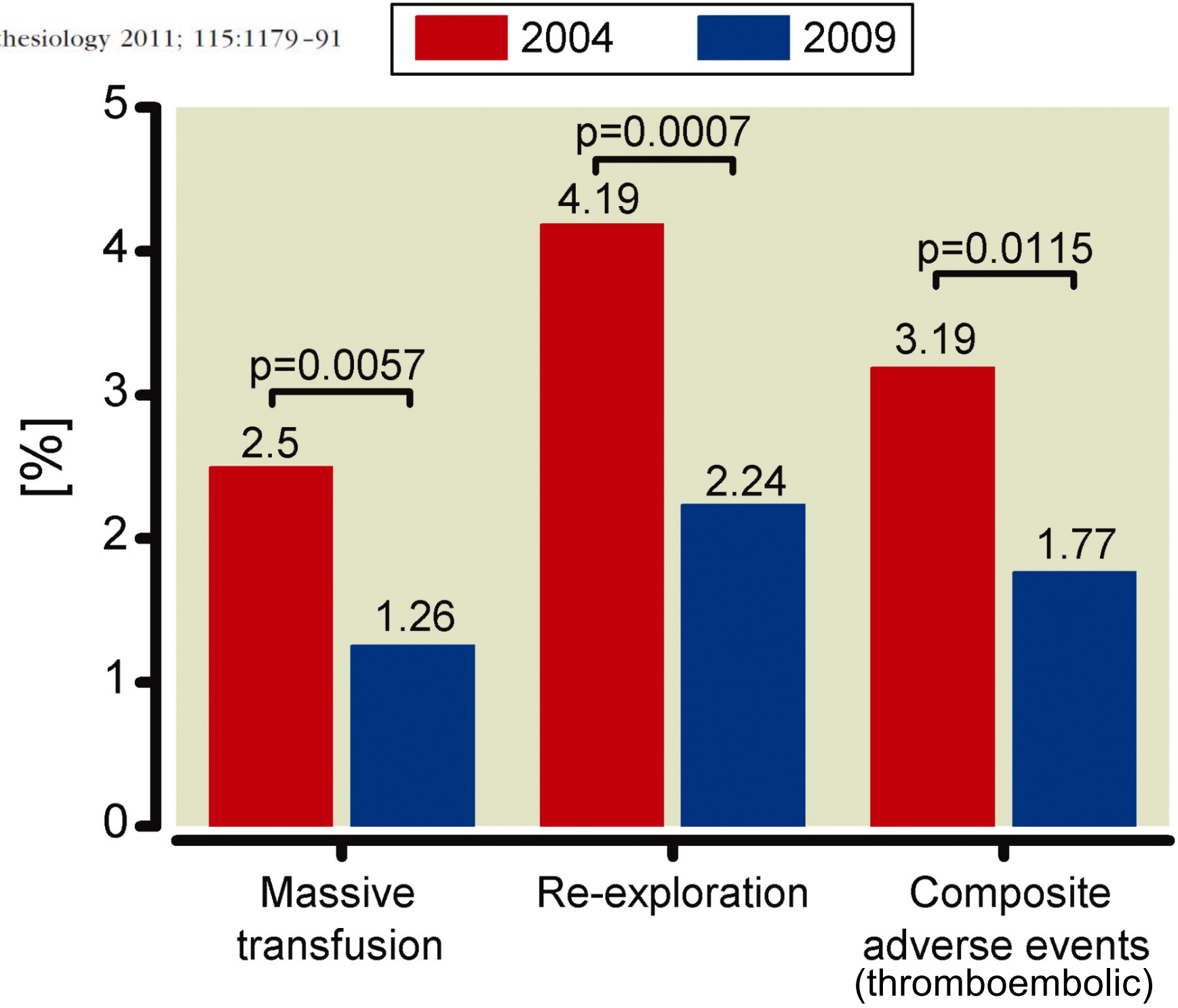
First-line Therapy with Coagulation Factor Concentrates Combined with Point-of-Care Coagulation Testing Is Associated with Decreased Allogeneic Blood Transfusion in Cardiovascular Surgery

A Retrospective, Single-center Cohort Study

Klaus Görlinger, Dr. med,* Daniel Dirkmann, Dr. med,† Alexander A. Hanke, Dr. med,† Markus Kamler, PD Dr. med,‡ Eva Kottenberg, PD Dr. med,* Matthias Thielmann, PD Dr. med,‡ Heinz Jakob, Prof. Dr. med,§ Jürgen Peters, Prof. Dr. med‖

Methods: In a retrospective cohort study including 3,865 patients, we analyzed the incidence of intraoperative allogeneic blood transfusions (primary endpoints) before and after algorithm implementation.

Anesthesiology 2011; 115:1179-91



A Prospective, Randomized Clinical Trial of Efficacy in Coagulopathic Cardiac Surgery Patients

Christian Friedrich Weber, Dr. med.,* Klaus Görlinger, Dr. med.,† Dirk Meininger, P.D. Dr. med.,‡ Eva Herrmann, Prof. Dr. rer. nat.,§ Tobias Bingold, Dr. med.,‡ Anton Moritz, Prof. Dr. med.,‖ Lawrence H. Cohn, M.D., Ph.D.,# Kai Zacharowski, Prof. Dr. med., Ph.D., F.R.C.A.**

Anesthesiology 2012; 117:531–47

- Elective cardiac surgery in 200 patients
- Pts randomized if diffuse bleeding post protamine
- Conventionnal Algorythme vs ROTEM®
- PRBCs Transfusion ad 24 h ICU
- Study stopped midpoint (50 % recrutement)
- PRBCs : 5 (4;9) vs 3 (2;6) $P < 0{,}001$

Evaluation of a Novel Transfusion Algorithm Employing Point-of-care Coagulation Assays in Cardiac Surgery

A Retrospective Cohort Study with Interrupted Time–Series Analysis

Karkouti et al. Anesthesiology 2015

	Pre-program (2012; *n* = 1312)	Post-program (2013; *n* = 1167)	*P*	Risk reduction
Culots %	52 %	41 %	< 0,0001	0,72 (0,67 – 0,79)
Plaquettes %	34 %	23 %	< 0,0001	0,59 (0,52 – 0,66)
Plasma %	34 %	14 %	< 0,0001	0,37 (0,32 – 0,43)
Cryo %	4,0 %	4,1 %	0,9	

Study and Procedure Manual

Transfusion Algorithm in Cardiac Surgery

Blood Conservation in Cardiac Surgery
using a Transfusion Algorithm
based on Point-of-Care Testing

Point-of-Care Hemostatic Testing in Cardiac Surgery

A Stepped-Wedge Clustered Randomized Controlled Trial

Karkouti et al. Circulation 2016

- 12 hôpitaux canadiens pendant 7 mois
- Sites vierges aux tests viscoélastiques
- 7402 patients randomisés
- 3555 dans le groupe contrôle
- 3847 dans le groupe intervention (88,7% respect)
- OUTCOME PRIMAIRE: transfusion de culots
- OUTCOME SECONDAIRE: transfusion autres produits

Point-of-Care Hemostatic Testing in Cardiac Surgery

A Stepped-Wedge Clustered Randomized Controlled Trial

Karkouti et al. Circulation 2016

Table 2. Effects of the Intervention on Transfusions and Bleeding

Outcome	Relative Risk (95% Confidence Interval)	*P* Value
Red blood cell transfusions	0.91 (0.85–0.98)	0.02
Platelet transfusions	0.77 (0.68–0.87)	<0.001
Plasma transfusions	0.98 (0.86–1.12)	0.79
Cryoprecipitate or fibrinogen concentrate transfusions	1.26 (0.94–1.69)	0.11
Major bleeding*	0.83 (0.72–0.94)	0.004

Practice Guidelines for Perioperative Blood Management

*An Updated Report by the American Society of Anesthesiologists Task Force on Perioperative Blood Management**

Anesthesiology 2015; 122:241-75.

Survey Findings: Both the consultants and ASA members agree that if coagulopathy is suspected, obtain viscoelastic assays (*e.g.*, TEG and ROTEM), when available, as well as platelet count. They both strongly agree that if viscoelastic assays are not available, obtain standard coagulation tests (*e.g.*, INR, aPTT, fibrinogen concentration), as well as platelet count for monitoring.

