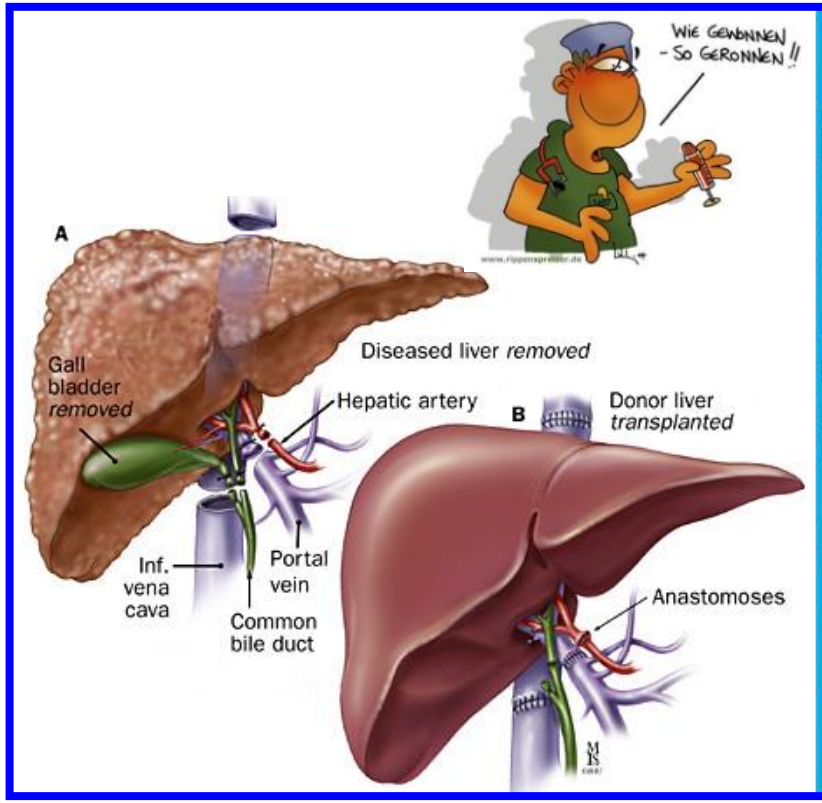


Workshop: (TEG and) ROTEM in Cirrhosis (and LTX)

International Congress on Coagulopathy in Liver Disease, Castellana Grotte, Italy, April 10, 2026

Klaus Görlinger, MD, Essen/Munich, Germany

Disclosures

- Senior Consultant for Anesthesiology, Emergency and Intensive Care Medicine, Hemostaseology, and Pain Therapy
- Dec 1986 - June 2012: Senior Consultant at the Department of Anesthesiology and Intensive Care Medicine, **University Hospital Essen, Germany** (Trauma, Liver Transplant and Cardiac Surgery)
- 2010 - 2012: Chair of the Section Clinical Hemotherapy and Hemostasis Management of the German Interdisciplinary Association of Critical Care and Emergency Medicine (**DIVI**)
- 2010 - 2012: Member of the European Society of Anesthesiology (**ESA**) Scientific Subcommittee Transfusion and Hemostasis and the Task Force / co-author of the **ESA Guidelines on the Management of Severe Perioperative Bleeding**
- Since July 2012, KG is the **Medical Director** of **Tem Innovations GmbH**, Munich, Germany, which belongs to **Werfen,** Barcelona, Spain since September 2016.

Scand J Gastroenterol. 2024 Sep;59(9):1062-1068.

Rotational Thromboelastometry Predicts Future Bleeding Events in Patients with Cirrhosis

Janko N, Majeed A, Commins I, Gow P, Kemp W, Roberts SK.

RESULTS: Nineteen of the 162 patients recruited experienced a **bleeding event within one year of ROTEM analysis.**

On univariate analysis, **MCF using both EXTEM and INTEM** tests was **significantly reduced in patients who had a bleeding event,** compared to those who did not **(50 mm vs. 57 mm, *P < 0.01* and 48 mm vs. 54 mm, *P < 0.01,* respectively).**

In addition, on univariate analysis, **CT in the INTEM** test was **prolonged in the bleeding group (214 s vs. 198 s, *P = 0.01*).**

On multivariate analysis, only EXTEM MCF was a significant predictor of bleeding events.

CONCLUSIONS: ROTEM may provide a **useful tool in predicting future bleeding events in patients with cirrhosis.**

Eur J Gastroenterol Hepatol. 2025 Apr 1;37(4):510-516.

Rotational Thromboelastometry Predicts Transplant-free Survival in Patients with Liver Cirrhosis

Janko N, Majeed A, Commins I, Gow P, Kemp W, Roberts SK.

RESULTS: Between April 2018 and October 2021, 162 patients with cirrhosis were recruited and **followed-up for a median of 42 months.** During follow-up, 36 patients died and 7 underwent liver transplantation.

On univariate analysis, **MCF** using **both EXTEM and INTEM tests** was **significantly reduced in the death/liver transplant group compared to the survivor group (52 vs. 57, *P = 0.02;* and 51 vs. 55, *P = 0.01,* respectively).**

After adjusting for age, sex, presence of clinically significant portal hypertension, hepatocellular carcinoma, care setting, bilirubin, sodium and creatinine, **only albumin (HR: 0.92,** 95% CI: 0.85-0.99, *P = 0.018*) **and MCF EXTEM (HR: 0.96,** 95% CI: 0.92-0.99, *P = 0.032*) remained **significant predictors of transplant-free survival.**

Liver Int. 2022 Nov;42(11):2492-2500.

Rotational Thromboelastometry-Guided Blood Component Use in Cirrhotic Children Undergoing Invasive Procedures: Randomized Controlled Trial

Maria A, Lal BB, Khanna R, Sood V, Mukund A, Bajpai M, Alam S.

RESULTS: A total of **423 invasive procedures** were screened for inclusion of which **60 were randomized** (30 in each group with comparable baseline parameters).

The **volume of total blood components,** FFP and platelets transfused was **significantly lower in ROTEM** as compared to conventional group. Only **46.7%** of children in **ROTEM** group received a blood component compared to **100%** in **conventional group (*P < 0.001*).**

The requirement of **FFP (ROTEM: 43.3%, Conventional: 83.3%, *P = 0.001*)** was significantly **lower** in the patients receiving **ROTEM**-guided transfusions.

There was no difference in procedure-related bleed and transfusion-related complications between the two groups. **ROTEM was cost-effective** (median: ₹750; IQR: ₹750–3298 vs. (median: ₹3687; IQR: ₹1511–6293; *P = 0.002*) **despite the additional cost of the test.**

J Clin Exp Hepatol. 2025 Jan-Feb;15(1):102409.

Rotational Thromboelastometry Reduces the Need for Preemptive Transfusion in Cirrhosis: A Randomized Controlled Trial (NCT:05698134)

Kumar R, Ng LXL, Wong YJ, Tan CK, Wang LZ, Qiu TY, Wong B, Lin KW, Li JW, Kwek ABE, Ang TL, Gokhle RS, Sivanath TP.

RESULTS: From August 2021 to January 2023, a total of **40 patients** were recruited (ROTEM (n = 20) and SOC (n = 20)). The trial was terminated earlier during interim analyses due to compelling benefit in the ROTEM group after a scheduled interim analysis.

The **ROTEM group** required **substantially less blood transfusion** than the SOC group (**40%** [8/20] **vs 100%** [20/20], *P < 0.001*). The benefit was consistent across all types of blood product, including **fresh frozen plasma (*P < 0.001*)** and **pooled platelets (*P = 0.046*).**

No patients experienced clinically significant bleeding events.

Transfusion-associated adverse events occurred in one patient (5%) in the SOC group (allergic reaction) and none in the ROTEM group (*P = NS*). The **mortality in both groups at 30 and 90 days was similar.**

Hepatol Int. 2025 May 21. doi: 10.1007/s12072-025-10840-4. Online ahead of print.

Comparison of Relaxed verses Standard Cut-offs of Rotational Thromboelastometry for guiding Blood Product Use before Invasive Procedures in Advanced Cirrhosis: A Randomized Controlled Trial

Kumar M, Madke T, Mukund A, Patidar Y, Shasthry SM, Bihari C, Agarwal P, Jindal A, Bajpai M, Maiwall R, Choudhary A, Rajan V, Arora V, Thevathia HV, Meena BL, Singh SP, Maheshwari A, Bhardwaj A, Kumar G, Sarin SK.

MATERIAL AND METHODS: Patients with **advanced cirrhosis** and **abnormalities on conventional coagulation tests** requiring correction (any of the following: **platelet count < 30 × 10^9/L, INR > 2.0, and plasma fibrinogen < 100 mg/dL),** were **randomized** to receive correction based on **standard ROTEM criteria** (n = 519, MELD = 26.5 ± 7.4) or **relaxed ROTEM criteria** (n = 524, MELD = 25.6 ± 8.0).

Patients in the standard and **relaxed criteria groups** received blood components using the following triggers, respectively: **Fresh frozen plasma** (FFP, 10 ml/kg) when **EXTEM-CT** > 80 or **> 90 s;** one pooled of single donor **platelet** unit or 6 pooled units of random donor platelet when **EXTEM-MCF / FIBTEM-MCF** < 35 / ≥ 8 mm or **< 30 / ≥ 7 mm [→ A5 < 15 / ≥ 5 mm];** and 5 pooled units of **cryoprecipitate** if **EXTEM-MCF / FIBTEM-MCF** < 35 / < 8 mm or < **30 / < 7 mm [→ A5 < 15 / < 5 mm].**

Hepatol Int. 2025 May 21. doi: 10.1007/s12072-025-10840-4. Online ahead of print.

Comparison of Relaxed verses Standard Cut-offs of Rotational Thromboelastometry for guiding Blood Product Use before Invasive Procedures in Advanced Cirrhosis: A Randomized Controlled Trial

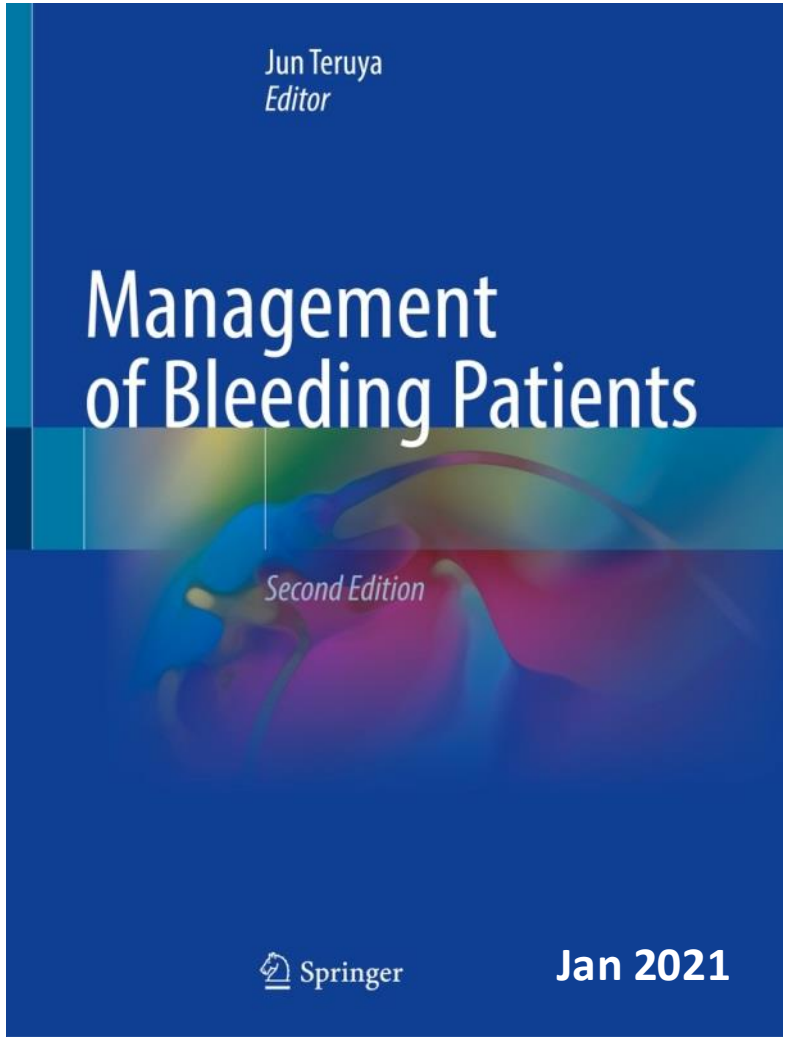
Kumar M, Madke T, Mukund A, Patidar Y, Shasthry SM, Bihari C, Agarwal P, Jindal A, Bajpai M, Maiwall R, Choudhary A, Rajan V, Arora V, Thevathia HV, Meena BL, Singh SP, Maheshwari A, Bhardwaj A, Kumar G, Sarin SK.

RESULTS: The **proportion of patients transfused any blood product** (FFP, platelets or cryoprecipitate) was 287/524 (**54.8%**) in the **relaxed ROTEM group** versus 352/519 (**67.8%**) in the **standard ROTEM group** (*P < 0.001*).

Procedure-related bleeding and **non-bleeding complications** and **28-day mortality** were **similar in both the groups.**

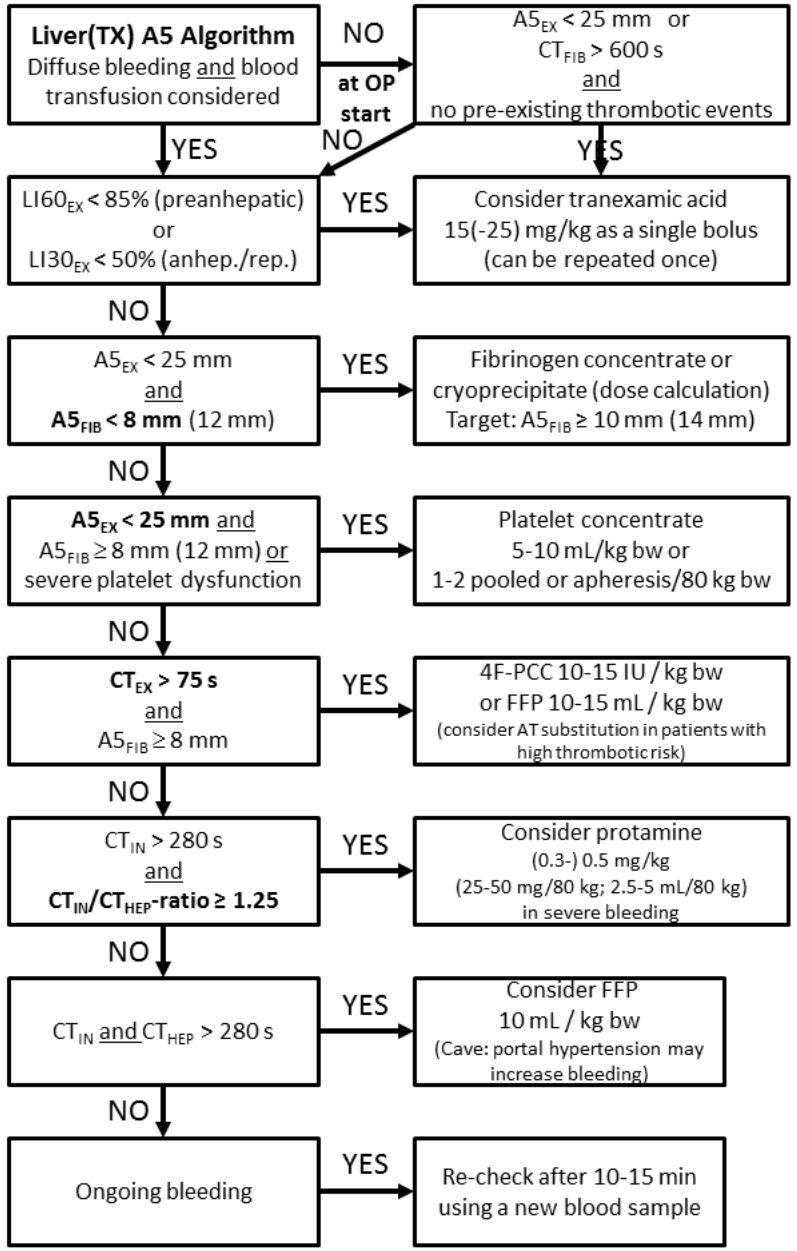
CONCLUSIONS: **Relaxation of ROTEM cut-offs** leads to **lower prophylactic blood products transfusions without increased risk of bleeding** in patients with advanced cirrhosis undergoing invasive procedures.