Society of Cardiovascular Anesthesiologists Clinical Practice Improvement Advisory for Management of Perioperative Bleeding and Hemostasis in Cardiac Surgery Patients

Anesth & Analg 2019; 129(5) : 1209-21.

Point of Care Testing

- We recommend the application of transfusion algorithms incorporating predefined intervention triggers based on point-of-care coagulation monitoring assays to guide hemostatic intervention.
- Implementation of transfusion and coagulation management algorithms (based on ROTEM/TEG) can reduce transfusion-associated adverse events.
- Goal-directed therapy with coagulation factor concentrates (fibrinogen and/or PCC)[5] may reduce transfusion associated adverse events.

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

Clinical Practice Improvement
Blood Conservation Group 2019

European Society of Anaesthesiology ESA

EJA European Journal of Anaesthesiology

European Society of Anaesthesiology ESA

EJA

Eur J Anaesthesiol 2013; **30:**1–112

Published online 25 April 2013

GUIDELINES

Management of severe perioperative bleeding

Guidelines from the European Society of Anaesthesiology

We recommend the application of transfusion algorithms incorporating predefined intervention triggers to guide haemostatic intervention during intraoperative bleeding.

1B

EJA

Eur J Anaesthesiol 2017; **34:**332–395

GUIDELINES

Management of severe perioperative bleeding: guidelines from the European Society of Anaesthesiology

First update 2016

We recommend the application of intervention algorithms incorporating pre-defined triggers and targets based on viscoelastic haemostatic assay (VHA) coagulation monitoring to guide individualised haemostatic intervention in the case of perioperative bleeding. **1C**

1C Strong recommendation. Low-quality evidence.

9.1.4. What is the evidence for the use of haemostatic management algorithms in cardiovascular surgery?

Recommendation

We recommend the use of standardised VHA-guided haemostatic algorithms with pre-defined intervention triggers. **1B**

1B Strong recommendation. Moderate-quality evidence.

EJA

Eur J Anaesthesiol 2023; **40:**226–304

GUIDELINES

Management of severe peri-operative bleeding: Guidelines from the European Society of Anaesthesiology and Intensive Care

Second update 2022

We recommend the use of standardised haemostatic algorithms with predefined intervention triggers over clinicians' discretion for the management of coagulopathy in cardiac surgery. 1B

1B Strong recommendation. Moderate-quality evidence.

We suggest the use of point-of-care haemostatic testing over conventional coagulation assays for the management of coagulopathy in cardiac surgery. 2C

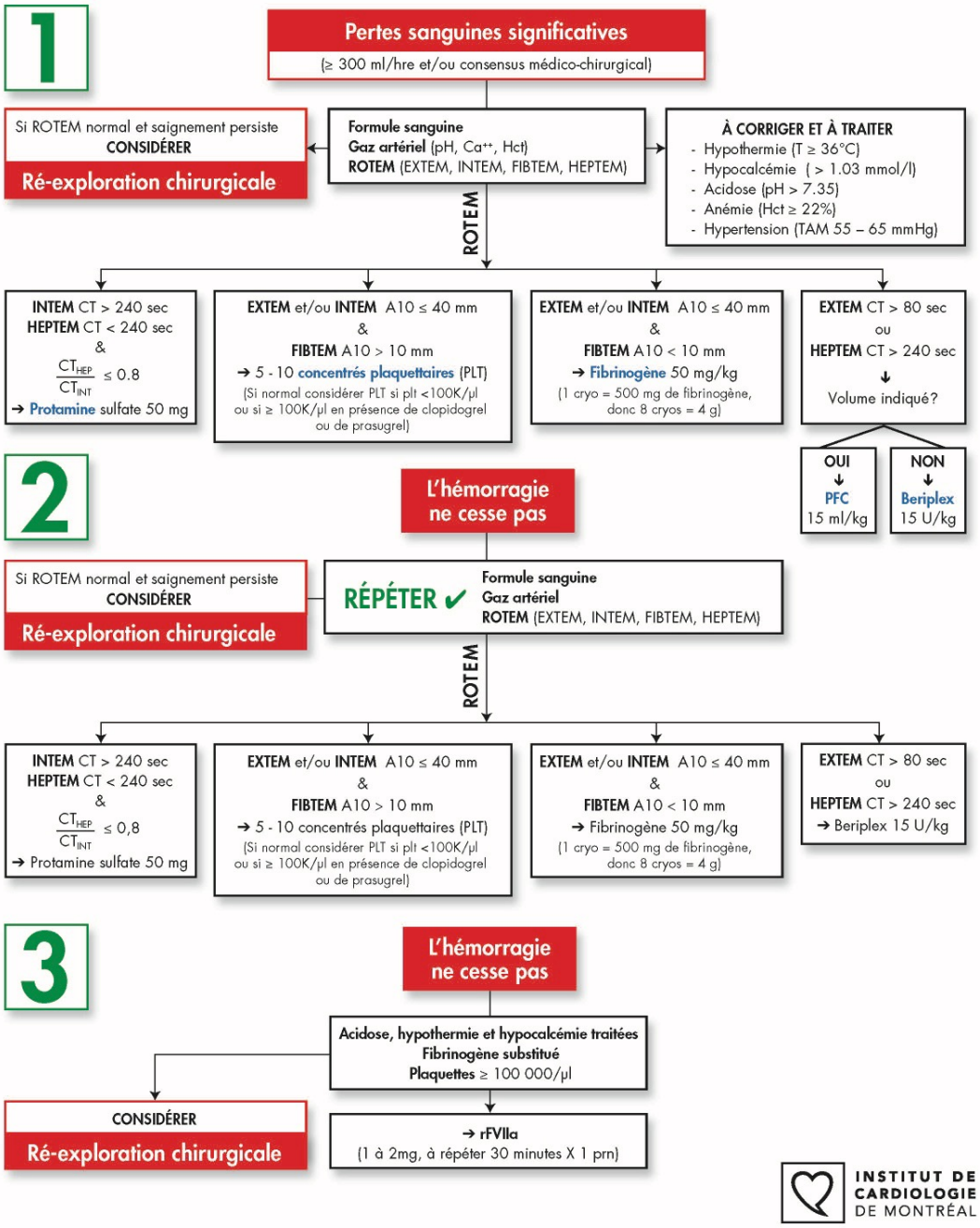
2C Weak recommendation Low-quality evidence


Le bon produit
au bon moment
au bon patient!

Que faire avec le Rotem?

ALGORITHME TRANSFUSIONNEL

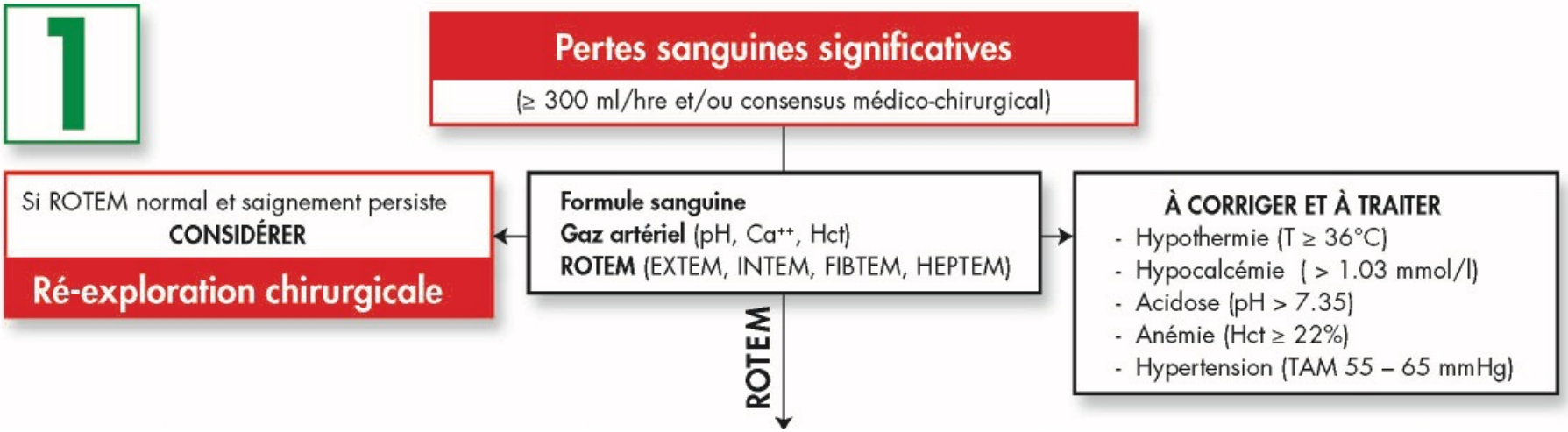
Bloc opératoire et soins intensifs

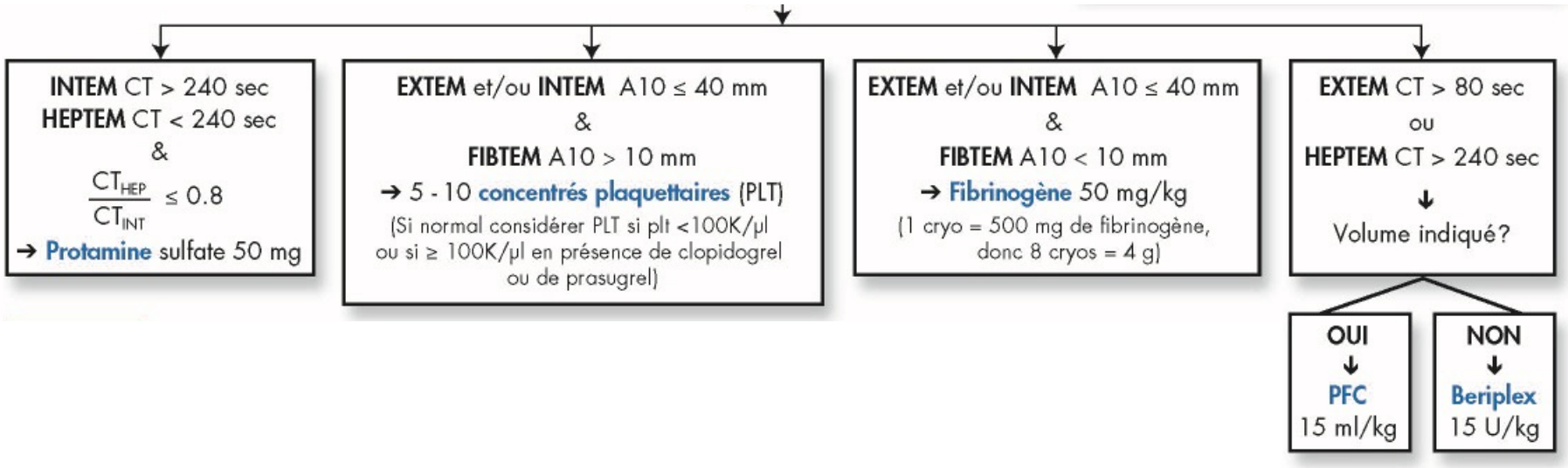


INSTITUT DE CARDIOLOGIE DE MONTRÉAL

ALGORITHME TRANSFUSIONNEL

Bloc opératoire et soins intensifs




INTEM CT > 240 sec
HEPTEM CT < 240 sec
&
CT_HEP / CT_INT ≤ 0.8
→ Protamine sulfate 50 mg
EXTEM et/ou INTEM A10 ≤ 40 mm
&
FIBTEM A10 > 10 mm
→ 5 - 10 concentrés plaquettaires (PLT)
(Si normal considérer PLT si plt <100K/µl ou si ≥ 100K/µl en présence de clopidogrel ou de prasugrel)
EXTEM et/ou INTEM A10 ≤ 40 mm
&
FIBTEM A10 < 10 mm
→ Fibrinogène 50 mg/kg
(1 cryo = 500 mg de fibrinogène, donc 8 cryos = 4 g)
EXTEM CT > 80 sec
ou
HEPTEM CT > 240 sec
↓
Volume indiqué?
OUI
↓
PFC
15 ml/kg
NON
↓
Beriplex
15 U/kg

INTEM CT > 240 sec

HEPTEM CT < 240 sec

&

$$\frac{CT_{HEP}}{CT_{INT}} \leq 0.8$$

→ Protamine sulfate 50 mg

PROTAMINE

EXTEM et/ou **INTEM** A10 ≤ 40 mm

&

FIBTEM A10 > 10 mm

→ 5 - 10 concentrés plaquettaires (CP)

(Considérer CP si plt <100K/µl Ou si ≥ 100K/µl en présence de clopidogrel ou de prasugrel)