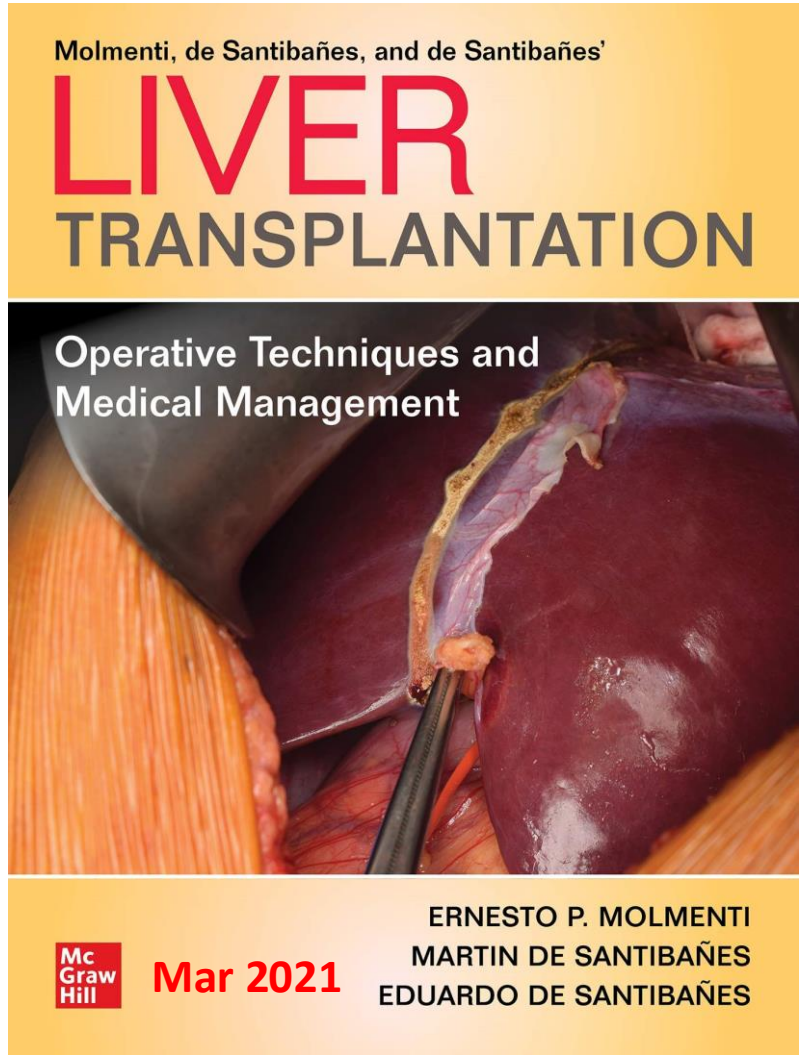
Evidence-based ROTEM A5 Liver Algorithm



Bleeding Related to Liver Transplant

Klaus Görlinger, Tetsuro Sakai, Daniel Dirkmann, Raymond M. Planinsic, Khaled Yassen, and Fuat H. Saner

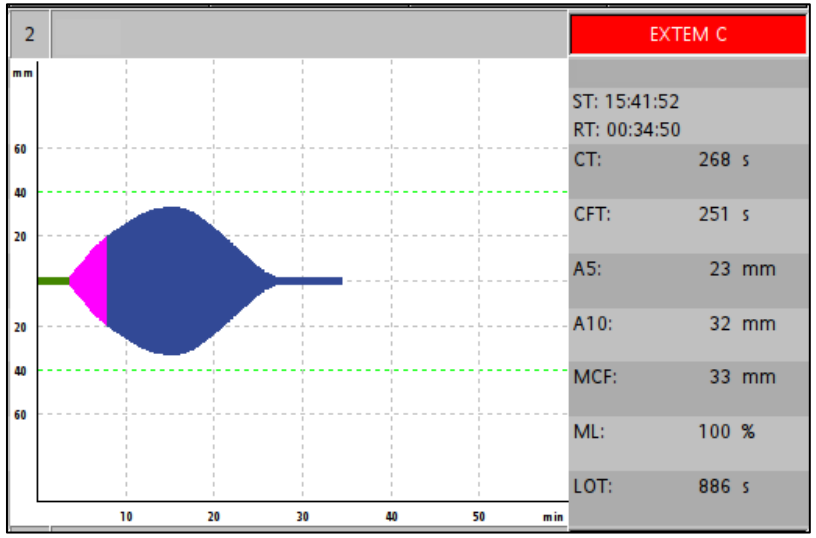


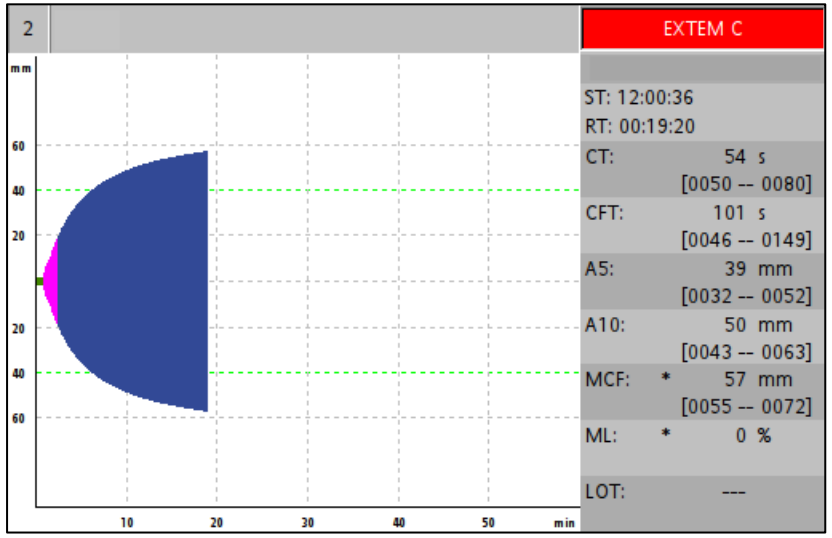


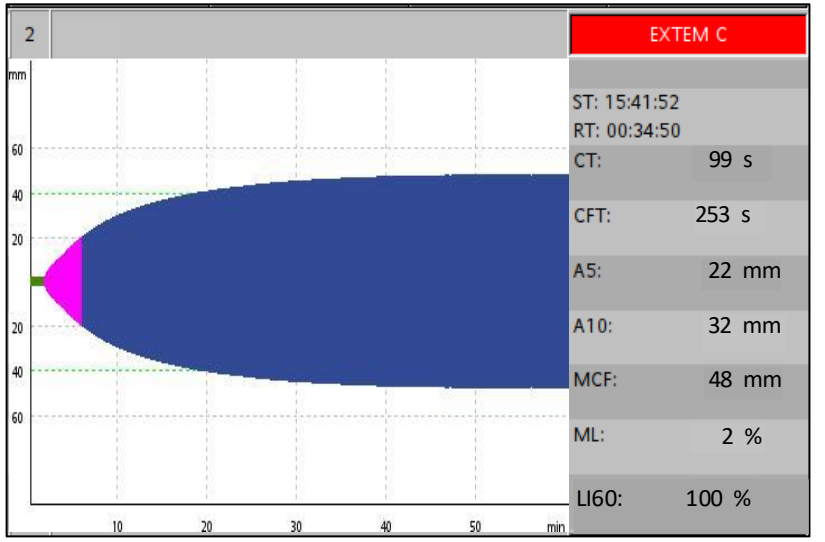
SECTION 6 – ANESTHESIA

Klaus Görlinger, Preet Mohinder Singh, and Adrian Alvarez

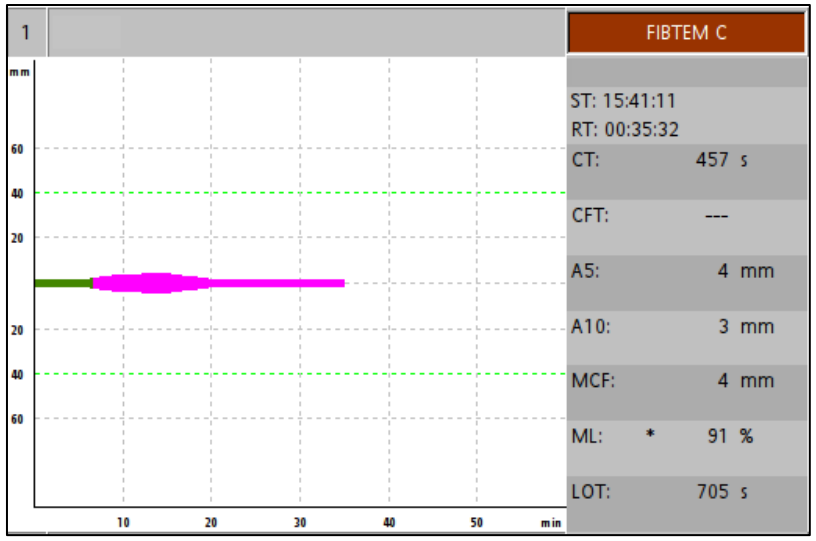
Fibrinolysis Management



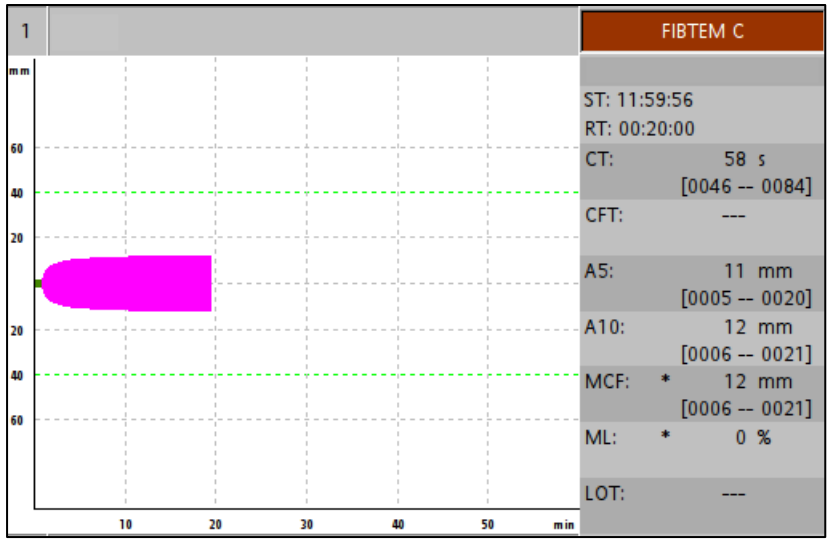




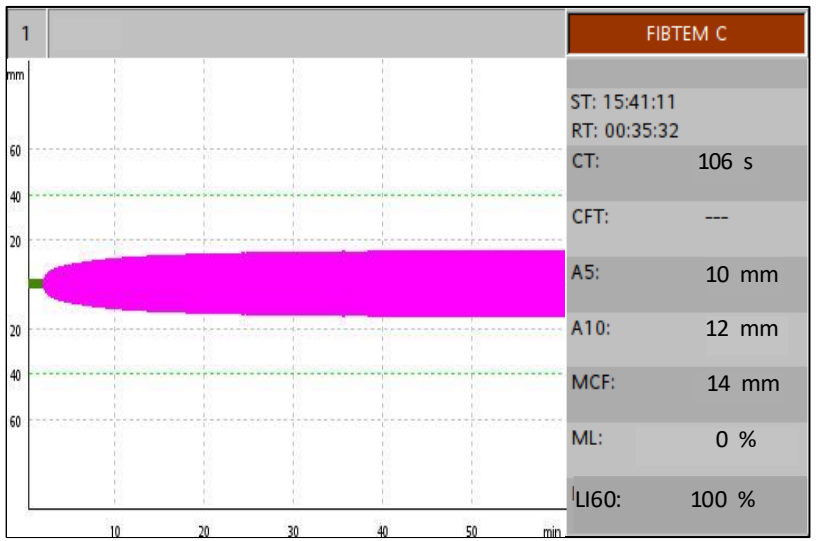
HYPERFIBRINOLYSIS



NORMAL



FIBRINOLYSIS SHUTDOWN



Br J Anaesth. 2016 Apr;116(4):507-12.

Comparison between Thrombelastography and Thromboelastometry in Hyperfibrinolysis Detection During Adult Liver Transplantation

Abuelkasem E, Lu S, Tanaka K, Planinsic R, Sakai T.

CONCLUSION: **FIBTEM** is **more sensitive** than **both EXTEM and k-TEG** in the diagnosis of **fibrinolysis** in LTs.

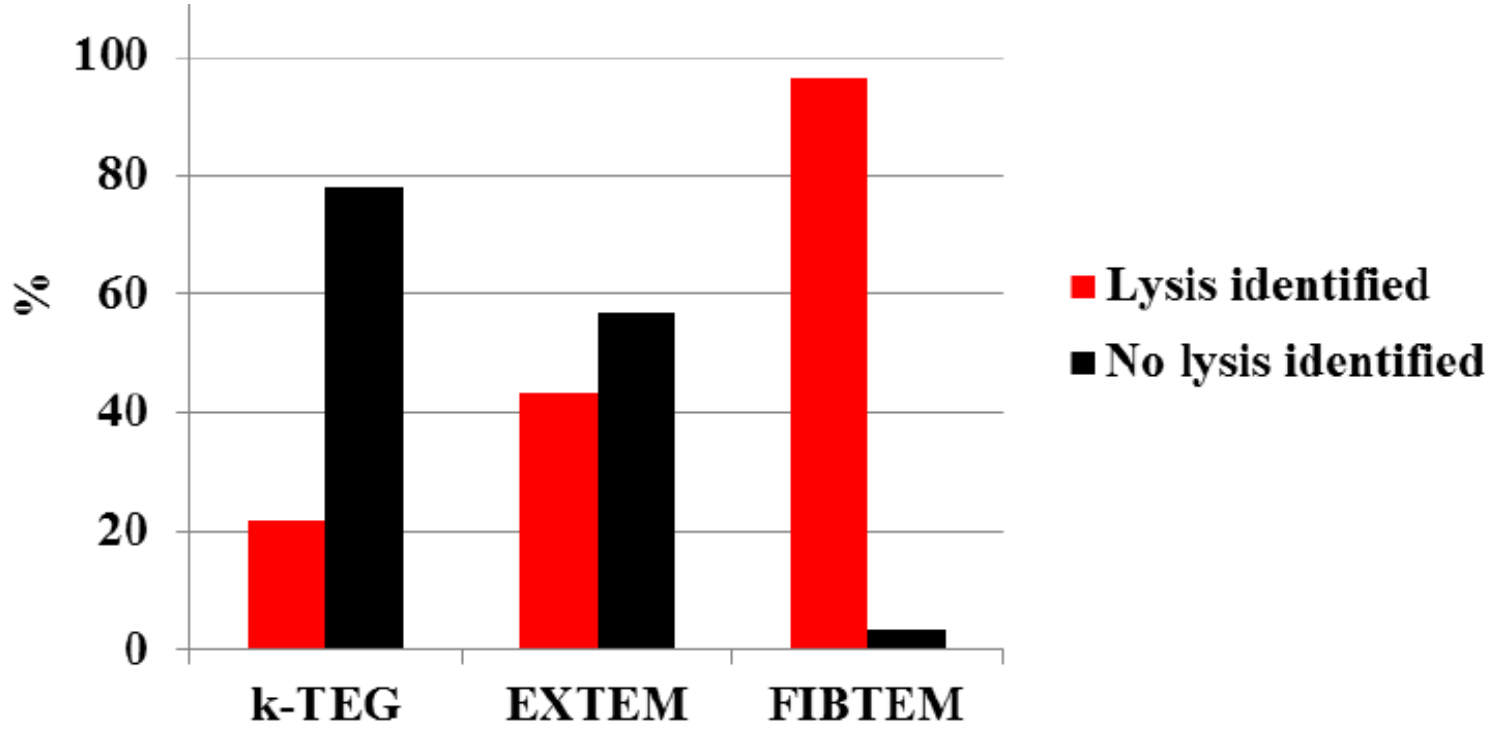
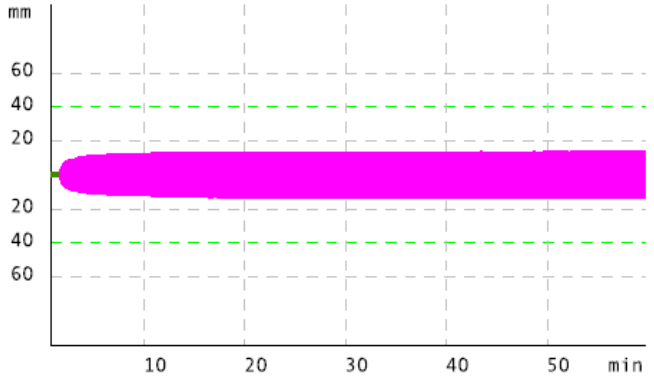


Fig. 4: Bar chart shows lysis identified by each channel collectively at all time points measurements (expressed as % of the 87 total fibrinolysis incidents)

Case #1: ROTEM at Baseline

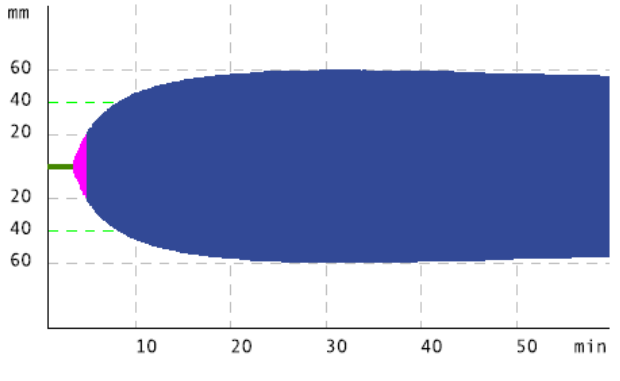


FIBTEM C [PreLim]

[redacted]

RT: 02:00:01 [redacted]

CT	:	55	s	[	46	- 84]
CFT	:		s			
A5	:	12	mm	[	5	- 20]
A10	:	13	mm	[	6	- 21]
A20	:	13	mm	[	6	- 21]
A30	:	13	mm	[	6	- 21]
MCF	:	13	mm	[	6	- 21]
LI30	:	100	%	[	91	- 100]
LI45	:	100	%	[	89	- 100]
LI60	:	100	%	[	89	- 100]
ML	:*	0	%			
LOT	:		s			

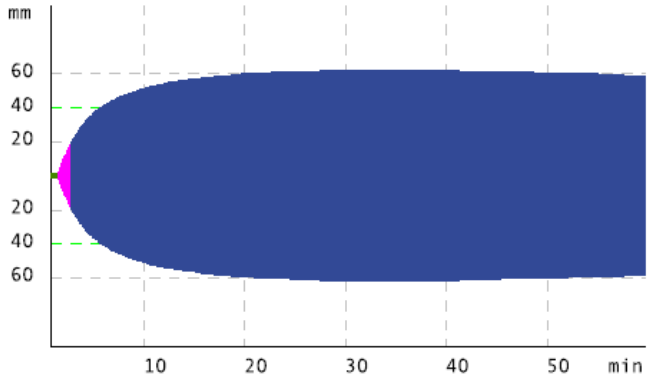


INTEM C [PreLim]

[redacted]

RT: 02:00:01 [redacted]

CT	:	188	s	[	161	- 204]
CFT	:	87	s	[	62	- 130]
A5	:	40	mm	[	33	- 52]
A10	:	51	mm	[	43	- 62]
A20	:	58	mm	[	50	- 62]
A30	:	59	mm	[	51	- 69]
MCF	:	59	mm	[	51	- 69]
LI30	:	100	%	[	98	- 100]
LI45	:	97	%	[	92	- 100]
LI60	:	93	%	[	87	- 100]
ML	:*	16	%			
LOT	:	6563	s			

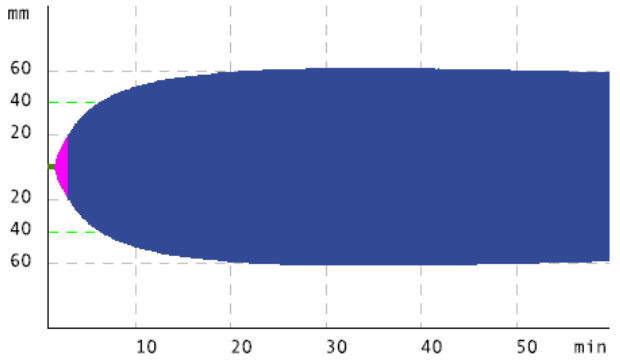


EXTEM C [PreLim]

[redacted]

RT: 02:00:00 [redacted]

CT	:	58	s	[	50	- 80]
CFT	:	79	s	[	46	- 149]
A5	:	43	mm	[	32	- 52]
A10	:	53	mm	[	43	- 63]
A20	:	60	mm	[	52	- 70]
A30	:	62	mm	[	52	- 72]
MCF	:	62	mm	[	56	- 72]
LI30	:	100	%			
LI45	:	98	%	[	98	- 100]
LI60	:	95	%	[	94	- 100]
ML	:*	16	%			
LOT	:	6483	s			



APTEM C [PreLim]