PLAQUETTES

EXTEM et/ou **INTEM** A10 ≤ 40 mm

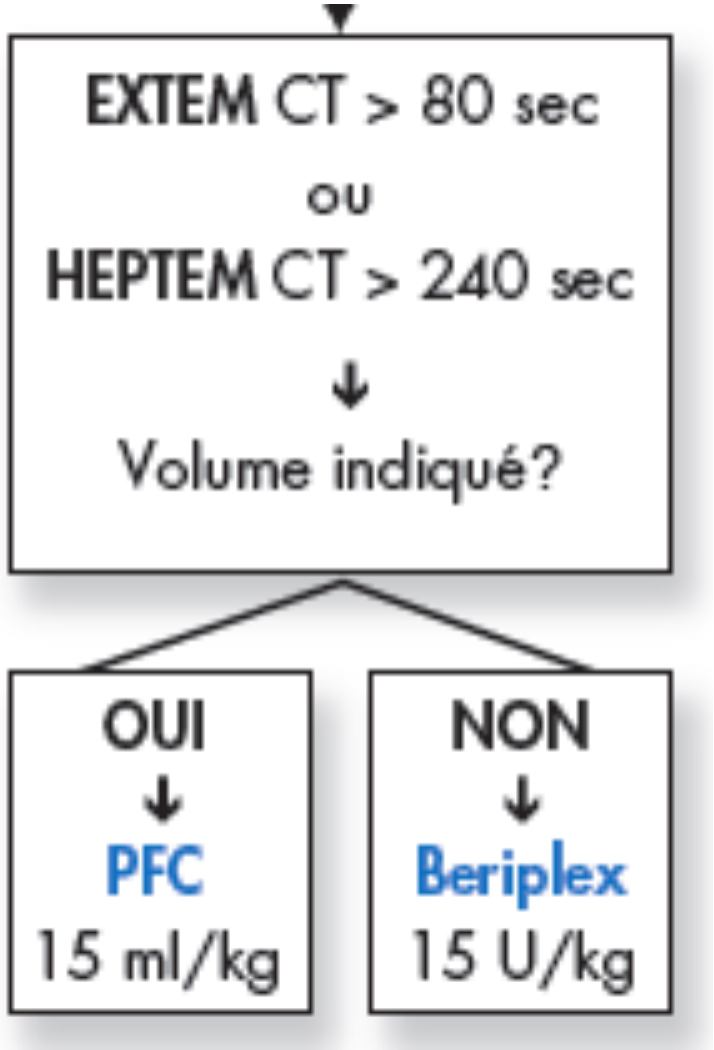
&

FIBTEM A10 < 10 mm

→ Fibrinogène 50 mg/kg

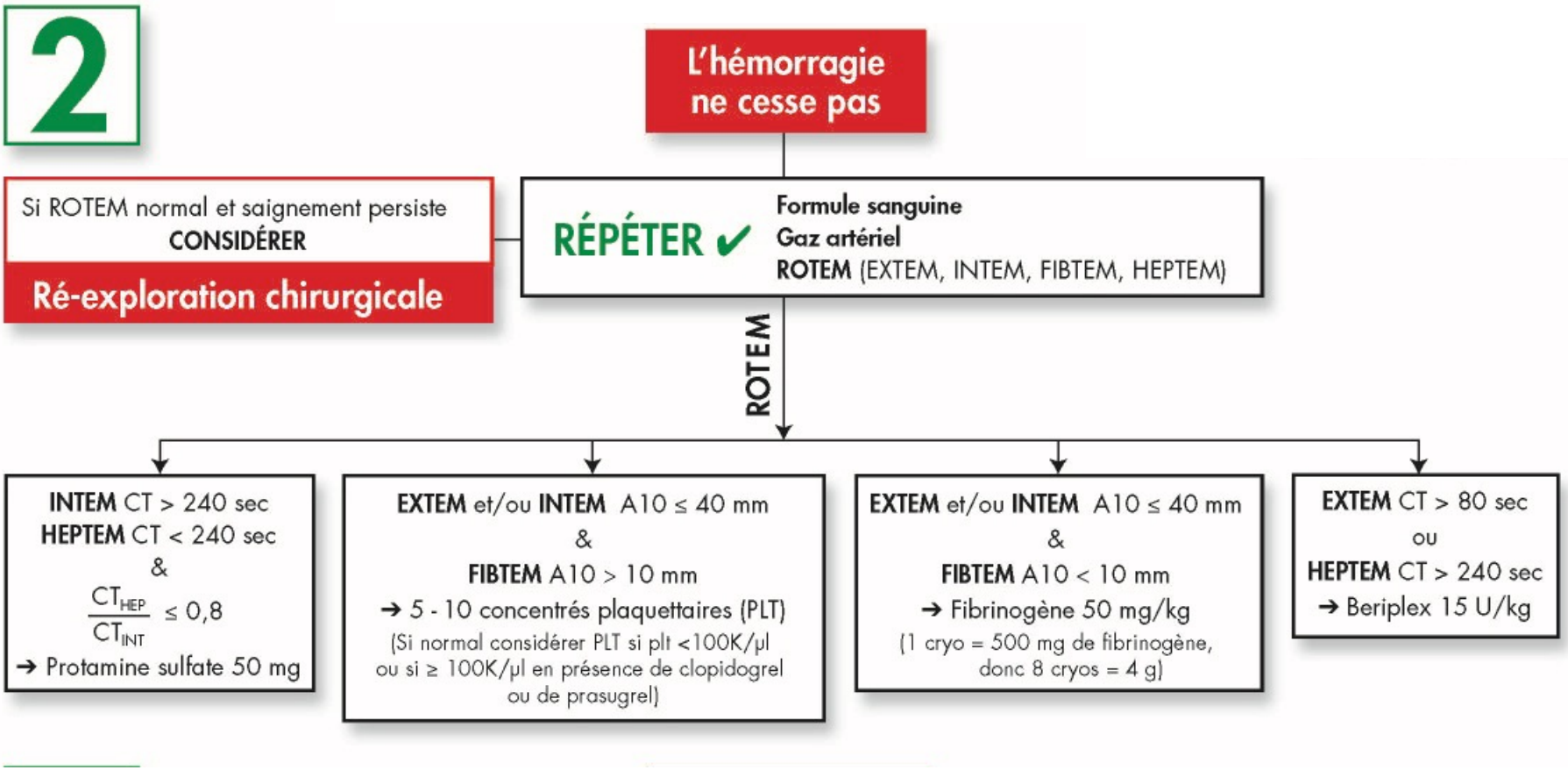
(1 cryo = 500 mg de fibrinogène,
donc 8 cryos = 4 g)

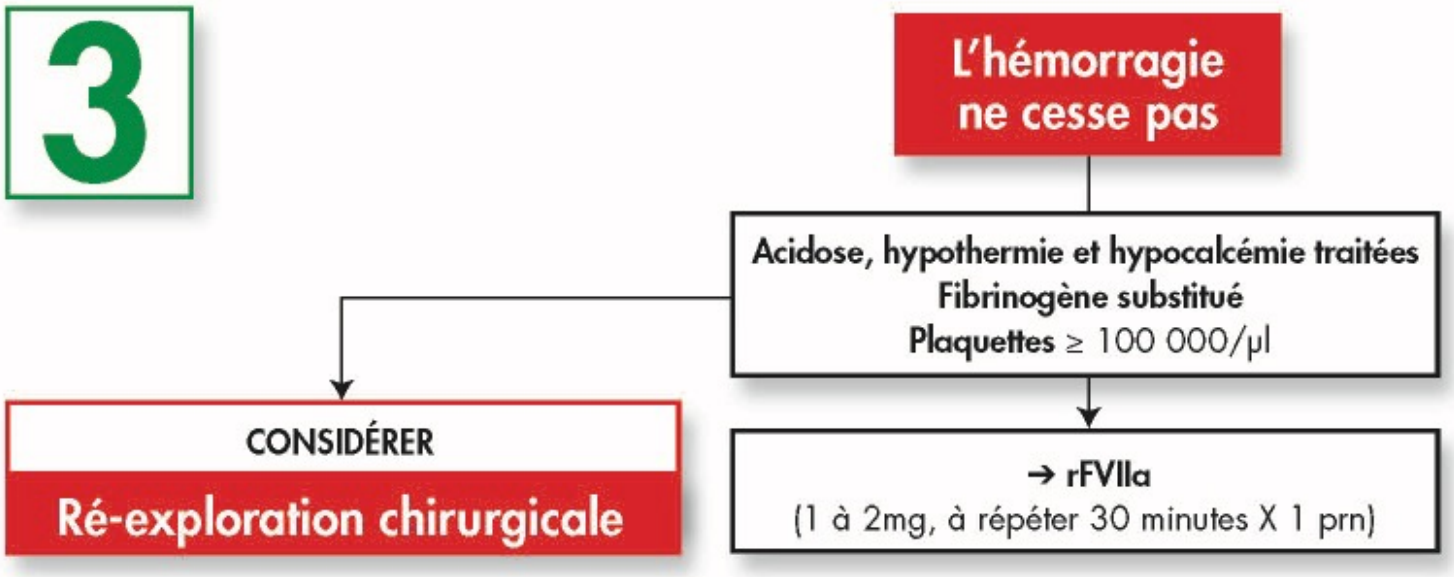
FIBRINOGÈNE



Post Étude FARES-2
CCP: 20-25 U/kg?

PLASMA / CCP


2
L'hémorragie ne cesse pas
RÉPÉTER ✔
Formule sanguine
Gaz artériel
ROTEM (EXTEM, INTEM, FIBTEM, HEPTEM)
Si ROTEM normal et saignement persiste
CONSIDÉRER
Ré-exploration chirurgicale
ROTEM
INTEM CT > 240 sec
HEPTEM CT < 240 sec
&
CT_HEP / CT_INT ≤ 0,8
➔ Protamine sulfate 50 mg
EXTEM et/ou INTEM A10 ≤ 40 mm
&
FIBTEM A10 > 10 mm
➔ 5 - 10 concentrés plaquettaires (PLT)
(Si normal considérer PLT si plt <100K/µl ou si ≥ 100K/µl en présence de clopidogrel ou de prasugrel)
EXTEM et/ou INTEM A10 ≤ 40 mm
&
FIBTEM A10 < 10 mm
➔ Fibrinogène 50 mg/kg
(1 cryo = 500 mg de fibrinogène, donc 8 cryos = 4 g)
EXTEM CT > 80 sec
ou
HEPTEM CT > 240 sec
➔ Beriplex 15 U/kg


3
L'hémorragie ne cesse pas
Acidose, hypothermie et hypocalcémie traitées
Fibrinogène substitué
Plaquettes ≥ 100 000/µl
→ rFVIIa
(1 à 2mg, à répéter 30 minutes X 1 prn)
CONSIDÉRER
Ré-exploration chirurgicale

Procédure Rotem à l'ICM:

1	**Hématologie 3698**
2	**Tube bleu** (citraté)
3	**Créer requête** OE
4	Brancardier
5	**SecureViewer**
6	**Courbes Rotem**
7-8	**Imprimer**

Toujours faire une formule sanguine
&
Un pH artériel
En même temps!

4

Faite transporter le tube citraté (bleu) en hématologie par le brancardier

Ne pas l'envoyer par pneumatique!