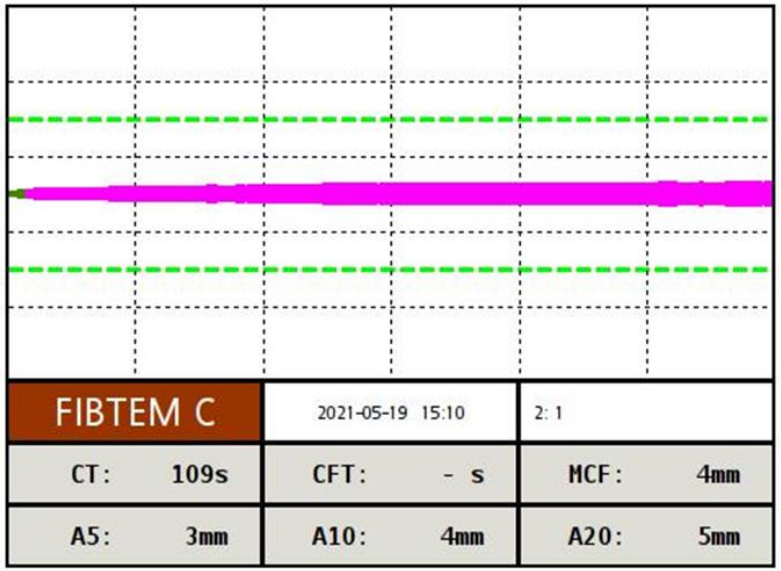
[redacted]

RT: 02:00:01 [redacted]

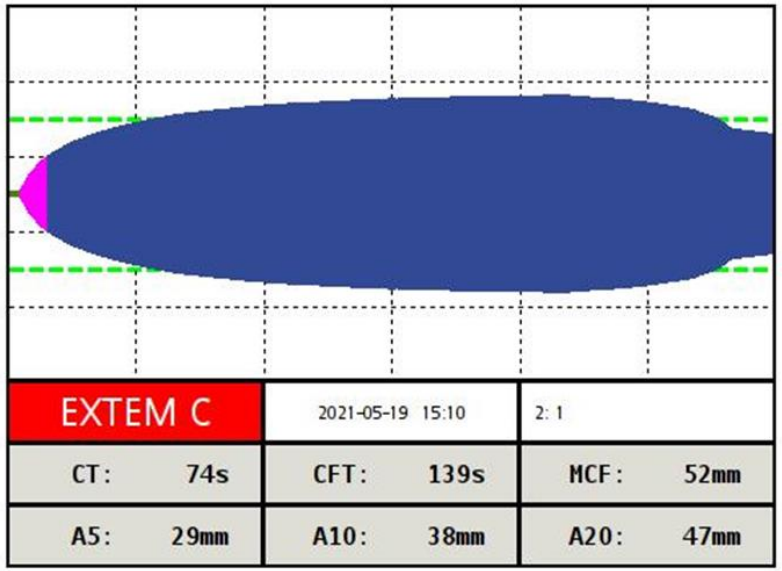
CT	:	55	s	[	41	- 80]
CFT	:	88	s	[	62	- 184]
A5	:	41	mm	[	28	- 50]
A10	:	52	mm	[	39	- 61]
A20	:	59	mm	[	48	- 68]
A30	:	61	mm	[	51	- 71]
MCF	:	61	mm	[	52	- 77]
LI30	:	100	%			
LI45	:	99	%	[	98	- 100]
LI60	:	95	%	[	93	- 100]
ML	:*	17	%			
LOT	:	6354	s			

FIBTEM A5 = 12 mm; FIBTEM LI60 = 100%; EXTEM A5 = 43 mm; PLTEM A5 = 31 mm; EXTEM CT = 58 s; EXTEM LI60 = 95%; APTEM LI60 = 95%; INTEM CT = 188 s; INTEM LI60 = 95%

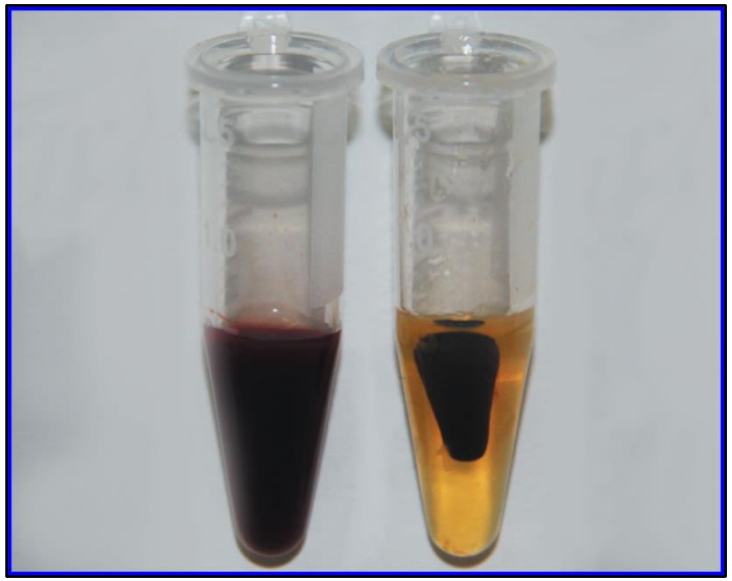
Case #2: Platelet-mediated Clot Retraction

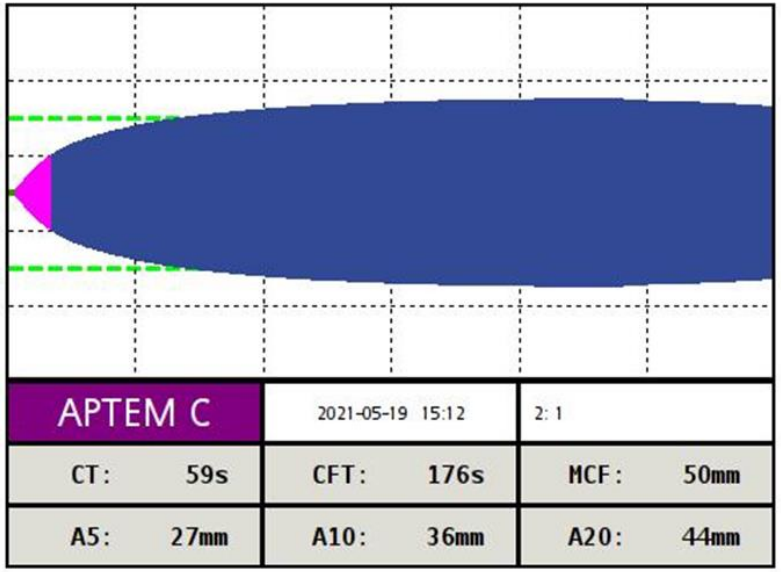


FIBTEM C	2021-05-19 15:10	2: 1
CT: 109s	CFT: - s	MCF: 4mm
A5: 3mm	A10: 4mm	A20: 5mm

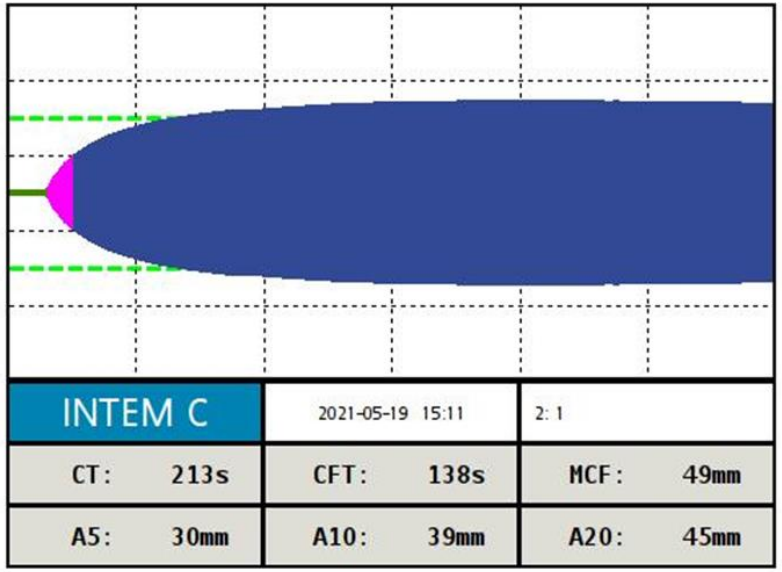


EXTEM C	2021-05-19 15:10	2: 1
CT: 74s	CFT: 139s	MCF: 52mm
A5: 29mm	A10: 38mm	A20: 47mm





APTEM C	2021-05-19 15:12	2: 1
CT: 59s	CFT: 176s	MCF: 50mm
A5: 27mm	A10: 36mm	A20: 44mm



INTEM C	2021-05-19 15:11	2: 1
CT: 213s	CFT: 138s	MCF: 49mm
A5: 30mm	A10: 39mm	A20: 45mm

J Clin Med. 2020 Oct 14;9(10):3298.

Pre-Liver Transplant ROTEM Clot Lysis Index Is Associated with 30-Day Mortality, But Is Not a Measure for Fibrinolysis

Hartmann M, Craciun B, Paul A, Brenner T, Saner FH.

Mortality was **4.2%,** when **CLI60 was <85%,** and increased to **25.7%** when the **CLI60 was >95%.**

Multivariate analysis including CLI60 and MELD score identified the **CLI60** as an **independent and the best predictor of 30-day-mortality.**

Interestingly, the inhibition of fibrinolysis did neither affect CLI60 nor the association of the variable with mortality. Thus, fibrinolysis can be excluded as the reason for low CLI60 values.

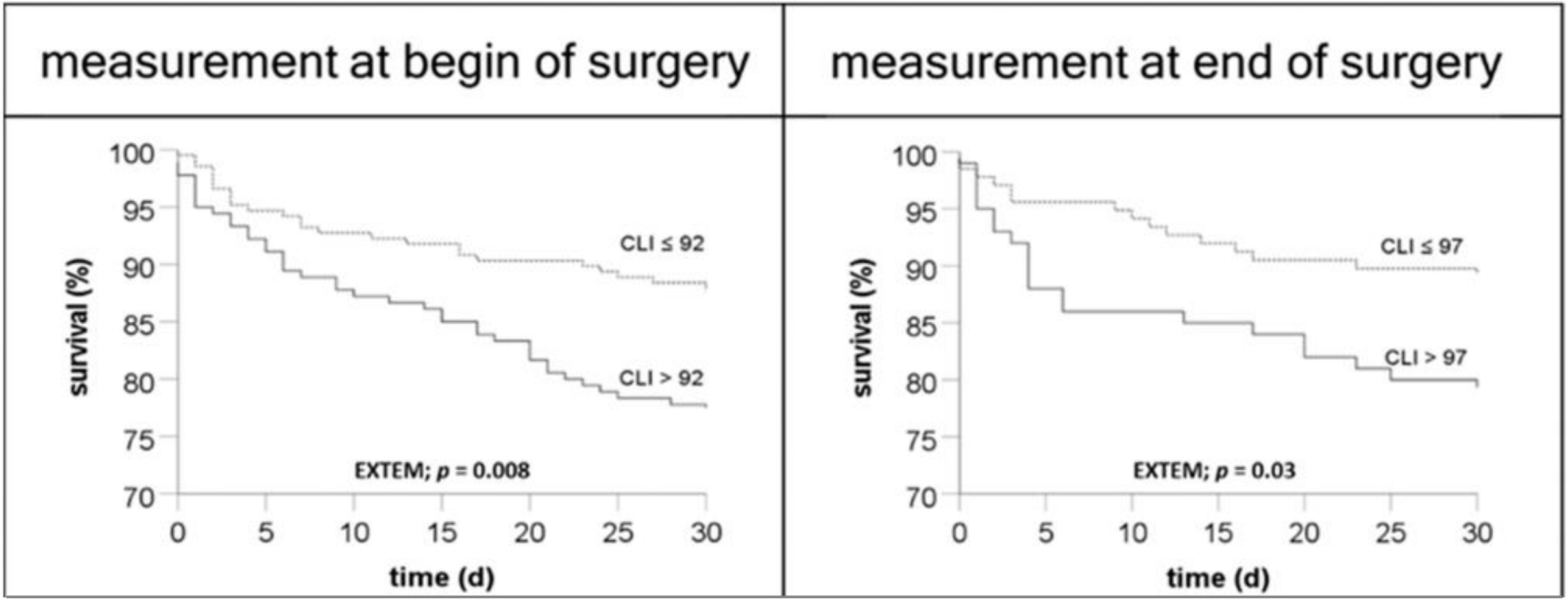
The inhibition of platelets abolished the predictive value of CLI. Probably, differences in CLI can be explained by differences in clot retraction.

In conclusion, **low CLI60 values measured before the beginning of liver transplantation** are associated with **reduced bleeding and mortality,** but do not indicate fibrinolysis.

Biomedicines. 2022 Aug 15;10(8):1975.

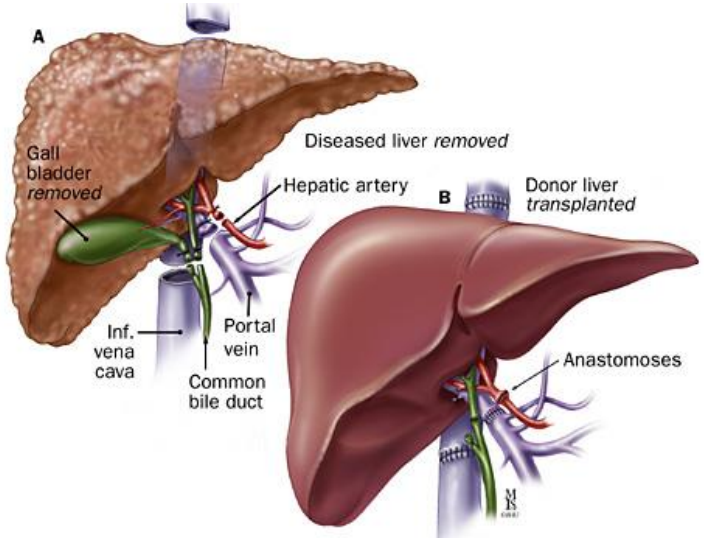
Elevated Pre- and Postoperative ROTEM™ Clot Lysis Indices Indicate Reduced Clot Retraction and Increased Mortality in Patients Undergoing Liver Transplantation

Hartmann M, Lorenz B, Brenner T, Saner FH.

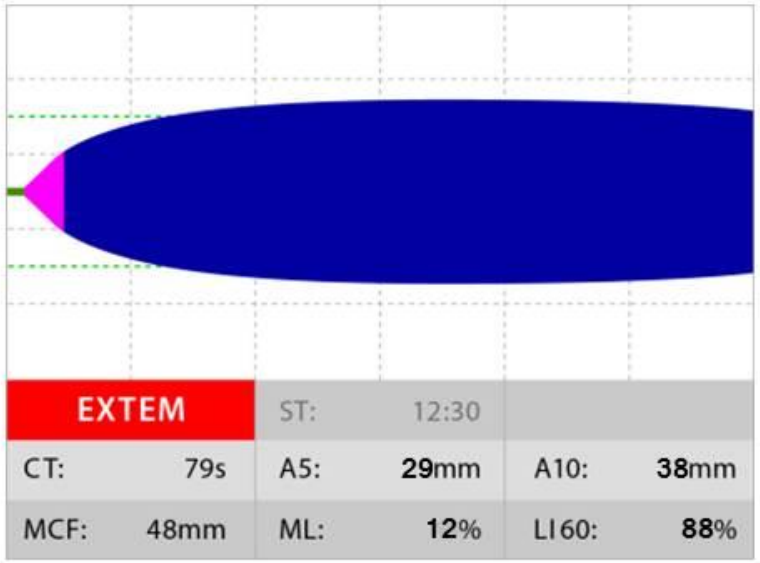


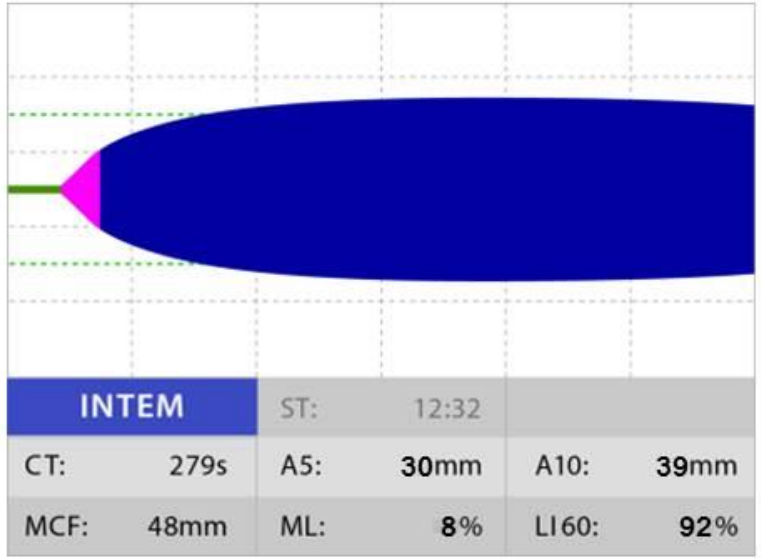
Case #3: Liver Transplantation at Baseline

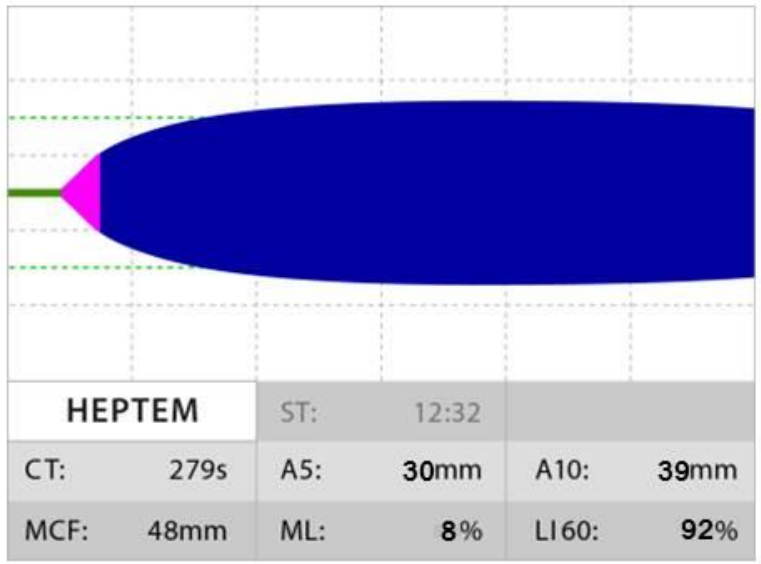
- Cadaveric donor (marginal organ)
- Center Offer
- Recipient 63 years old male
- Hepatitis C + HCC
- Renal insufficiency, Creatinine 1.5 mg/dL
- Factor V Leiden Mutation + Protein C Deficiency
- Hb 11.2 g/dL; Platelet count 42,000/µL; INR 1.9



Case #3: Liver Transplantation at Baseline







What do you see?

A. Normal ROTEM

B. Late Hyperfibrinolysis

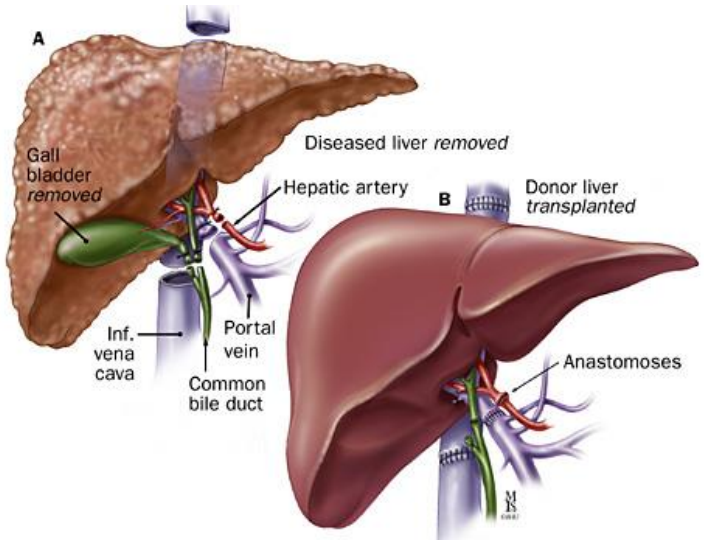
C. Platelet-mediated Clot Retraction

D. Fibrinolysis Shutdown

FIBTEM A5 = 9 mm
FIBTEM LI60 = 73% (ML = 27%)
EXTEM A5 = 29 mm
PLTEM A5 = 20 mm
EXTEM CT = 79 s
EXTEM LI60 = 88% (ML = 12%)
INTEM CT = 279 s
HEPTEM CT = 279 s
INTEM/HEPTEM CT-ratio = 1.0

Case #4: Liver Transplantation – Resection Phase

- Significant Bleeding (Splanchnicus area)
- RR 92/55 mm Hg
- HR 119/min
- CVP 8 mm Hg
- CO 5.5 L/min
- Hb 7.5 g/dL; SvO_2 66%
- Ca_i^{2+} 1.1 mmol/L



Case #4: ROTEM during Liver Resection Phase

What do you see?

A. Low Fibrin Contribution

B. Low Platelet Contribution

C. Endogenous Heparin-like Effect

D. Hyperfibrinolysis and low Fibrin Contribution

FIBTEM A5 = 4 mm

FIBTEM ML* = 91 % (LOT = 705 s)

EXTEM A5 = 23 mm

PLTEM A5 = 19 mm

EXTEM CT = 268 s

ML = 100% (LOT = 886 s)

INTEM CT = 495 s

HEPTEM CT = 478 s

INTEM/HEPTEM CT-ratio = 1.04

Liver Transpl. 2026 Mar 1;32(3):411-418.

Evaluation of Low Fibrinolytic Activity by Rotational Thromboelastometry and Outcomes in Liver Transplantation: A Single-center Prospective Study

Belfiore J, Castellani Nicolini N, Bindi ML, Saner FH, Blasi A, Piaggi P, Ghinolfi D, Biancofiore G.

Low Fibrinolytic Activity (LFA) has been **linked to adverse outcomes** such as **splanchnic thrombosis** and **increased perioperative mortality.**

This study aimed to evaluate the **incidence of LFA during LT,** its **association with thrombotic and clinical outcomes,** and its **predictive value for the 28-day mortality.**

LFA was **defined as a maximum lysis (ML) < 3.5% in EXTEM** and **confirmed by FIBTEM to exclude platelet clot retraction.**

LFA occurred in **27.5%** of patients at one or more time points. LFA was **strongly associated with splanchnic thrombosis (OR = 32.7,** 95% CI: 14.7-72.7, *P < 0.001*) and **28-day mortality (OR = 8.7,** 95% CI: 1.7-44.2, *P = 0.002*).

Liver Transpl. 2026 Mar 1;32(3):411-418.

Evaluation of Low Fibrinolytic Activity by Rotational Thromboelastometry and Outcomes in Liver Transplantation: A Single-center Prospective Study

Belfiore J, Castellani Nicolini N, Bindi ML, Saner FH, Blasi A, Piaggi P, Ghinolfi D, Biancofiore G.

ROC curve analysis demonstrated **excellent predictive accuracy for splanchnic thrombosis (AUC = 0.84)** and **good accuracy for 28-day mortality (AUC = 0.75).**

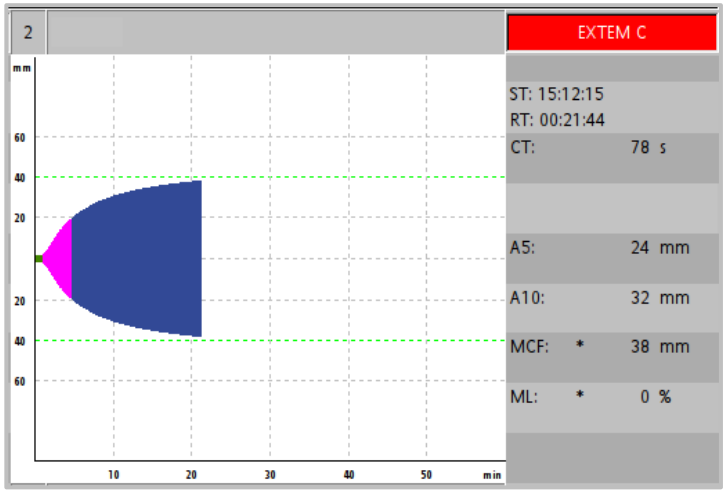
Significant associations were also observed between the LFA and **Postreperfusion Syndrome (PRS; OR = 6.1,** $P < 0.001$), **re-LT (OR = 5.7,** $P < 0.001$), and **Massive Blood Transfusion (MBT; OR = 3.8,** $P < 0.001$).

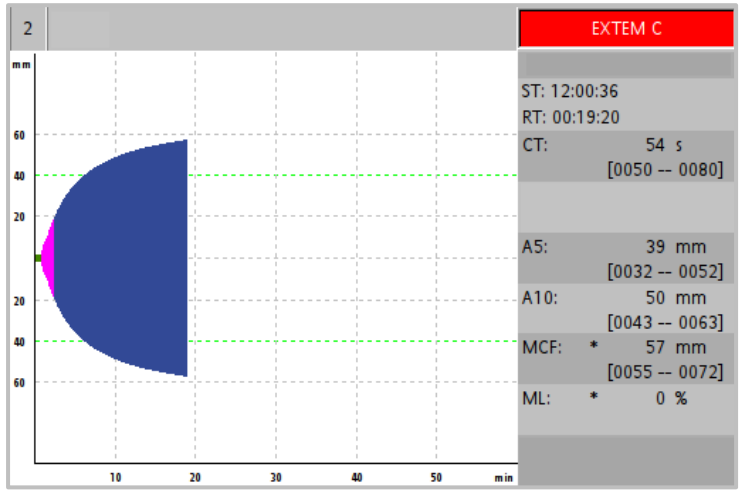
LFA was not associated with MELD score or HCC.

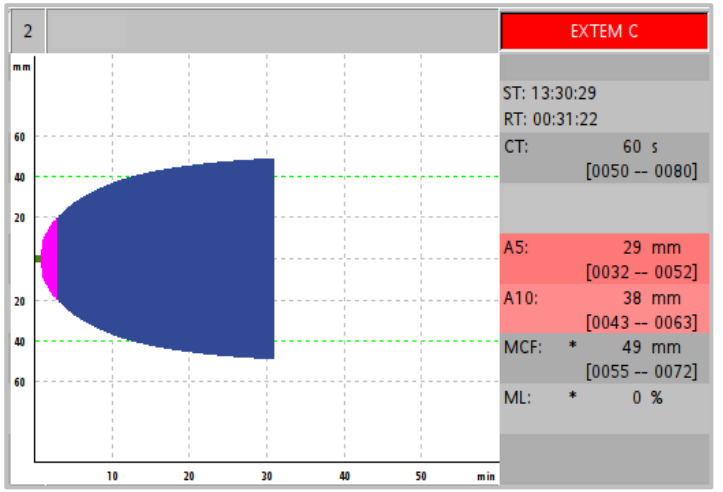
LFA identified using ROTEM is a **significant predictor of adverse outcomes,** including splanchnic thrombosis and 28-day mortality, in LT patients.

The real-time diagnostic capability of ROTEM offers critical prognostic insights and **may guide therapeutic interventions to mitigate the thrombotic risk.**

Clot Firmness Management



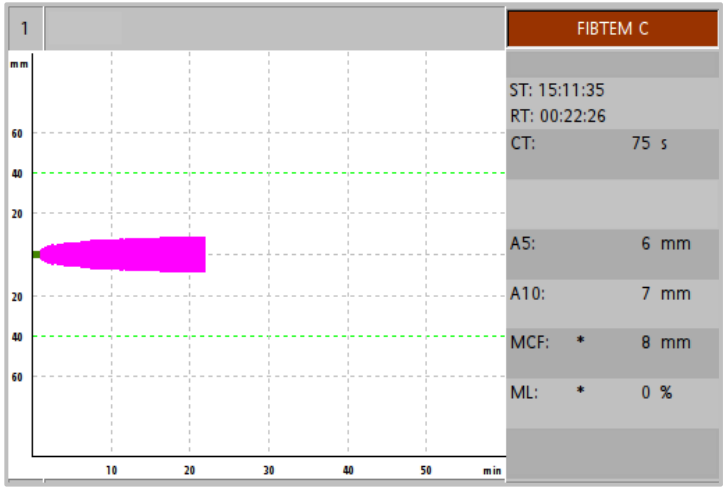


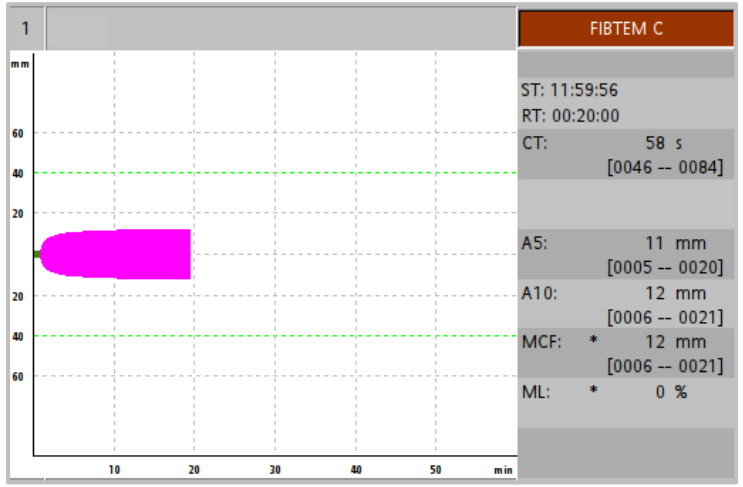


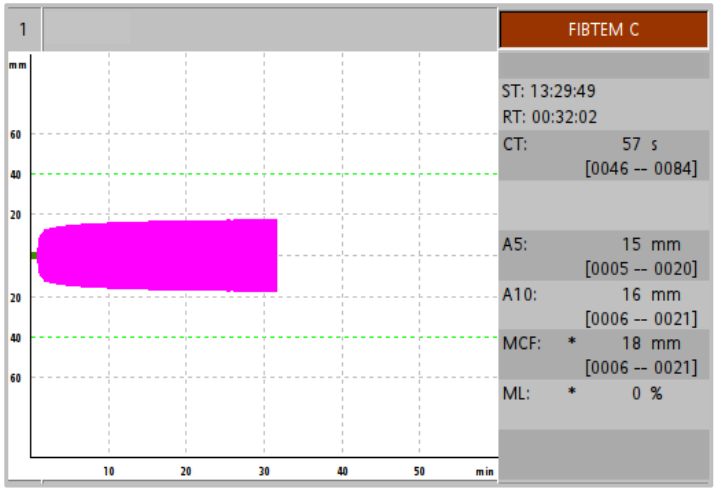
LOW FIBRIN CONTRIBUTION

NORMAL

LOW PLATELET CONTRIBUTION







Sci Rep. 2024 Aug 16;14(1):19022.

Risk Factors associated with Blood Transfusion in Liver Transplantation

Pérez L, Sabate A, Gutierrez R, Caballero M, Pujol R, Llaurado S, Peñafiel J, Hereu P, Blasi A.

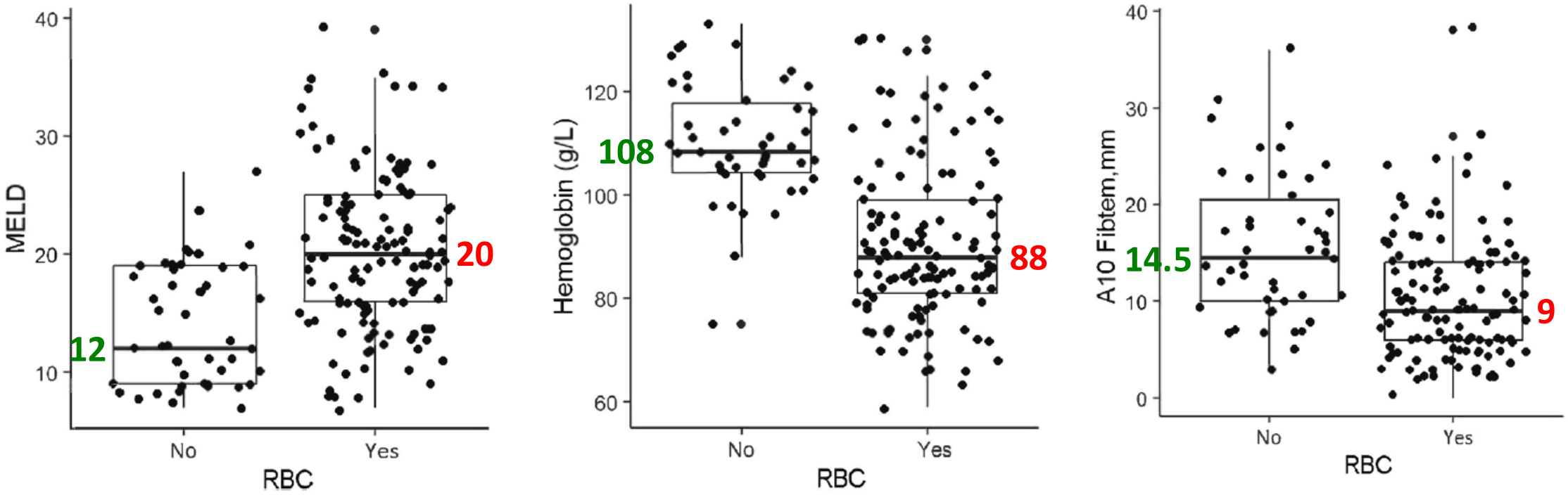
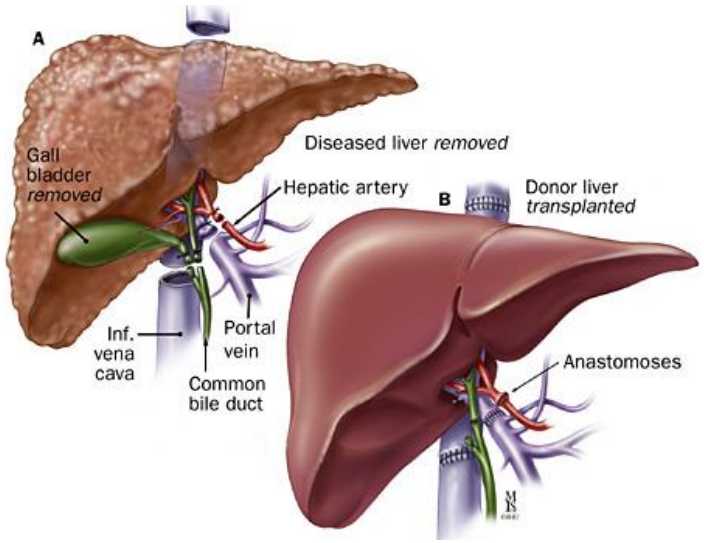


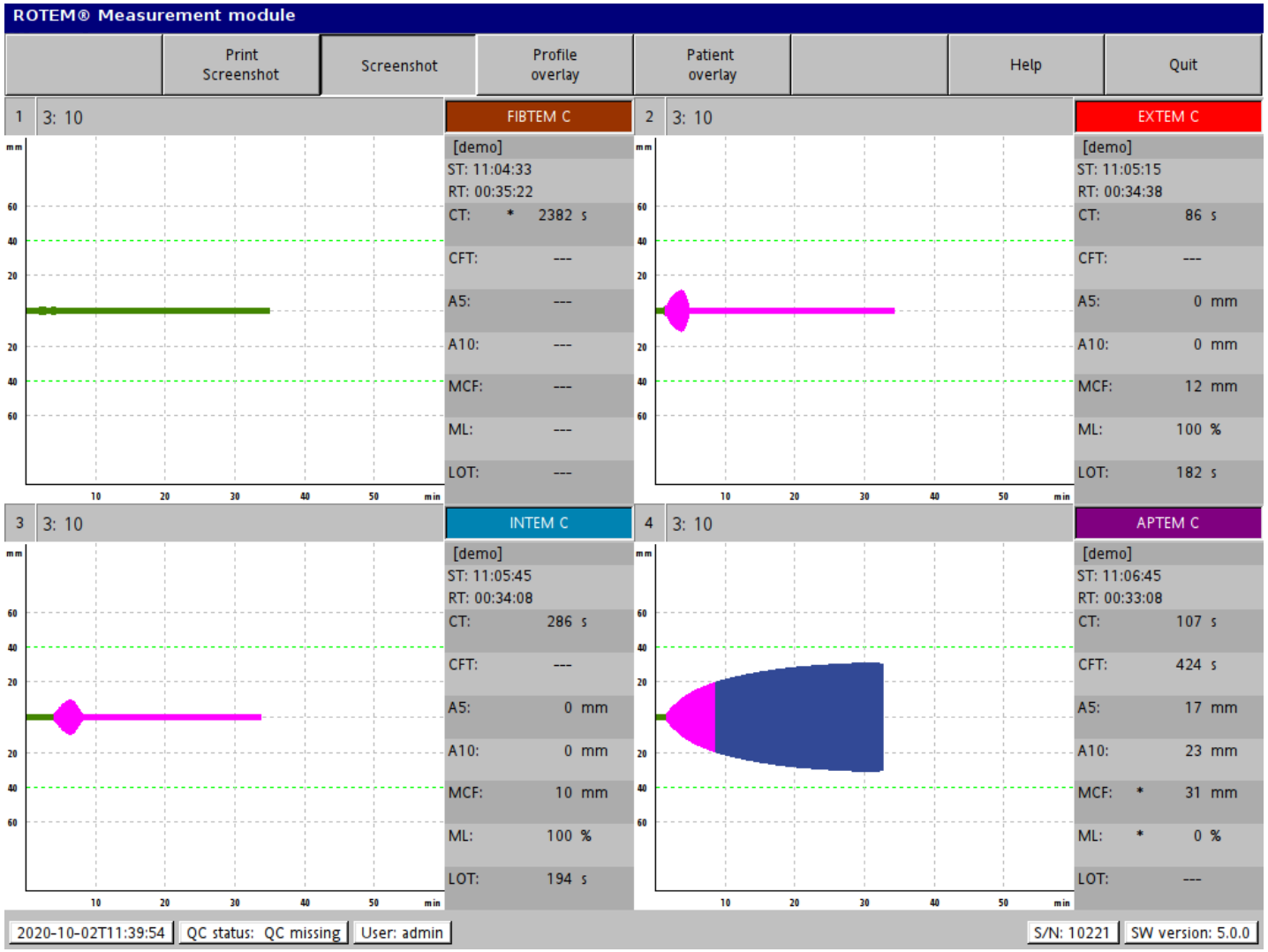
Figure 1. Main baseline factors associated with RBC transfusion. Box plots for ("yes") or with non- RBC transfusion ("no"). Horizontal lines indicate medians, boxes the interquartile range, and dots the individual patient data. A10FIBTEM, the maximum clot firmness amplitude measured at 10 min by thromboelastometry for fibrin tissue factor activation and platelet inhibition. MELD, Model for End-Stage Liver Disease, RBC, packed red blood cells.