ROTEM ® = Thromboélastométrie rotatoire

Rotem® : impact à l'ICM

ROTEM® & ICM : produits sanguins labiles

2012 – 2015

ROTEM® disponible SOP & SIC 24 / 7 / 365

	Pré-algorithm (2012-13)	Post-algorithm (2013-14)	Post-algorithm (2014-15)	% Change	Économie ($)
Culots (n)	5227	3750	3385	-28	516 684
Plaquettes (n)	1459	1048	947	-28	249 283
Plasma (n)	1764	1179	922	-33	97 127
Cryo (n)	1976	1634	1448	-17	55 239
rFVIIa (1mg)	59	26	27	-56	38 806
CCP (500U)	171	234	104	37	-24 255
CCP (1000U)		25	194		**932 887**

ROTEM® & ICM : produits sanguins labiles

ROTEM® disponible SOP & SIC 24 / 7 / 365

Année	Culots	Plasma	PCC	plaquettes	Cryos	rFVIIa
2011 – 2012	5321	2061	113	1316	2184	85
2012 – 2013	5227	1764	171	1459	1976	63
2013 – 2014	3750	1179	259	1048	1634	26
2014 – 2015	3385	922	298	947	1448	27
2015 – 2016	3459	806	375	1051	1296	23
2016 – 2017	3307	708	510	994	1324	29
2017 – 2018	2967	524	446	930	1090	2
2018 – 2019	3022	703	525	956	837	2
2019 – 2020	3455	714	631	1060	1150	12
2023 - 2024	3383	414	1099	927	1333	8
2024 - 2025	3694	561	1019	988	2001	14

Prix des produits sanguins labiles & stables

2024 – 2025

Produits	Prix
Culot globulaire	482,62 $
Cryoprécipité	318,02 $
Plasma (250 ml)	362,71 $
Plaquettes	736,32 $
rFVIIa (1mg)	1280,03 $
CCP (500U)	300 $
CCP (1000U)	600 $
AT3 (1000U)	1390,00 $

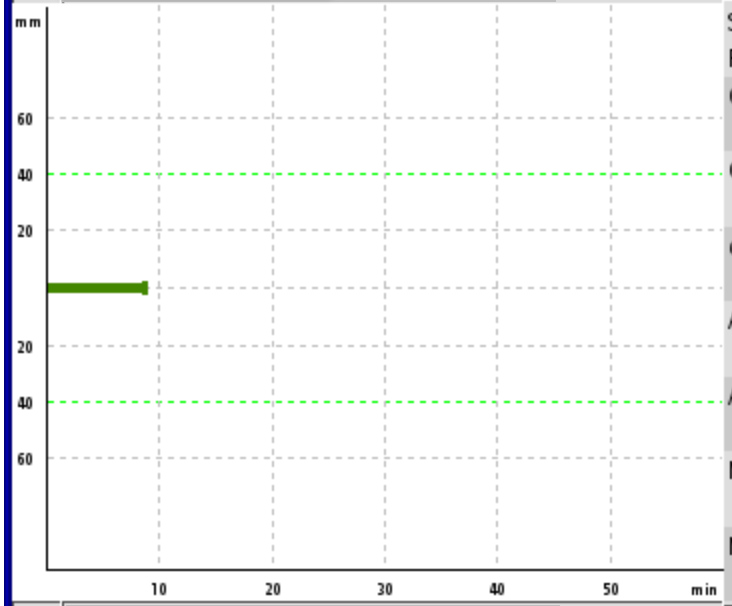
5 x = 1590,10 $

Rotem®: cas cliniques

Device:_DELTA_LAB1

Cas 1

1

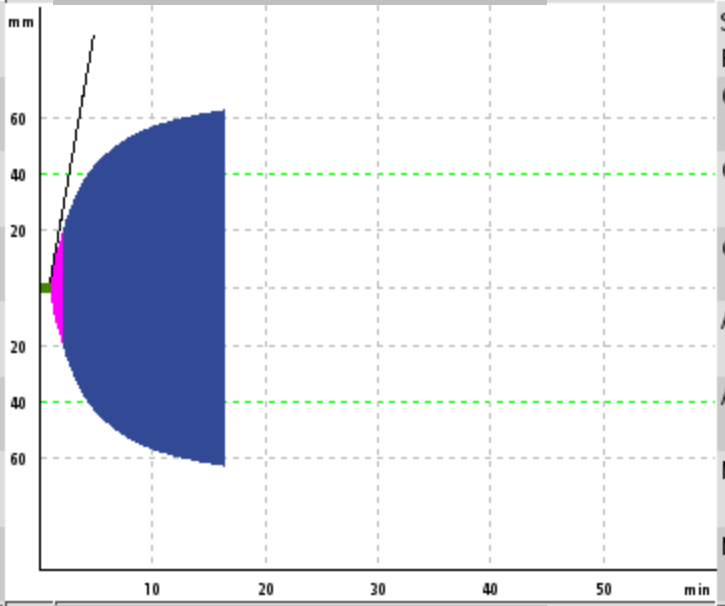


INTEM

ST: 12:49:09
RT: 00:18:12

CT:	*	526 s
		[0100 -- 0240]
CFT:		---
α:		---
A10:		---
A20:		---
MCF:		---
ML:		---

2

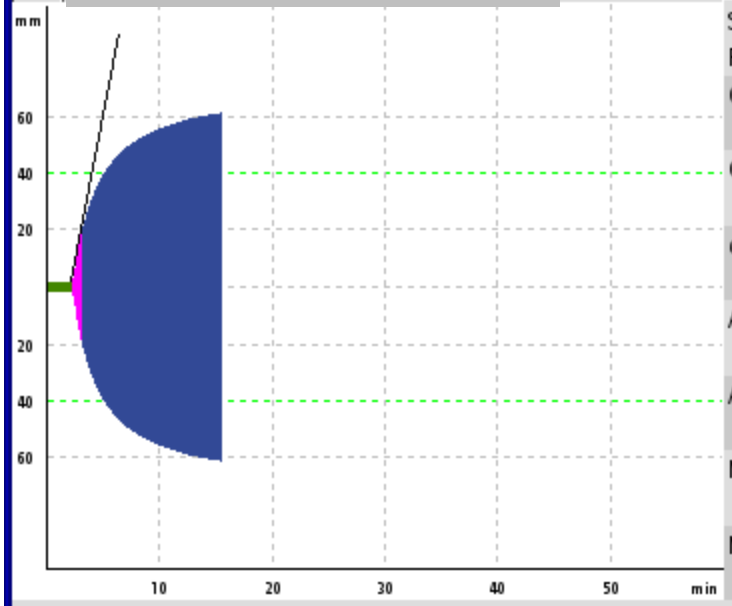


EXTEM

ST: 12:50:33
RT: 00:16:48

CT:		58 s
		[0038 -- 0079]
CFT:		63 s
		[0034 -- 0159]
α:		81 °
		[0063 -- 0083]
A10:		58 mm
A20:		---
MCF:	*	63 mm
		[0050 -- 0072]
ML:	*	0 %