Case #5: Liver Transplantation – Reperfusion Phase

- Severe Bleeding (from everywhere)
- RR 77/49 mm Hg
- HR 68/min
- CVP 15 mm Hg
- CO 3.5 L/min
- Hb 6.5 g/L
- Ca_i^{2+} 1.1 mmol/L



Case #5: ROTEM after Liver Graft Reperfusion



What do you see?

A. Severe Hyperfibrinolysis

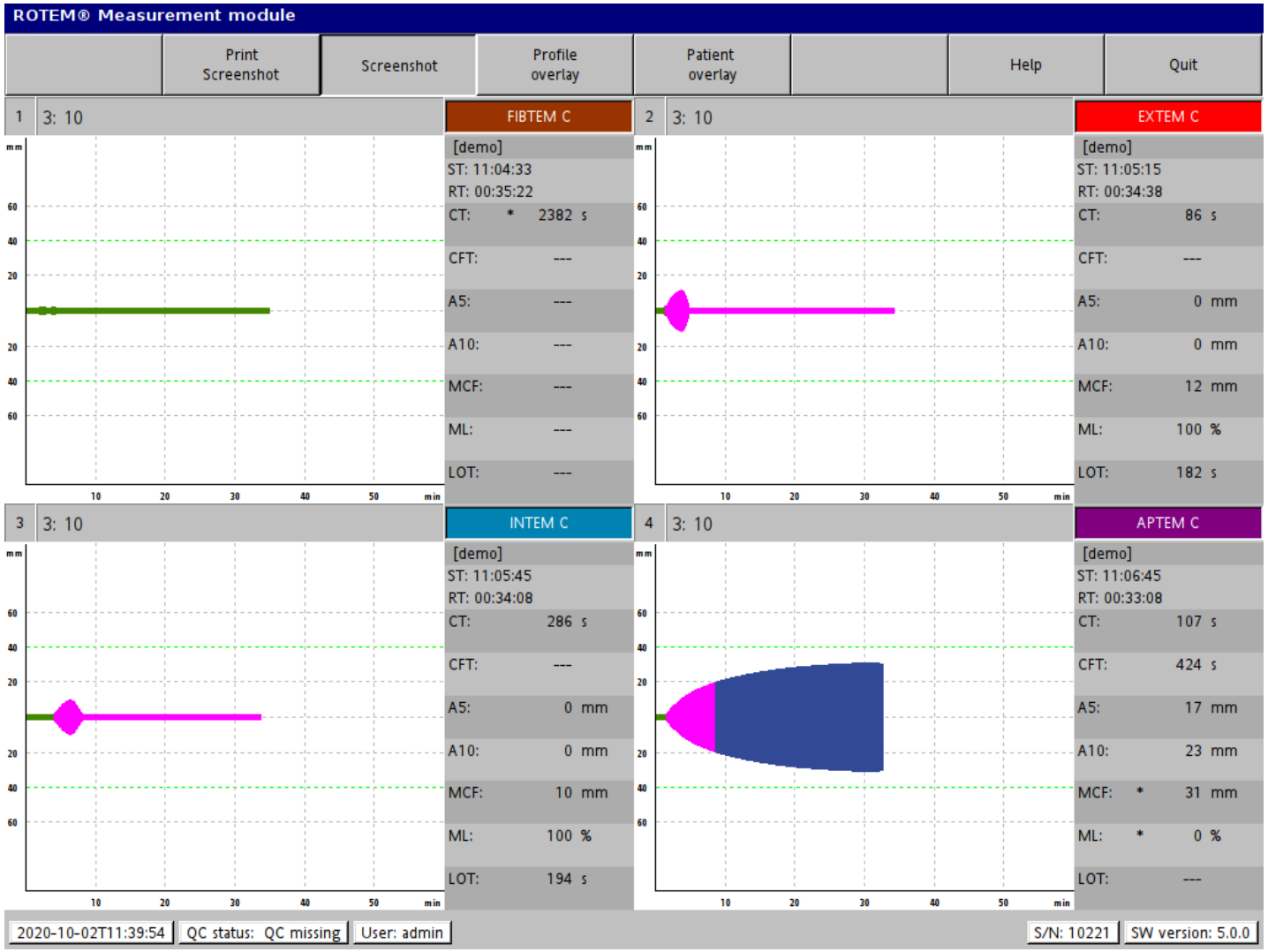
B. Low Fibrin Contribution

C. Low Platelet Contribution

D. Severe HF and Low Fibrin Contribution

FIBTEM A5 = - mm
FIBTEM ML = -%
EXTEM A5 = 0 mm
EXTEM CT = 96 s
EXTEM ML = 100%
APTEM A5 = 17 mm
APTEM ML* = 0%
INTEM CT = 286 s

Case #5: ROTEM after Liver Graft Reperfusion



What is the right Intervention?

A. Wait and see

B. RBC, Plasma and Platelet Transfusion

C. TXA only

D. RBC, TXA and Fibrinogen

FIBTEM A5 = - mm
FIBTEM ML = -%
EXTEM A5 = 0 mm
EXTEM CT = 96 s
EXTEM ML = 100%
APTEM A5 = 17 mm
APTEM ML* = 0%
INTEM CT = 286 s

Case #5: ROTEM after Liver Graft Reperfusion

ML_{EX} 100% after 5 min → Fulminant hyperfibrinolysis → TXA

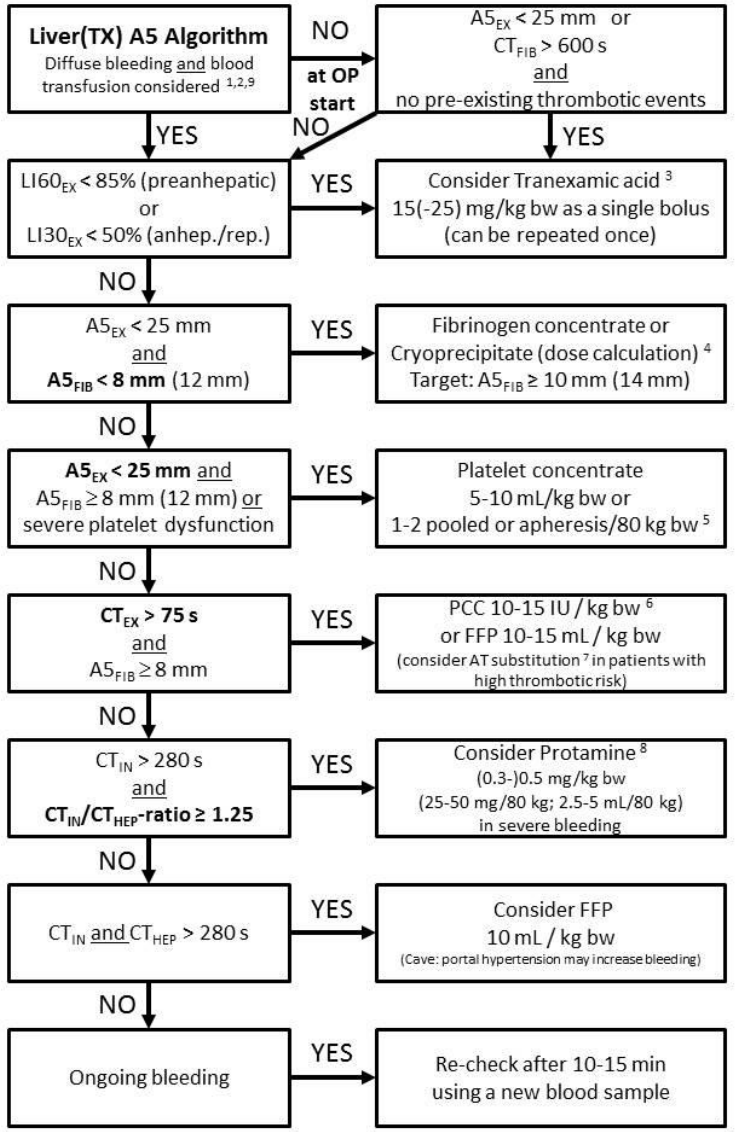
$A5_{EX}$ < 25 mm AND $A5_{FIB}$ < 8 mm → Fibrinogen deficiency

Targeted increase 10 mm → 62.5 x 80 kg = 5 g fibrinogen

Platelet contribution ($A5_{AP}$ – $A5_{FIB}$ = 17 mm): still OK

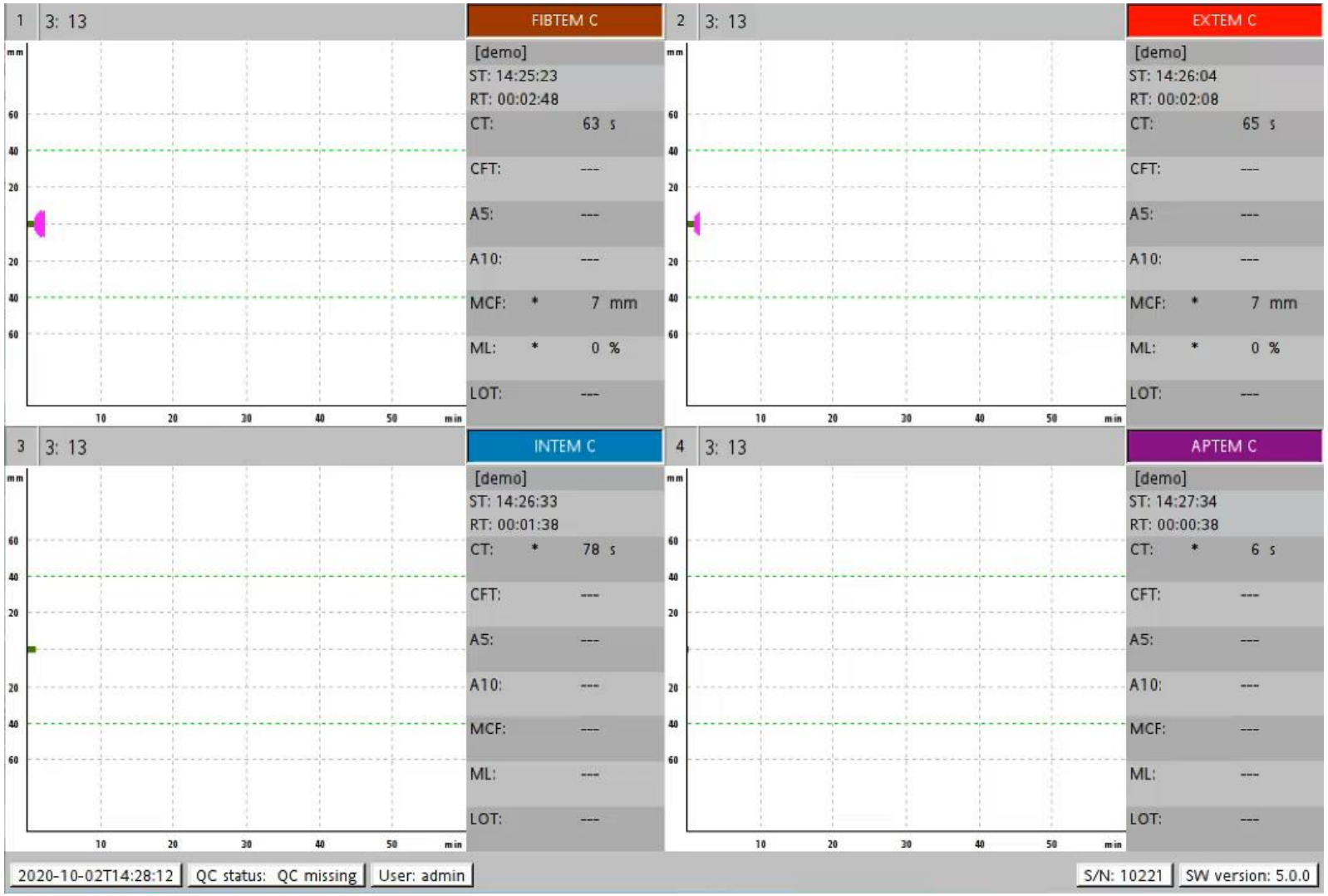
Prolonged CT_{EX} and CT_{IN} can only be considered if $A5_{FIB}$ is OK

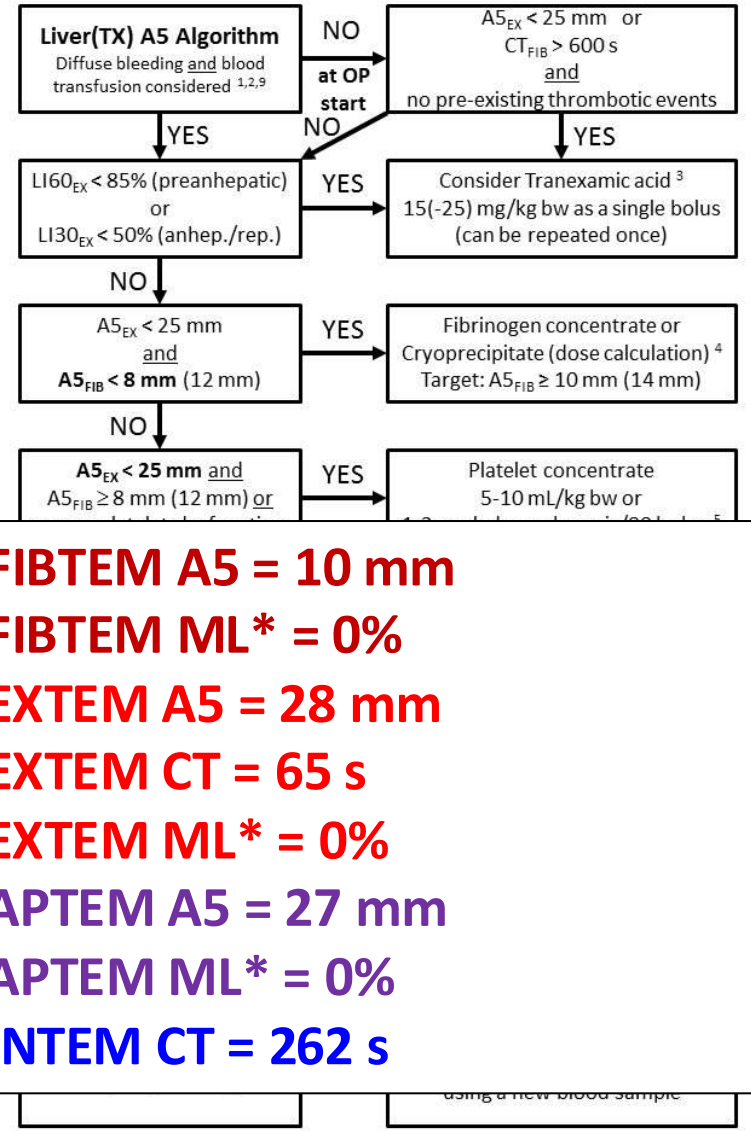
→ Double-check after TXA and Fibrinogen in case of ongoing bleeding



Targeted increase in $A5_{FIB}$ (mm)	Fibrinogen dose (mg/ kg bw)	Fibrinogen concentr. (mL / kg bw)	Cryoprecipitate (mL / kg bw)
2	12.5	0.6 [1 g per 80 kg]	1 [5 U per 80 kg]
4	25	1.2 [2 g per 80 kg]	2 [10 U per 80 kg]
6	37.5	1.9 [3 g per 80 kg]	3 [15 U per 80 kg]
8	50	2.5 [4 g per 80 kg]	4 [20 U per 80 kg]
10	62.5	3.1 [5 g per 80 kg]	5 [25 U per 80 kg]
12	75	3.8 [6 g per 80 kg]	6 [30 U per 80 kg]

Case #5: ROTEM after 2 g TXA and 6 g Fibrinogen





FIBTEM A5 = 10 mm
FIBTEM ML* = 0%
EXTEM A5 = 28 mm
EXTEM CT = 65 s
EXTEM ML* = 0%
APTEM A5 = 27 mm
APTEM ML* = 0%
INTEM CT = 262 s

BMC Anesthesiol. 2019 Jun 11;19(1):97.

Safety of Coagulation Factor Concentrates guided by ROTEM-Analyses in Liver Transplantation: Results from 372 Procedures

Hartmann M, Walde C, Dirkmann D, Saner FH.

Methods: Retrospective data analysis with **372 consecutive adult liver transplant patients** performed between 2007 and 2011.

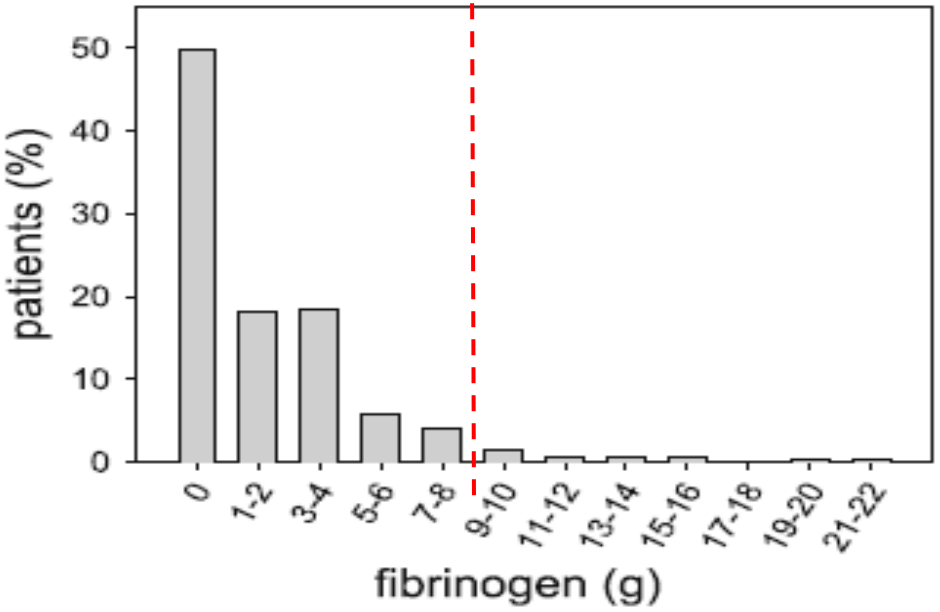
Results: **Thrombelastometry guided coagulation management** resulted in a **transfusion rate** for
fibrinogen concentrates in 50.2%,
PCC in 18.8%,
platelet concentrates in 21.2%,
tranexamic acid in 4.5%, and
red blood cell concentrates in 59.4%.