3

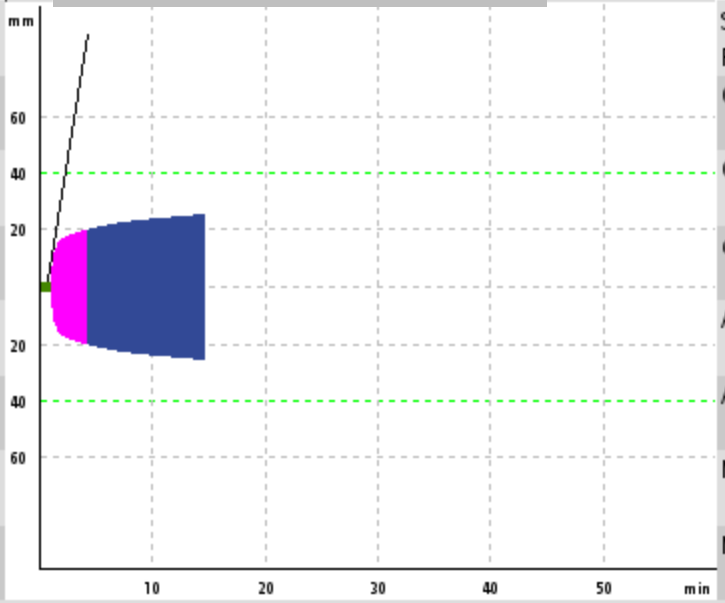


HEPTEM

ST: 12:51:25
RT: 00:15:56

CT:		134 s
CFT:		53 s
α:		80 °
A10:		59 mm
A20:		---
MCF:	*	61 mm
ML:	*	0 %

4



FIBTEM

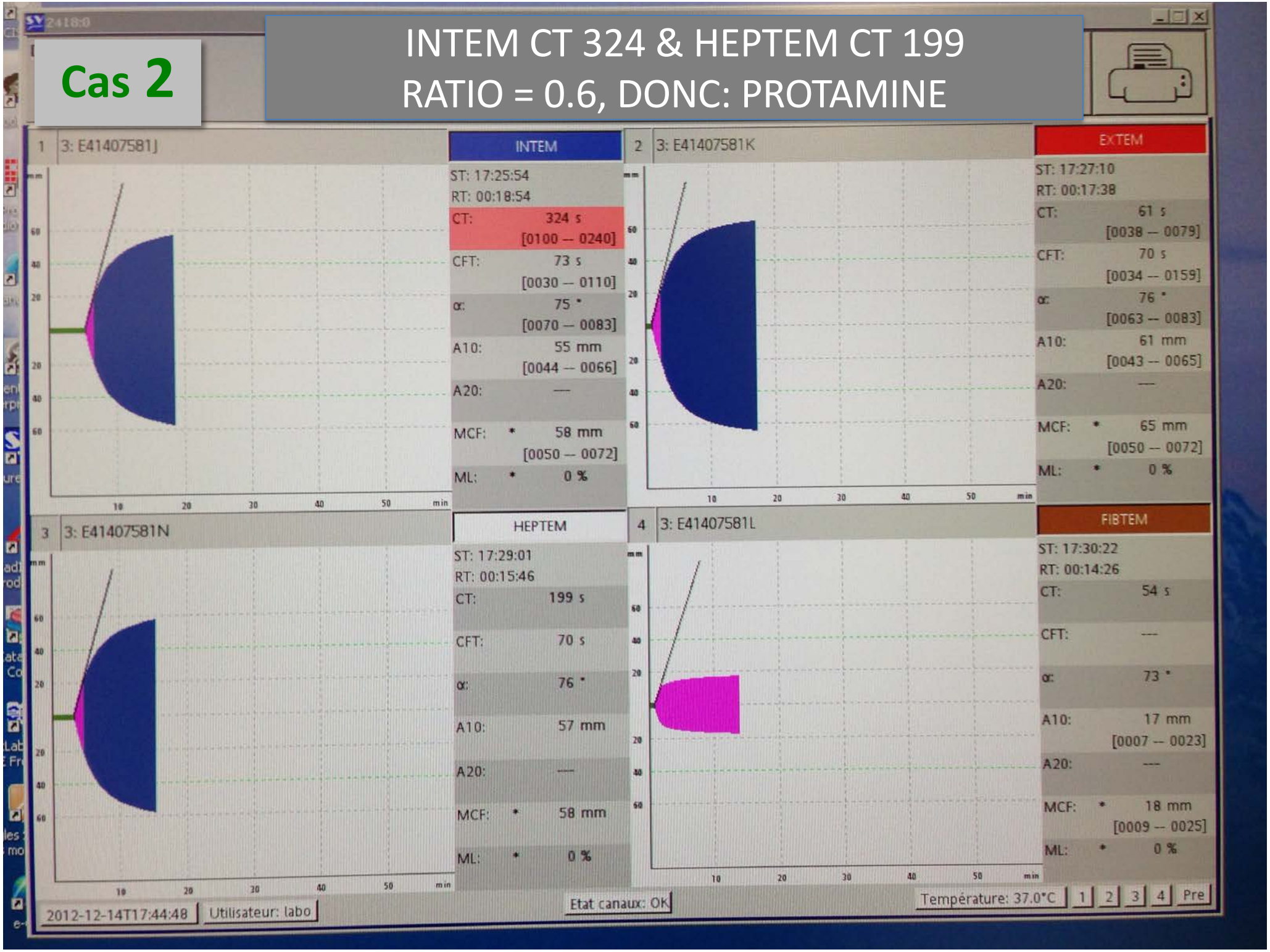
ST: 12:52:16
RT: 00:15:04

CT:		52 s
CFT:		193 s
α:		82 °
A10:		24 mm
A20:		---
MCF:	*	25 mm
		[0009 -- 0025]
ML:	*	0 %

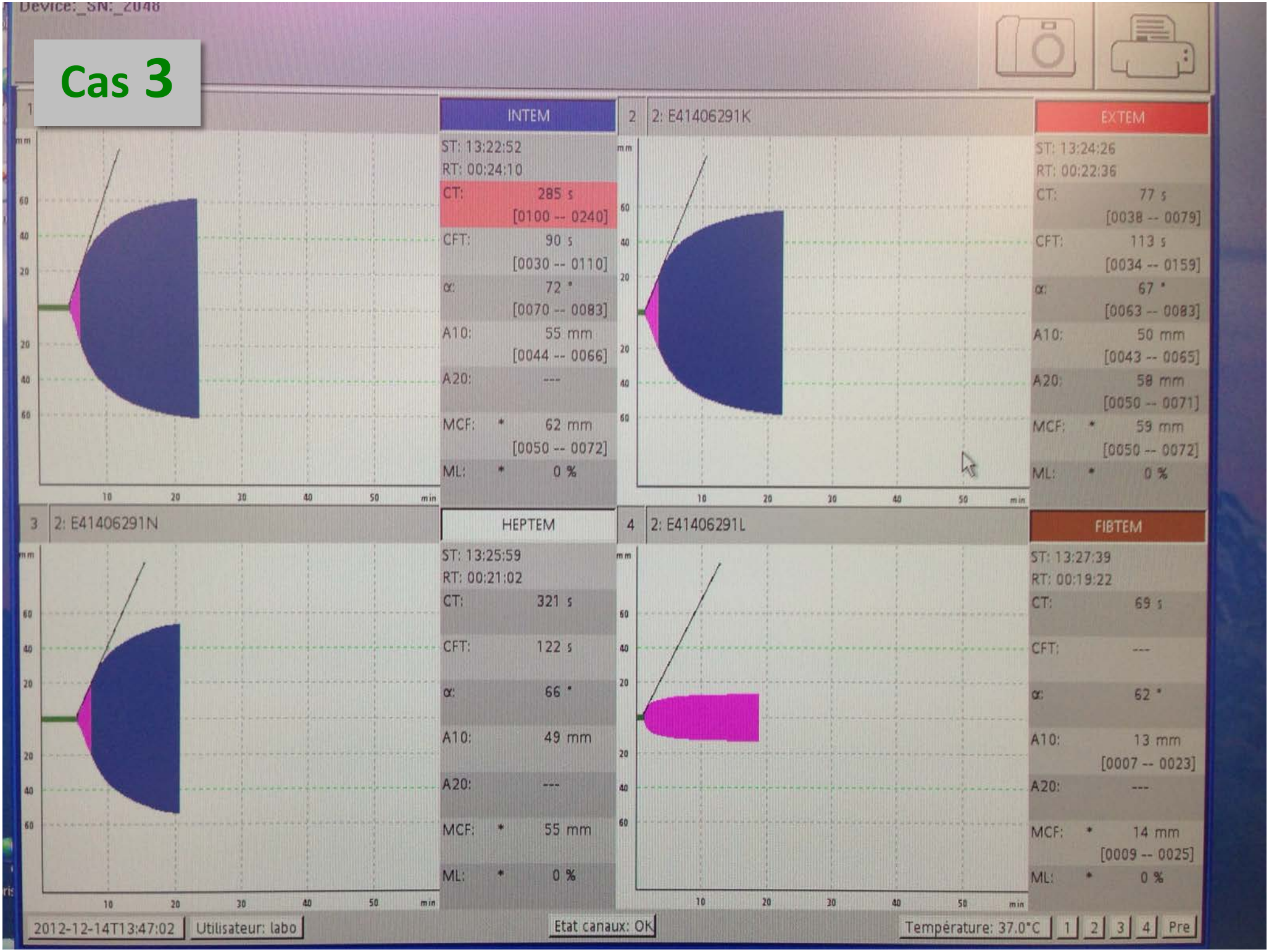
2013-10-02T13:07:21 | v2.3.1-us | Utilisateur: labo | Température: 37.0°C | Pre | 1 | 2 | 3 | 4