BMC Anesthesiol. 2019 Jun 11;19(1):97.

Safety of Coagulation Factor Concentrates guided by ROTEM-Analyses in Liver Transplantation: Results from 372 Procedures

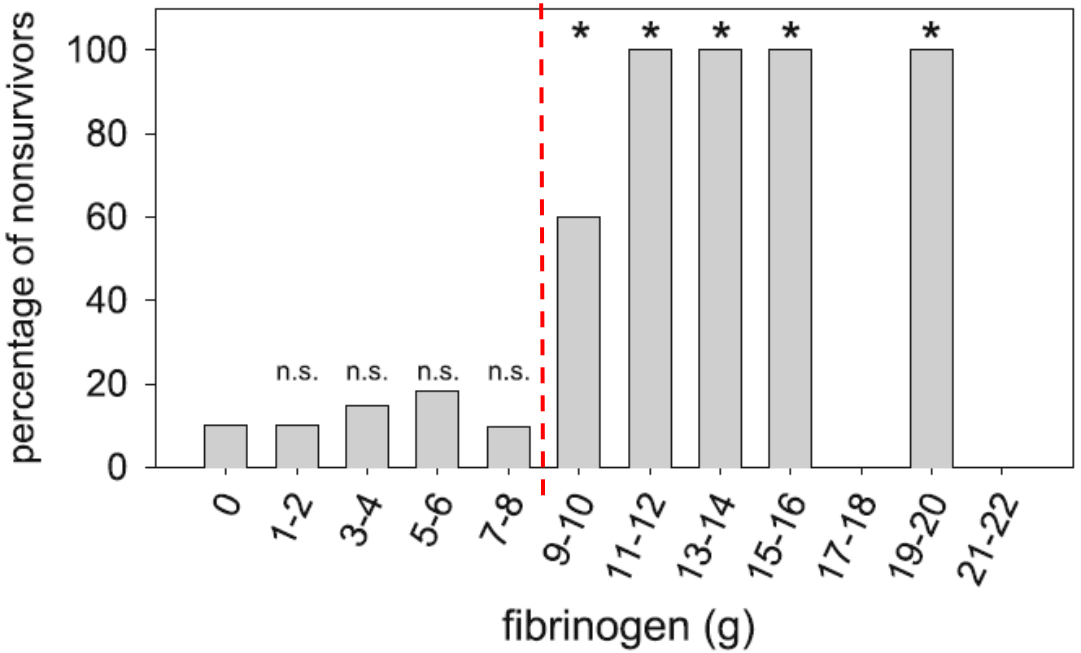
Hartmann M, Walde C, Dirkmann D, Saner FH.

Results: **30-day mortality** for the whole cohort was **14.2%.** Further univariate analyses demonstrated, that **up to 8 g of fibrinogen did not increase mortality** compared to patients not receiving the coagulation factor.



← **Fig. 1** Frequencies of intraoperative fibrinogen concentrate use in 372 patients undergoing liver transplantation. Notably, blood products were not transfused in many cases.

Fig. 4 → Effect of fibrinogen dosage on non-survival.



BMC Anesthesiol. 2019 Jun 11;19(1):97.

Safety of Coagulation Factor Concentrates guided by ROTEM-Analyses in Liver Transplantation: Results from 372 Procedures

Hartmann M, Walde C, Dirkmann D, Saner FH.

Multivariate analysis demonstrated that

platelet concentrates (*P = 0.0002*, OR 1.87 per unit),

infused volume (*P = 0.0004*, OR = 1.13 per litre), and

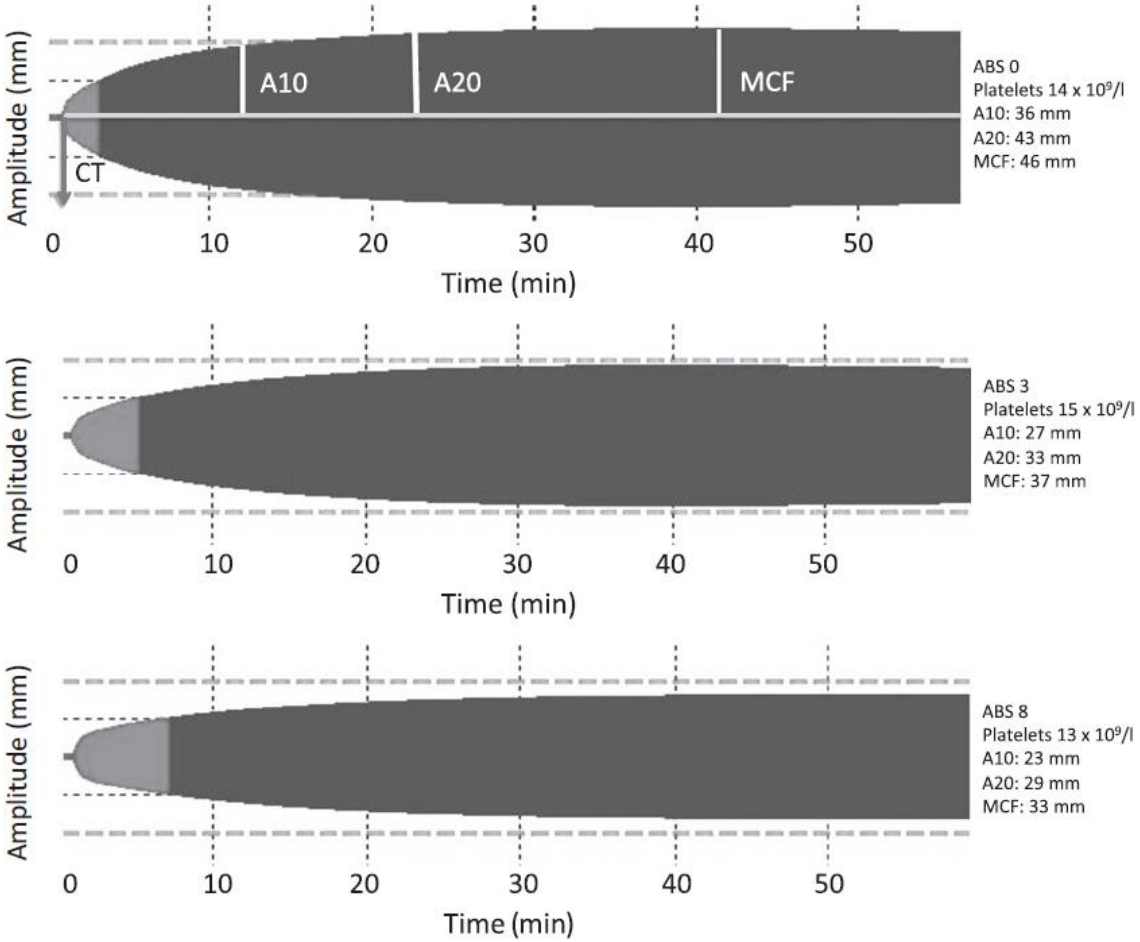
MELD score (*P = 0.024*; OR 1.039)

are independent predictors for mortality.

Br J Haematol. 2014 Aug;166(4):592-600.

Beyond the Platelet Count: Immature Platelet Fraction and Thromboelastometry Correlate with Bleeding in Patients with Immune Thrombocytopenia

Greene LA, Chen S, Seery C, Imahiyerobo AM, Bussel JB.



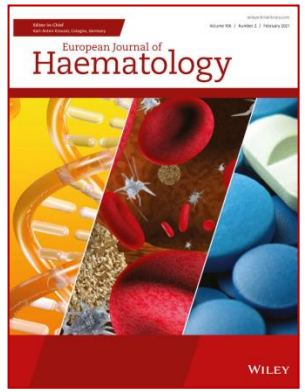
ABS 0; $A10_{EX}$ 36 mm; PC 14 x 10^9/L

ABS 3; $A10_{EX}$ 27 mm; PC 15 x 10^9/L

ABS 8; $A10_{EX}$ 23 mm; PC 13 x 10^9/L

Fig 4. EXTEM thromboelastogram tracings of three adult subjects with similar platelet counts with varying clinical bleeding symptomatology. ABS = acute bleeding score; CT = clot time; A10 = amplitude 10 min after CT; A20 = amplitude 20 min after CT; MCF = maximal clot firmness; mm = millimetre (firmness).

Eur J Haematol. 2021 Feb;106(2):175-183.



The Role of ROTEM Variables Based on Clot Elasticity and Platelet Component in Predicting Bleeding Risk in Thrombocytopenic Critically Ill Neonates

Parastatidou S, Sokou R, Tsantes AG, Konstantinidi A, Lampridou M, Ioakeimidis G, Panagiotounakou P, Kyriakou E, Kokoris S, Gialeraki A, Douramani P, Iacovidou N, Piovani D, Bonovas S, Nikolopoulos G, Tsantes AE.

Results: Neonates with bleeding events had significantly lower PLTEM MCE and PLTEM MCF values compared to those without bleeding events ($P < 0.001$).

Platelet count was found to be strongly positively correlated with EXTEM A5 (Spearman rho=0.61, $P < 0.001$) and A10 (rho=0.64, $P < 0.001$).

EXTEM A10 demonstrated the best prognostic performance (AUC = 0.853) with an optimal cut-off value (≤ 37 mm) (sensitivity = 91%, specificity = 76%) for prediction of bleeding events in thrombocytopenic neonates.

Thromb Haemost. 2021 Feb;121(2):131-139.

A Risk Score for Predicting the Incidence of Hemorrhage in Critically Ill Neonates: Development and Validation Study

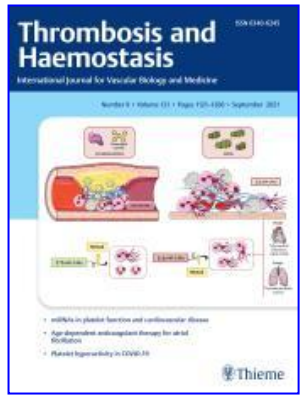
Sokou R, Piovani D, Konstantinidi A, Tsantes AG, Parastatidou S, Lampridou M, Ioakeimidis G, Gounaris A, Iacovidou N, Kriebardis AG, Politou M, Kopterides P, Bonovas S, Tsantes AE.

The aim of the study was to **develop and validate a prediction model for hemorrhage in critically ill neonates which combines rotational thromboelastometry (ROTEM) parameters and clinical variables.**

Bleeding within 24 hours of the ROTEM testing was the **outcome variable,** while patient characteristics, biochemical, hematological, and thromboelastometry parameters were the candidate predictors of bleeding.

EXTEM A10 and LI60, platelet counts, and creatinine levels were identified as the **most robust predictors of bleeding** and **included them into a Neonatal Bleeding Risk (NeoBRis) index.** The NeoBRis index demonstrated **excellent model performance with an AUC of 0.908** (95% CI, 0.870-0.946).

Thromb Haemost. 2021 Sep;121(9):1263-1266.



Prospective Temporal Validation of the Neonatal Bleeding Risk (NeoBRis) Index

Sokou R, Piovani D, Konstantinidi A, Tsantes AG, Parastatidou S, Lampridou M, Ioakeimidis G, Iacovidou N, Bonovas S, Tsantes AE.

After applying the scoring algorithm to the patients of the validation cohort (**n = 134;** missing data prevented computing the index in three patients), we plotted the AUC (►Fig. 1). We obtained an **AUC** [95% CI] of **0.938** [0.874–0.999] **in agreement with** the **AUC of 0.908** [0.870–0.946] observed in the derivation sample, which indicates an excellent model discrimination. The Brier score was close to zero (0.0582), indicating optimal performance.

Although the NeoBRis score was developed as a tool to predict the immediate (i.e., 24 hours) risk of any bleeding event, we tested its **capacity to predict severe bleeding events (i.e., NeoBAT score ≥ 3).** We obtained an **excellent AUC of 0.952** [0.911–0.993], suggesting that the **NeoBRis score can accurately predict also the risk of severe bleeding.**

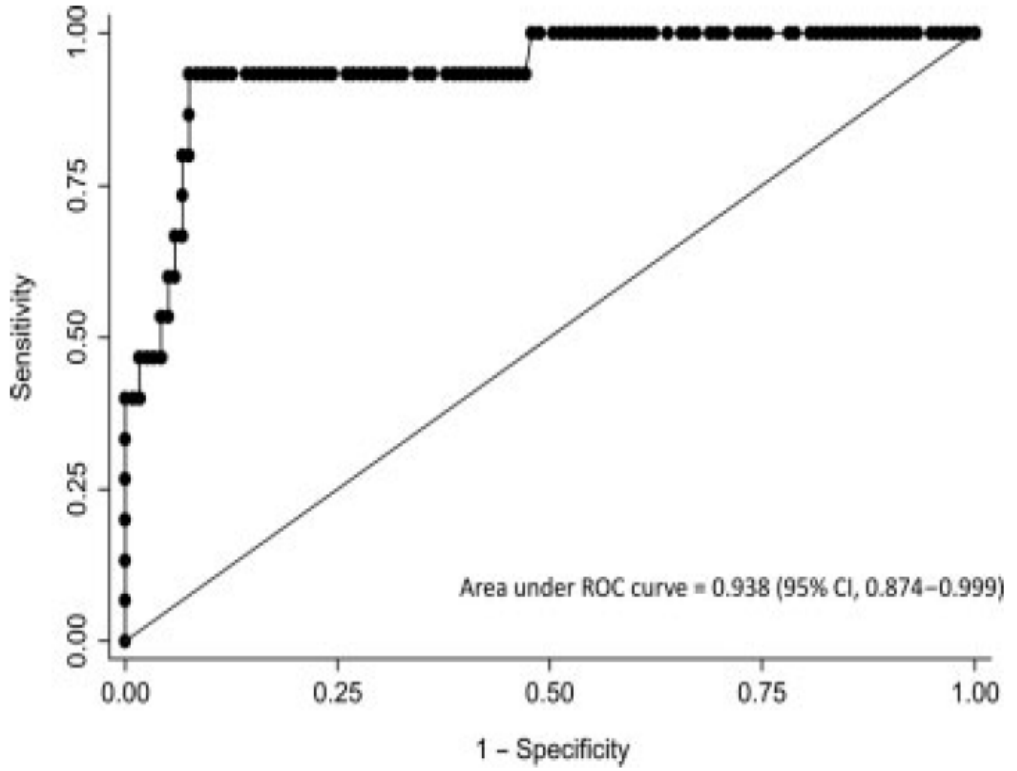
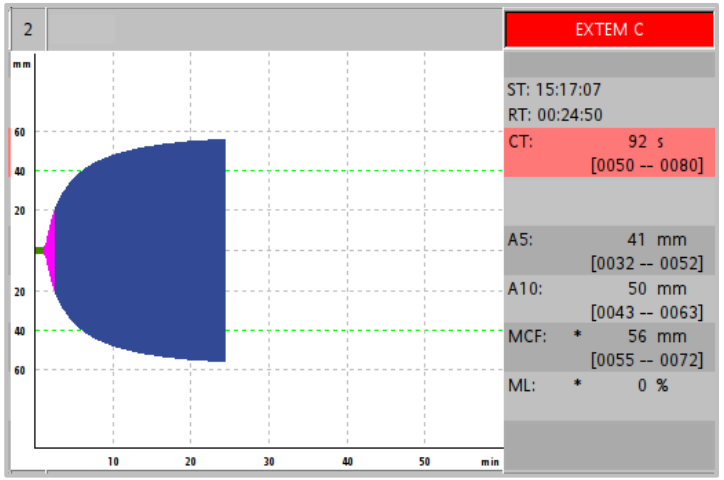
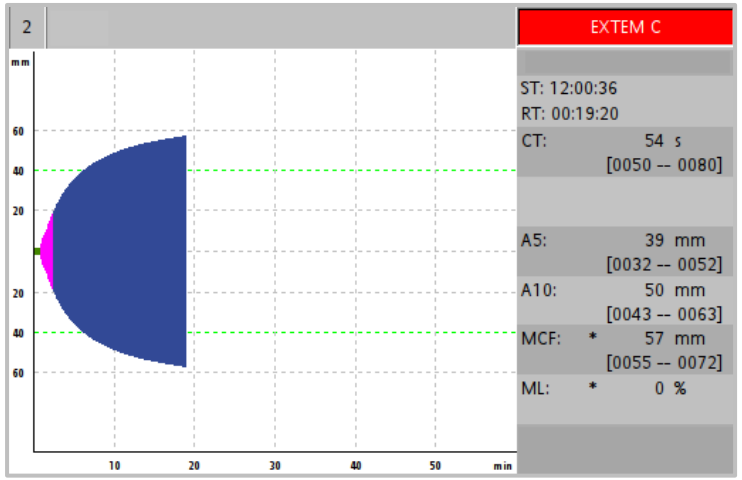


Fig. 1 Area under the receiver-operating characteristic (ROC) curve of the NeoBRis index in the validation cohort.