Cas 2

INTEM CT 324 & HEPTEM CT 199
RATIO = 0.6, DONC: PROTAMINE



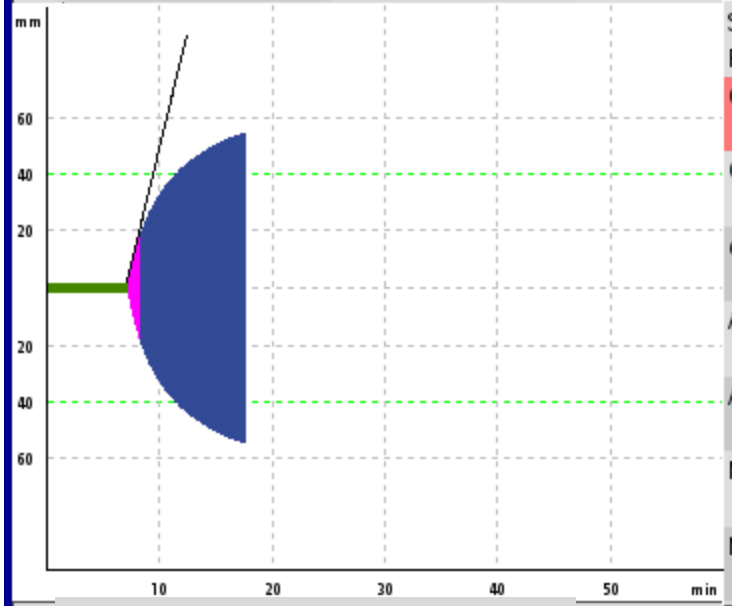
Cas 3


Device: SN: 2048
INTEM
ST: 13:22:52
RT: 00:24:10
CT: 285 s
[0100 -- 0240]
CFT: 90 s
[0030 -- 0110]
α: 72 °
[0070 -- 0083]
A10: 55 mm
[0044 -- 0066]
A20: ---
MCF: * 62 mm
[0050 -- 0072]
ML: * 0 %
2: E41406291K
EXTEM
ST: 13:24:26
RT: 00:22:36
CT: 77 s
[0038 -- 0079]
CFT: 113 s
[0034 -- 0159]
α: 67 °
[0063 -- 0083]
A10: 50 mm
[0043 -- 0065]
A20: 58 mm
[0050 -- 0071]
MCF: * 59 mm
[0050 -- 0072]
ML: * 0 %
3
2: E41406291N
HEPTEM
ST: 13:25:59
RT: 00:21:02
CT: 321 s
CFT: 122 s
α: 66 °
A10: 49 mm
A20: ---
MCF: * 55 mm
ML: * 0 %
4
2: E41406291L
FIBTEM
ST: 13:27:39
RT: 00:19:22
CT: 69 s
CFT: ---
α: 62 °
A10: 13 mm
[0007 -- 0023]
A20: ---
MCF: * 14 mm
[0009 -- 0025]
ML: * 0 %
mm
min
2012-12-14T13:47:02
Utilisateur: labo
Etat canaux: OK
Température: 37.0°C
1
2
3
4
Pre

Device:_DELTA_LAB1

Cas 4

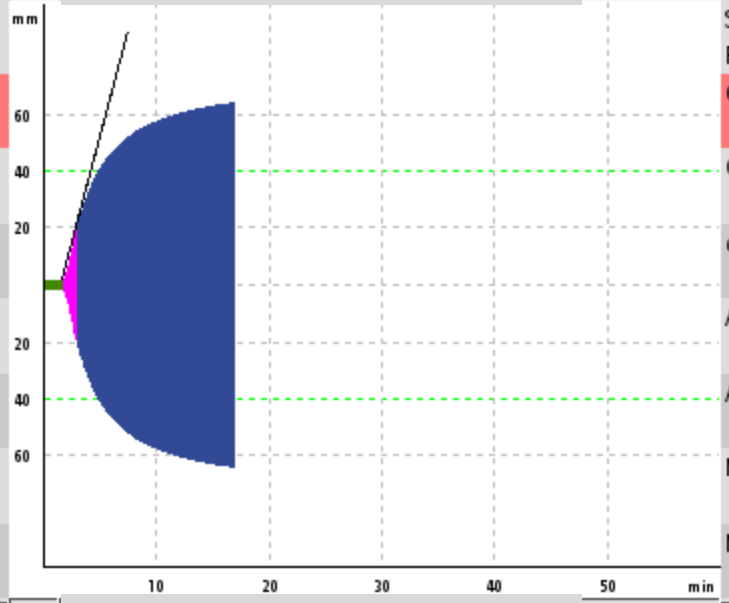
1



INTEM

ST: 07:05:47
RT: 00:18:08
CT: 428 s [0100 -- 0240]
CFT: 74 s [0030 -- 0110]
α: 77 ° [0070 -- 0083]
A10: 54 mm
A20: ---
MCF: * 55 mm [0050 -- 0072]
ML: * 0 %

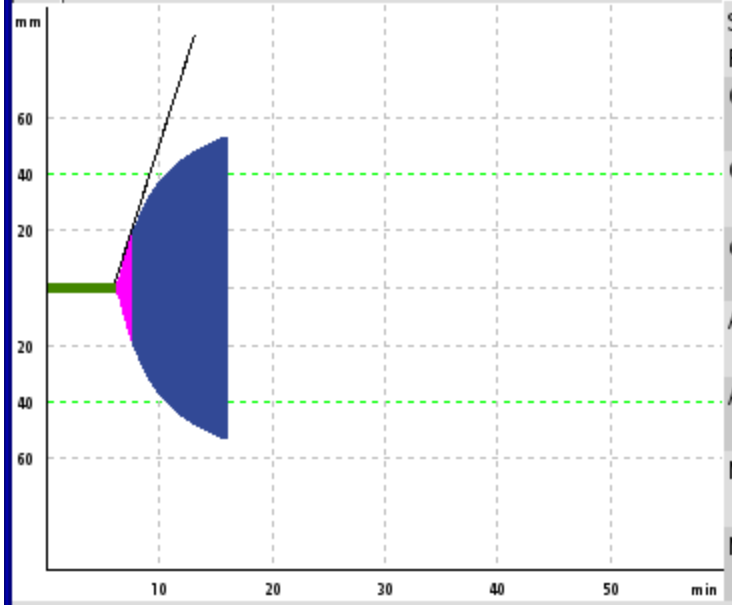
2



EXTEM

ST: 07:06:36
RT: 00:17:18
CT: 102 s [0038 -- 0079]
CFT: 70 s [0034 -- 0159]
α: 76 ° [0063 -- 0083]
A10: 60 mm
A20: ---
MCF: * 64 mm [0050 -- 0072]
ML: * 0 %

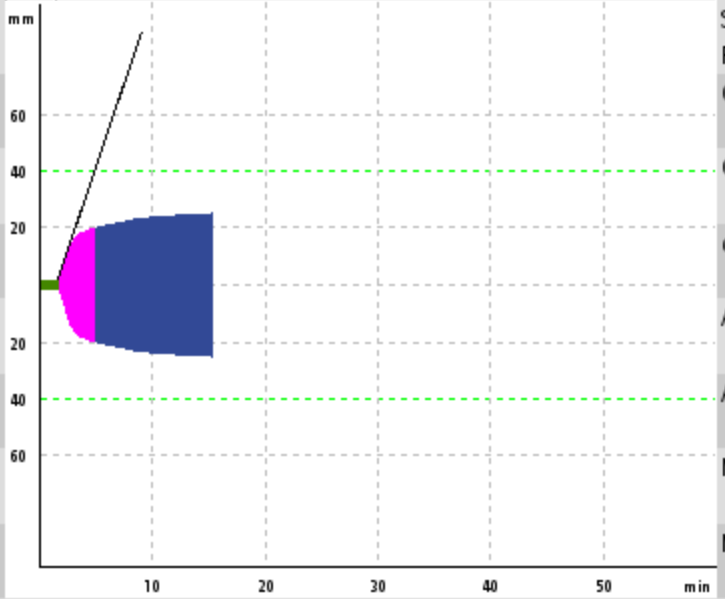
3



HEPTEM

ST: 07:07:24
RT: 00:16:30
CT: 369 s
CFT: 86 s
α: 73 °
A10: ---
A20: ---
MCF: * 54 mm
ML: * 0 %