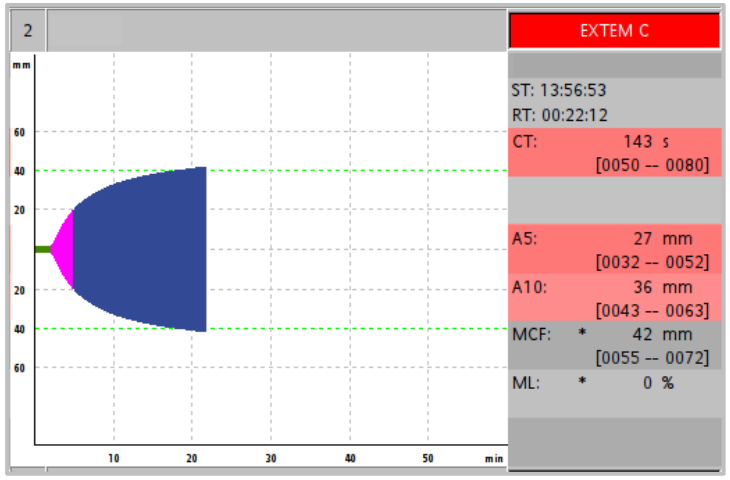
Thrombin Generation Management



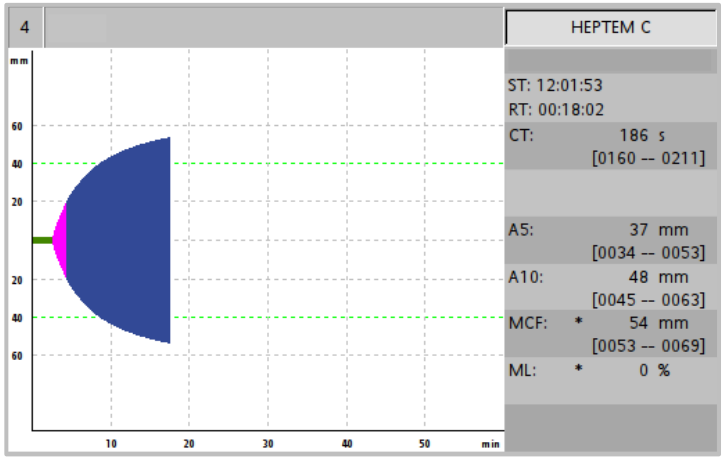
DEFICIENCY OF VITAMIN K-DEPENDENT FACTORS OR VKA (e.g., WARFARIN)

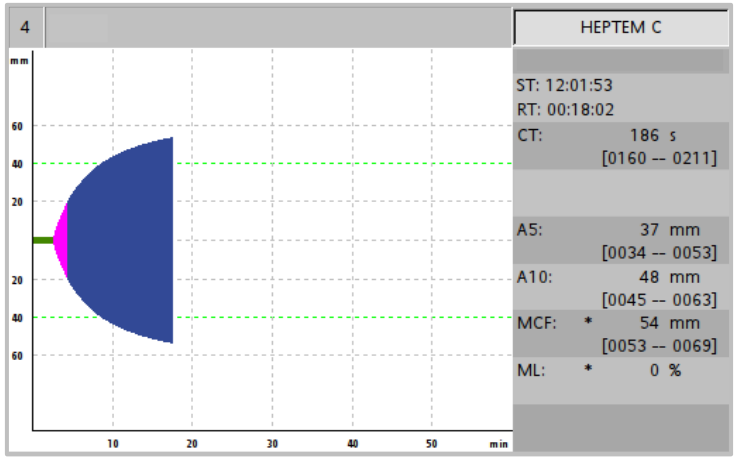


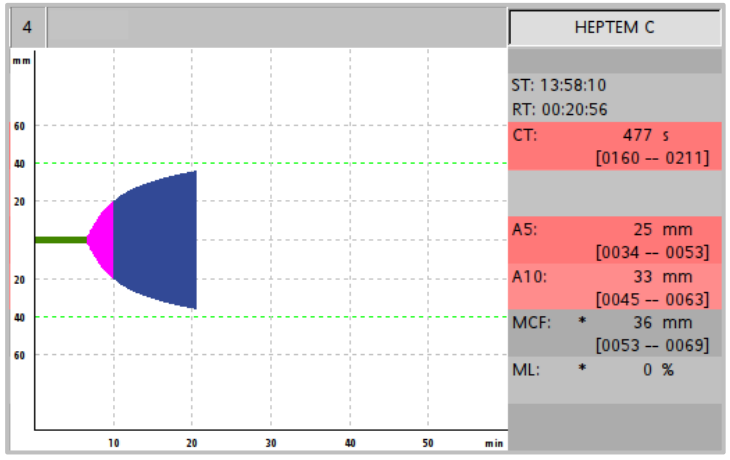
NORMAL

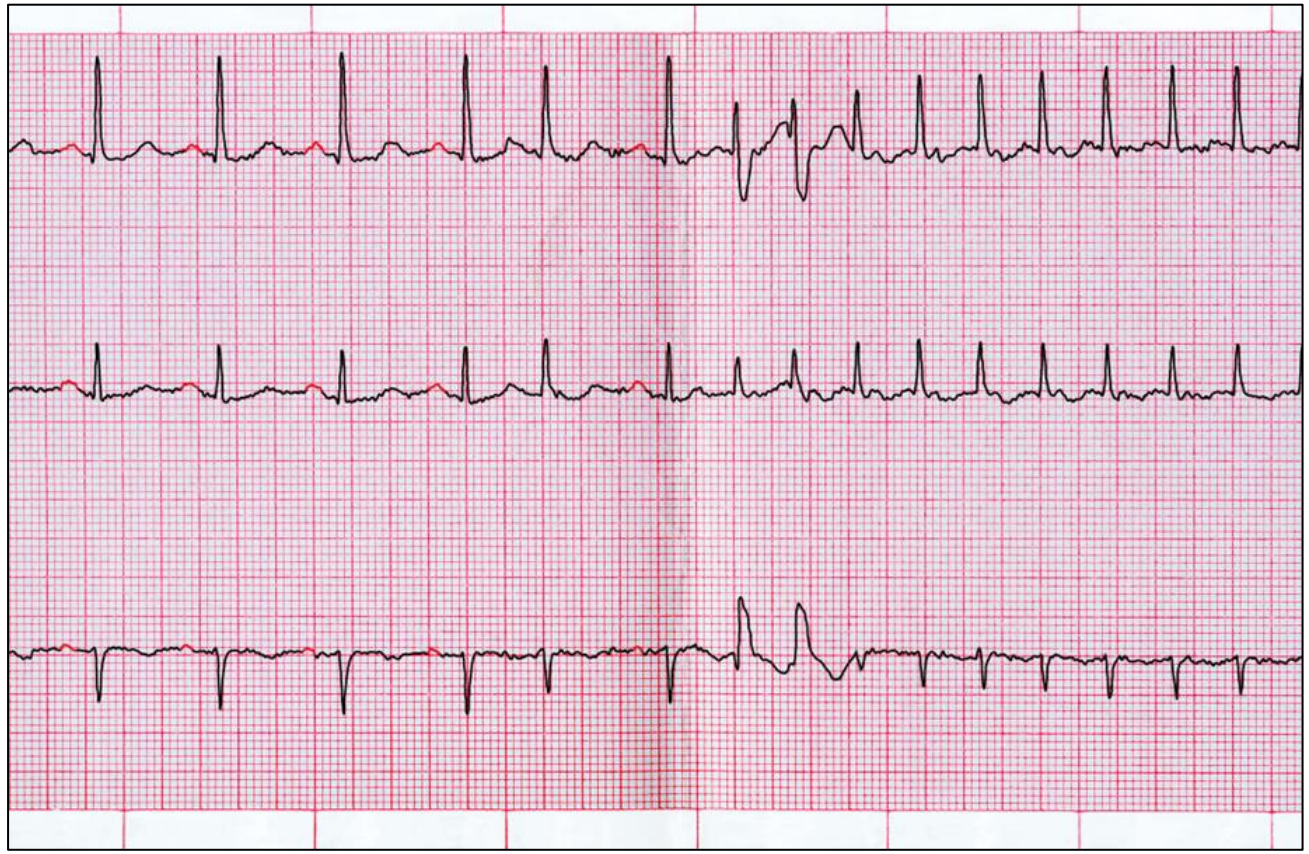


DEFICIENCY OF FACTORS OF THE COMMON PATHWAY OR DOACs (e.g., DABIGATRAN)









Case #6: Pre-LTX, Atrial Fibrillation and PVT

Case #6: Pre-LTX, Atrial Fibrillation and PVT (Apixaban, 2 x 5 mg)

Liver(TX) A5 Algorithm NO $A5_{EX}$ < 25 mm or

What do you do?

A. Andexanet Alfa

B. 4F-PCC

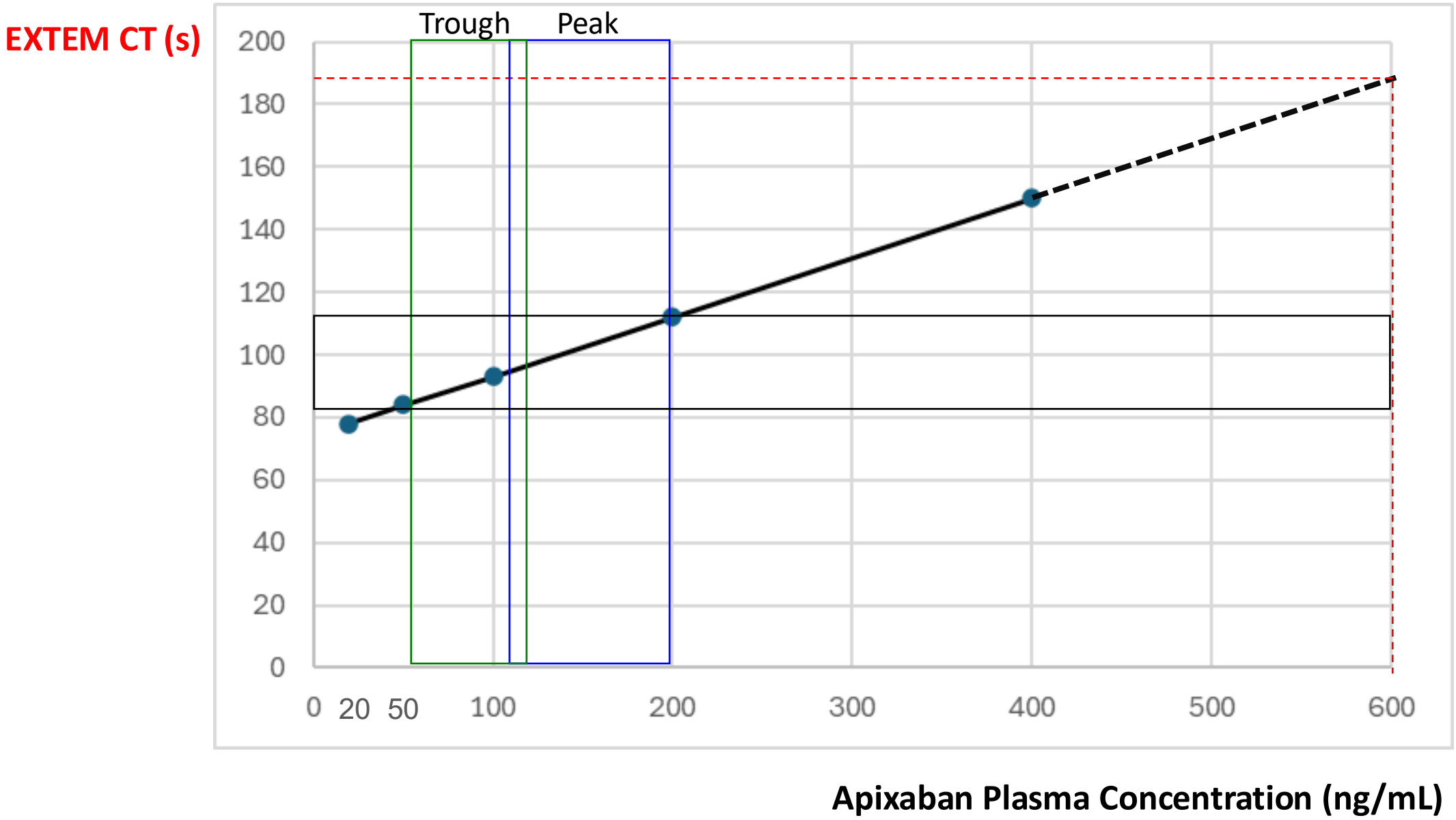
C. rFVIIa

D. Wait and See (Liver Graft on Extracorporeal Perfusion)

E. Hemoperfusion with Cytosorb Filter in the Recipient

FIBTEM A5 = 21 mm
EXTEM A5 = 50 mm
EXTEM CT = 189 s
INTEM CT = 253 s
HEPTEM CT = 258 s
INTEM/HEPTEM CT-ratio = 0.98

Tripodi A, et al. Diagnostics (Basel). 2024 Nov 14;14(22):2553.



Diagnostics (Basel). 2024 Nov 14;14(22):2553.

Comparative Investigation of Thromboelastometry and Thrombin Generation for Patients Receiving Direct Oral Anticoagulants or Vitamin K Antagonists

Tripodi A, Capecchi M, Scalambrino E, Clerici M, Scimeca B, Agosti P, Bucciarelli P, Artoni A, Peyvandi F.

METHODS: A total of 131 patients on **DOACs [apixaban (n = 37), rivaroxaban (n = 34), dabigatran (n = 30), edoxaban (n = 30)]** and **33 on VKAs** were analyzed.

Whole blood was analyzed for **thromboelastometry (EXTEM** and INTEM) and plasma was analyzed for thrombin generation.

RESULTS: While the **thromboelastometry clotting time (CT)** was **responsive to the hypocoagulability induced by DOACs or VKAs,** clot formation time and maximal clot formation were not.

Apixaban showed **relatively small differences (peak vs. trough) in the plasma concentration** and a **relatively small (peak vs. trough) difference of hypocoagulability** when assessed by the **CT** or the ETP. The **CT** and the ETP were **strongly correlated with DOAC concentrations** or with the **VKA-INR.**

Thromboelastometry Parameters vs. DOAC Concentrations			CT Value (95% CI) Corresponding to DOAC Concentrations of *	
CT-EXTEM (seconds)	**Rho**	***p* value**	**400 ng/mL**	**20 ng/mL**
DOACs (all)	0.725	<0.001	241 (233–249)	89 (81–97)
Apixaban	0.667	<0.001	150 (144–156)	78 (72–84)
Rivaroxaban	0.788	<0.001	236 (222–250)	99 (85–113)
Dabigatran	0.824	<0.001	224 (212–236)	91 (79–103)
Edoxaban	0.86	<0.001	341 (331–351)	105 (95–115)
CT-INTEM (seconds)				
DOAC (all)	0.49	<0.001		
Apixaban	0.23	<0.05		
Rivaroxaban	0.62	<0.001		
Dabigatran	0.75	<0.001		
Edoxaban	0.53	<0.001		

Table 1. Correlations of the thromboelastometry parameters vs. the DOAC concentrations or the VKA-INR, as measured for patients on chronic anticoagulation. Peak + trough DOAC concentrations were included in this analysis. CT-EXTEM or INTEM, coagulation time determined with extrinsic or intrinsic reagents. CFT-EXTEM or INTEM, clot formation time. MCF-EXTEM or INTEM, maximal clot firmness. VKA-INR, international normalized ratio for patients on VKAs. * Based on the linear regression line (DOAC concentration vs. the thromboelastometry CT).

Diagnostics (Basel). 2024 Nov 14;14(22):2553.

Comparative Investigation of Thromboelastometry and Thrombin Generation for Patients Receiving Direct Oral Anticoagulants or Vitamin K Antagonists

Tripodi A, Capecchi M, Scalambrino E, Clerici M, Scimeca B, Agosti P, Bucciarelli P, Artoni A, Peyvandi F.

CONCLUSIONS: **DOACs and VKAs altered thromboelastometry** and thrombin generation to an extent that probably reflects the mode of action of these drugs and may also have **practical implications for patients' management.**

Apixaban showed a **small difference of hypocoagulability (peak vs. trough),** suggesting a **more stable anticoagulation** over the daily course of treatment.

Based on the **correlations of the CT** or the ETP **vs. the DOAC concentrations,** we estimated that **critical values of the CT** or the ETP would correspond to **DOAC concentrations of 400 or 20 ng/mL.**

Whenever dedicated tests for DOAC concentrations are not available, the CT or the ETP **can be used as surrogates to evaluate the level of anticoagulation induced by DOACs.**

J Cardiothorac Vasc Anesth. 2022 Jun;36(6):1636-1644.

In Vitro Apixaban Removal By CytoSorb Whole Blood Adsorber: An Experimental Study

Røed-Undlien H. Schultz NH, Lunnan A, Husebråten IM, Wollmann BM, Molden E. Biørnstad JL.

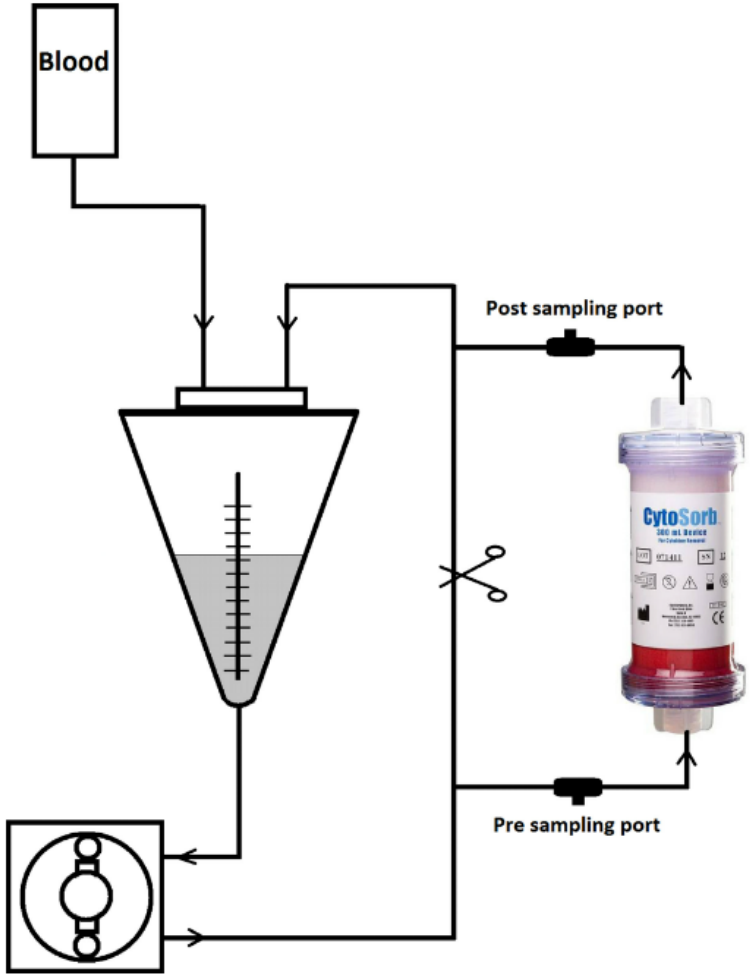


Fig. 1. The CytoSorb whole blood adsorber was connected to the circuit. The flow was kept at 300 mL/min.

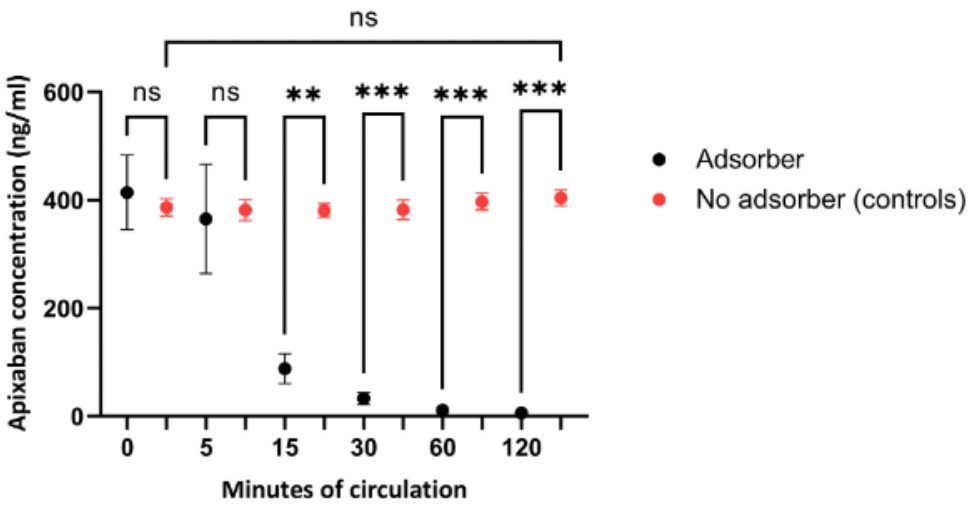


Fig. 3. The mean apixaban concentration measured as antifactor Xa activity, from blood samples drawn from the **pre-adsorber sampling port (black color)** and from the **circuit without adsorber (red color),** after 0, 5, 15, 30, 60, and 120 minutes. Statistical significances are indicated as follows: ***p < 0.001, **p = 0.001-0.01, *p = 0.01-0.05, ns = p > 0.05.