4



FIBTEM

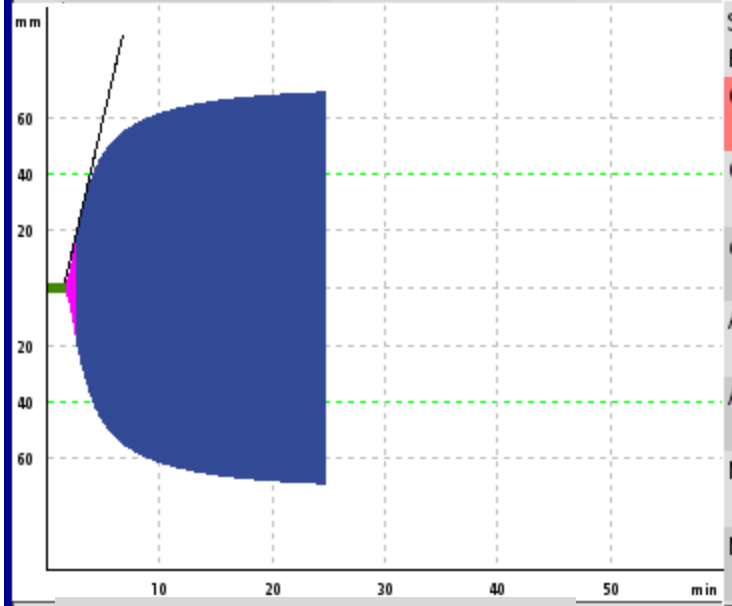
ST: 07:08:14
RT: 00:15:40
CT: 98 s
CFT: 194 s
α: 72 °
A10: 24 mm
A20: ---
MCF: * 25 mm [0009 -- 0025]
ML: * 0 %

2014-02-28T07:23:55 | v2.3.1-us | Utilisateur: labo | Température: 37.0°C | Pre | 1 | 2 | 3 | 4

Cas 5

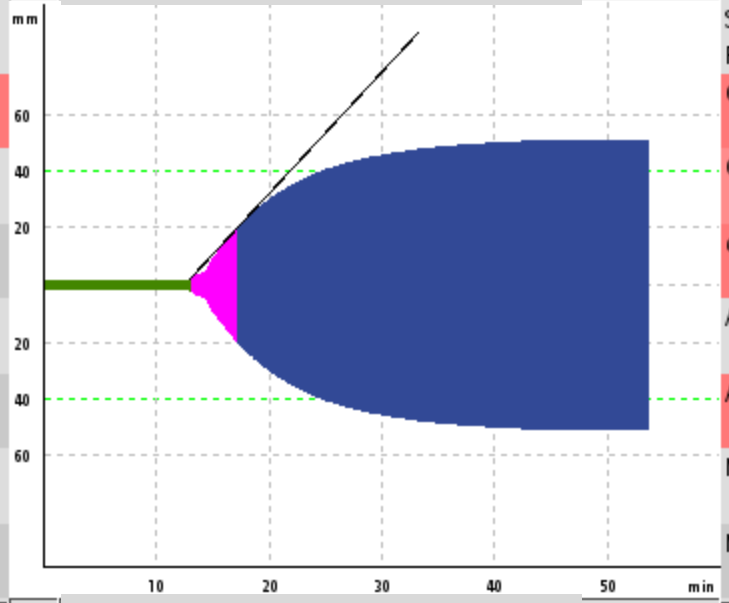
ROTEM® Measurement module

Multi-TEM | Screenshot | Standard overlay | Patient overlay | | Help | Quit



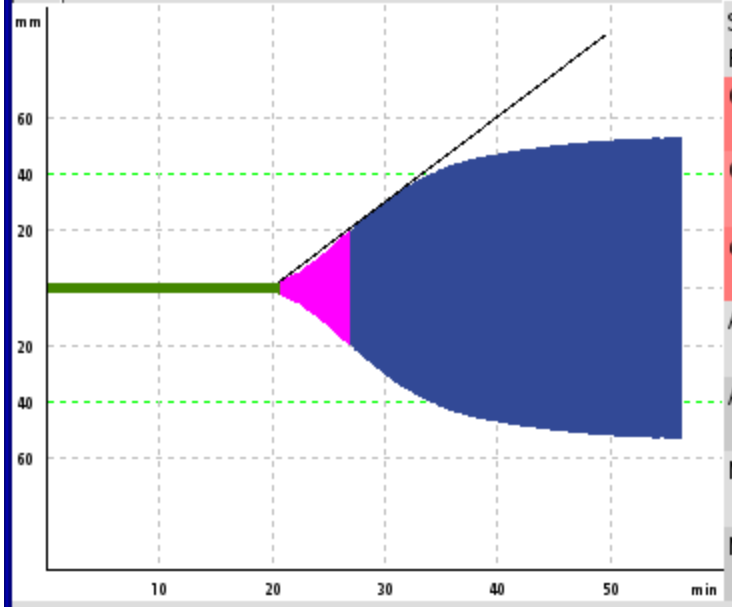
1 EXTEM

ST:	15:02:49	
RT:	00:25:08	
CT:	101 s	[0043 -- 0082]
CFT:	61 s	[0048 -- 0127]
α:	78 °	[0065 -- 0080]
A10:	64 mm	
A20:	69 mm	[0050 -- 0070]
MCF: *	69 mm	[0052 -- 0070]
ML: *	0 %	



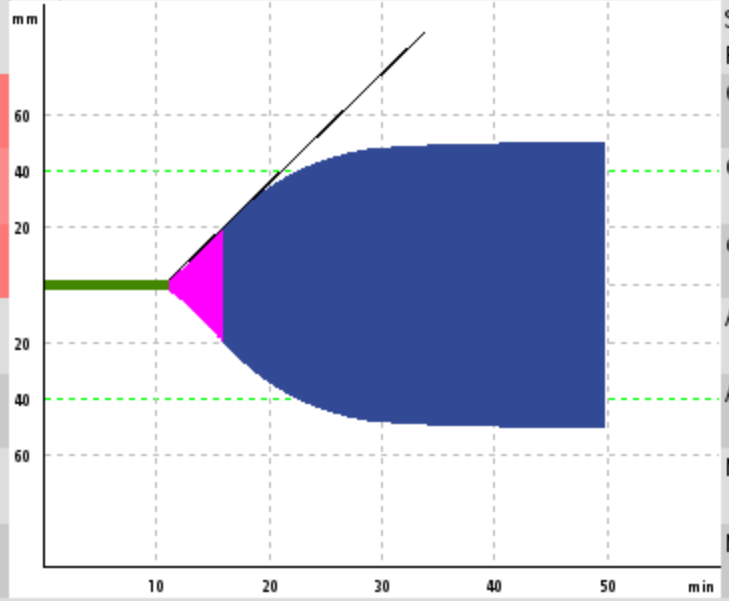
2 INTEM

ST:	14:33:48	
RT:	00:54:08	
CT:	780 s	[0122 -- 0208]
CFT:	251 s	[0045 -- 0110]
α:	47 °	[0070 -- 0081]
A10:	37 mm	
A20:	48 mm	[0051 -- 0072]
MCF: *	51 mm	[0051 -- 0072]
ML: *	0 %	



3 NATEM

ST:	14:31:12	
RT:	00:56:44	
CT:	1240 s	[0254 -- 0837]
CFT:	377 s	[0072 -- 0357]
α:	37 °	[0039 -- 0075]
A10:	32 mm	
A20:	48 mm	[0040 -- 0067]
MCF: *	53 mm	[0046 -- 0069]
ML: *	0 %	



4 HEPTEM

ST:	14:37:49	
RT:	00:50:06	
CT:	673 s	
CFT:	282 s	
α:	44 °	
A10:	37 mm	
A20:	49 mm	
MCF:	50 mm	
ML: *	0 %	

2015-01-11T15:27:57 | v2.3.1-us | User: admin | Temperature: 37.0°C | Pre | 1 | 2 | 3 | 4

Limitations des tests viscoélastiques

- La composante vasculaire n’est pas inclue
- Les thérapies anti-thrombotiques ne sont pas détectées
- Les tests viscoélastiques standards sont effectués à 37°C
- Le rôle de l’hématocrite n’est pas réflété
- L’utilité clinique n’a été validé que pour les patients avec un saignement actif

Le Rotem® en résumé:

- Test fonctionnel de la coagulation
- Plus rapide que les tests standards
- Utilisé dans un algorithme = patients mieux transfusés = moins de transfusions
- Meilleur devenir post-opératoire

Merci!