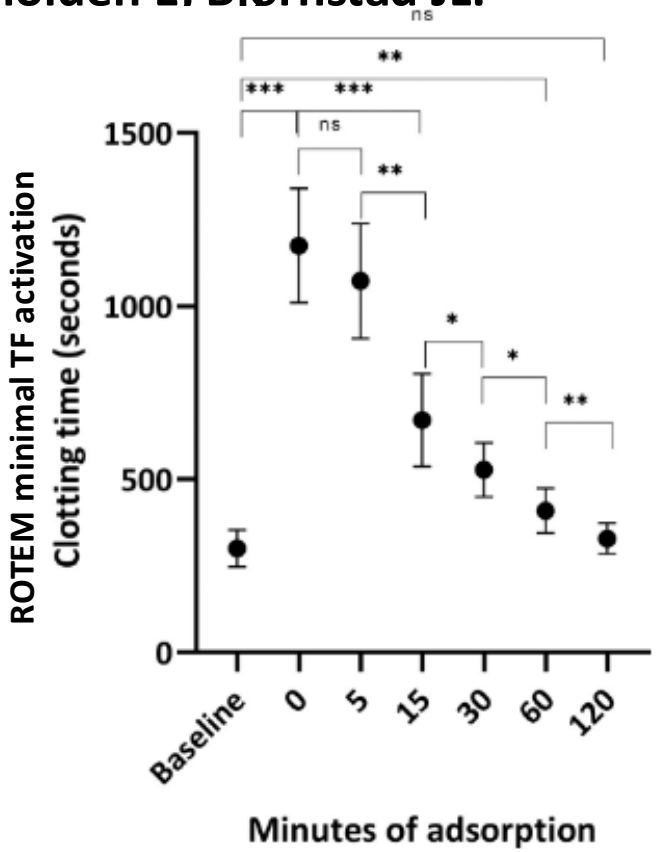
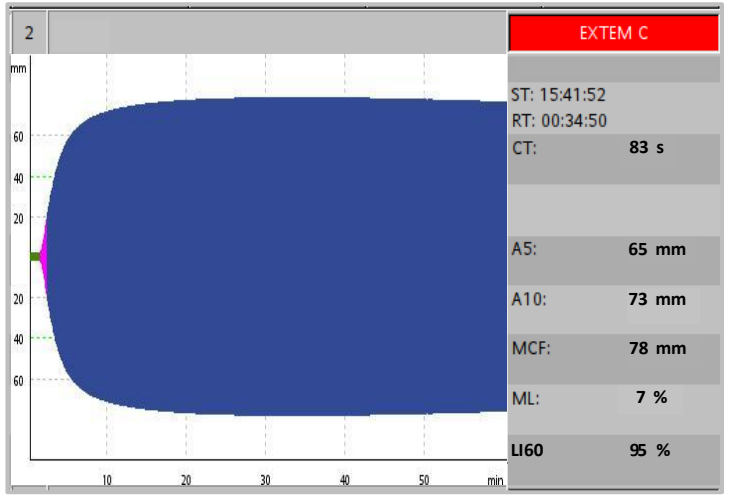
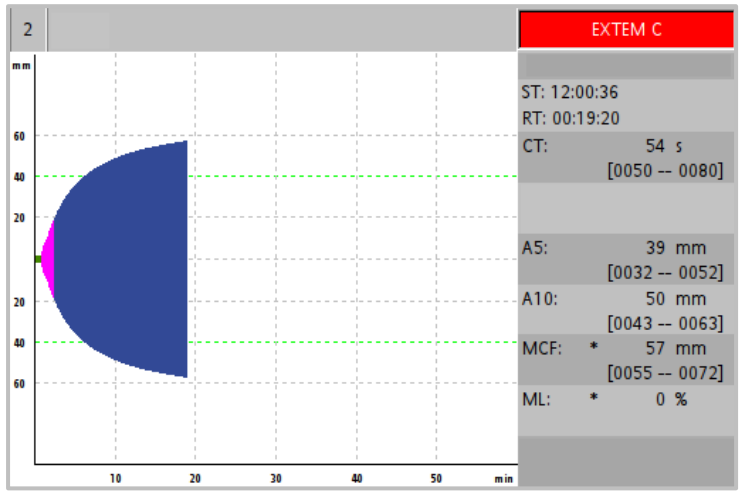


Fig. 5. The mean clotting time measured by ROTEM in blood samples drawn from the inlet sampling port at 0, 5, 15, 30, 60, and 120 minutes of adsorption. Baseline represents values before adding apixaban. Statistical significances are indicated as follows: ***p < 0.001, **p = 0.001-0.01, *p = 0.01-0.05, ns = p > 0.05.

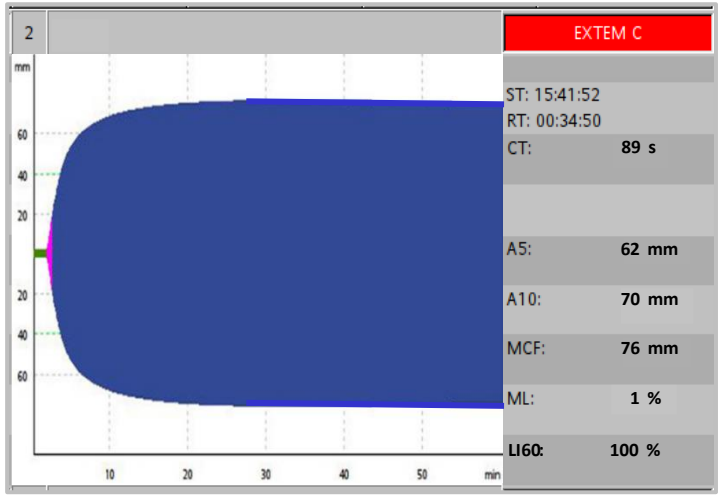
Hypercoagulability



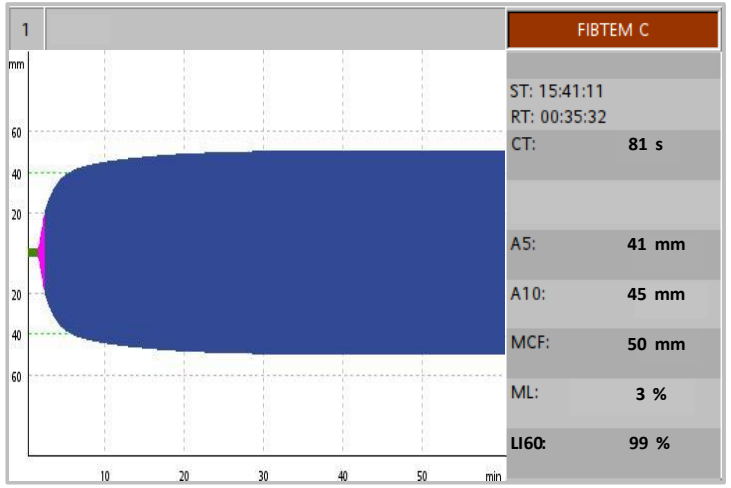
HYPERCOAGULABILITY WITH PHYSIOLOGIC FIBRINOLYSIS

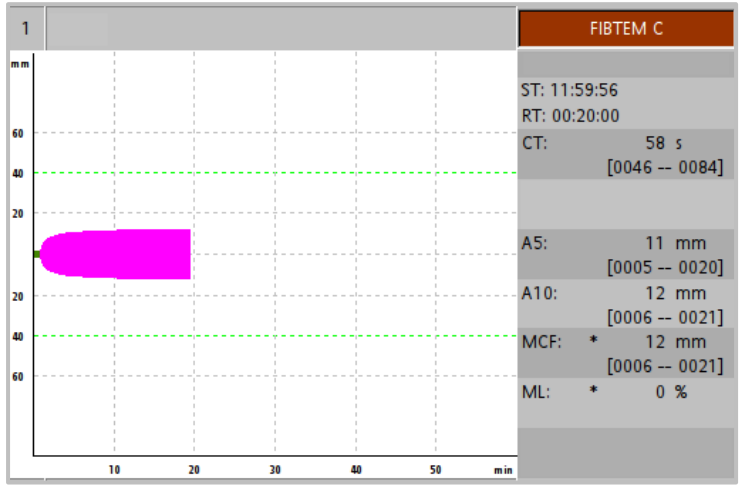


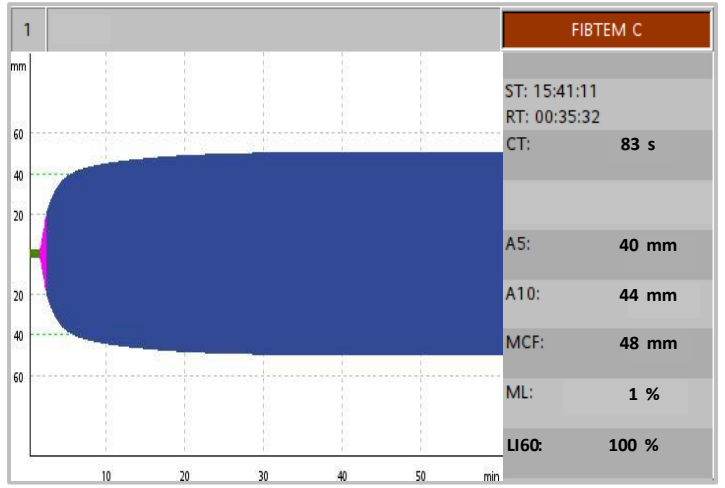
NORMAL



HYPERCOAGULABILITY WITH FIBRINOLYSIS SHUTDOWN







Dig Liver Dis. 2017 Apr;49(4):440-445.

Thromboelastometry Hypercoagulable Profiles and Portal Vein Thrombosis in Cirrhotic Patients with Hepatocellular Carcinoma

Zanetto A, Senzolo M, Vitale A, Cillo U, Radu C, Sartorello F, Spiezia L, Campello E, Rodriguez-Castro K, Ferrarese A, Farinati F, Burra P, Simioni P.

RESULTS: **In HCC, FIBTEM MCF > 25 mm** was associated with a **5-fold increased PVT risk** [RR: 4.8 (2-11.3); ***P = 0.0001***].

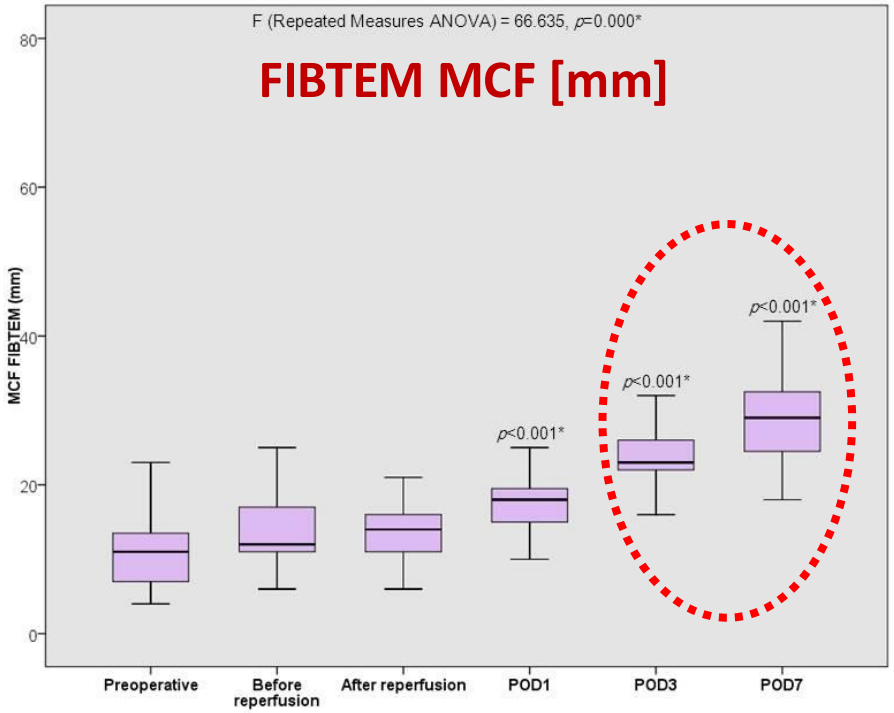
Cox multivariate analysis confirmed HCC and increased MCF (FIBTEM) to be independently associated with increased PVT risk.

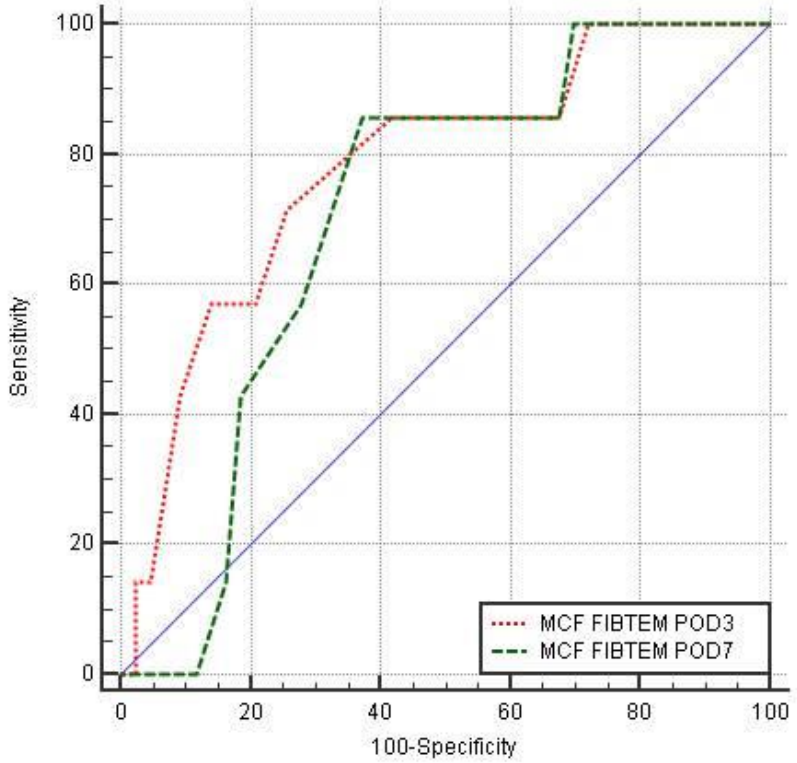
CONCLUSIONS: **Hypercoagulability** in HCC which can be **detected by thromboelastometry** is associated with **increased risk of PVT even in Child A patients.**

Transfus Med Hemother. 2018 Nov;45(6):404-412.

Perioperative Thromboelastometry for Adult Living Donor Liver Transplant Recipients with a Tendency to Hypercoagulability: A Prospective Observational Cohort Study

Kamel Y, Hassanin A, Ahmed AR, Gad E, Afifi M, Khalil M, Görlinger K, Yassen K.

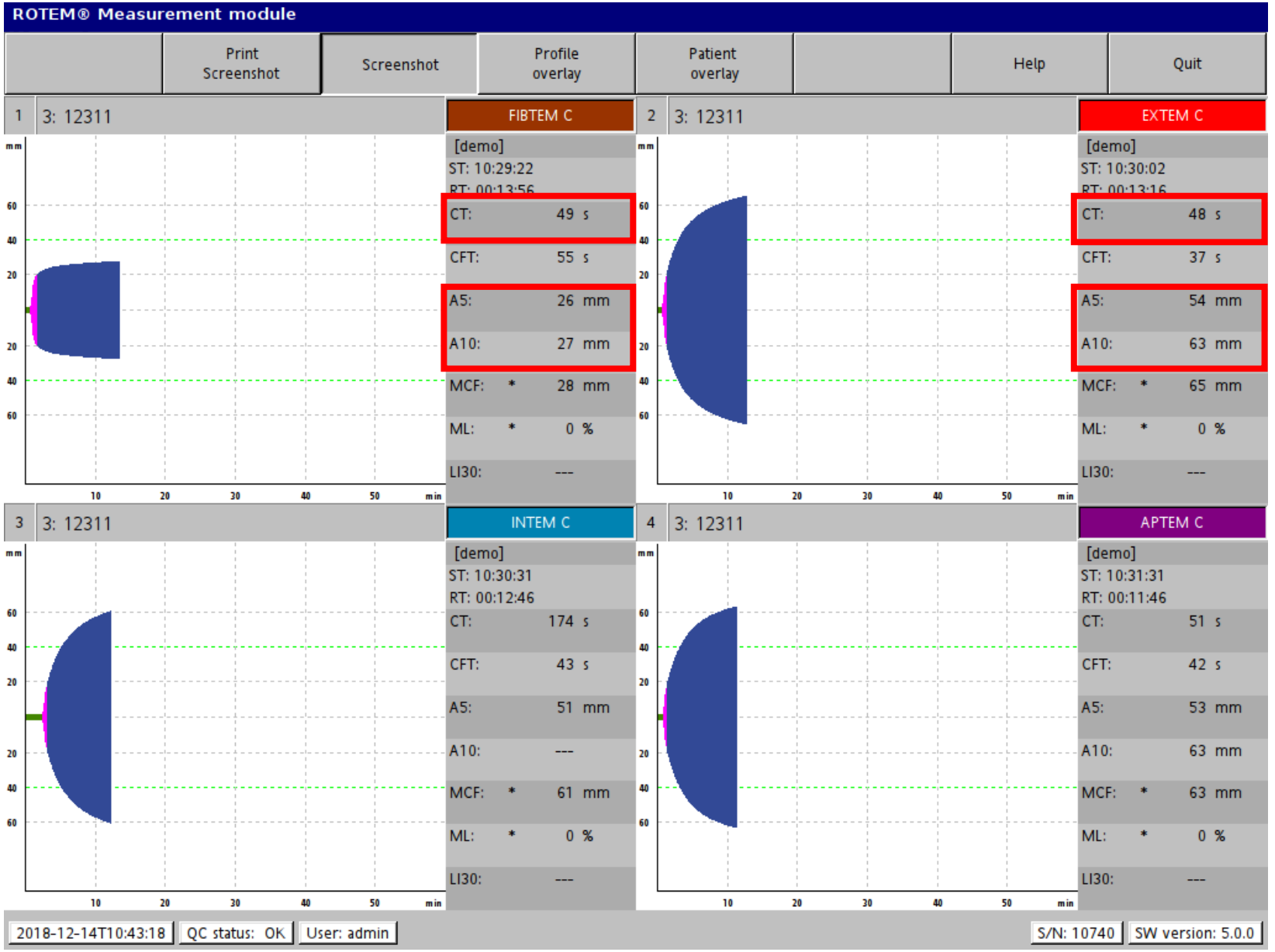


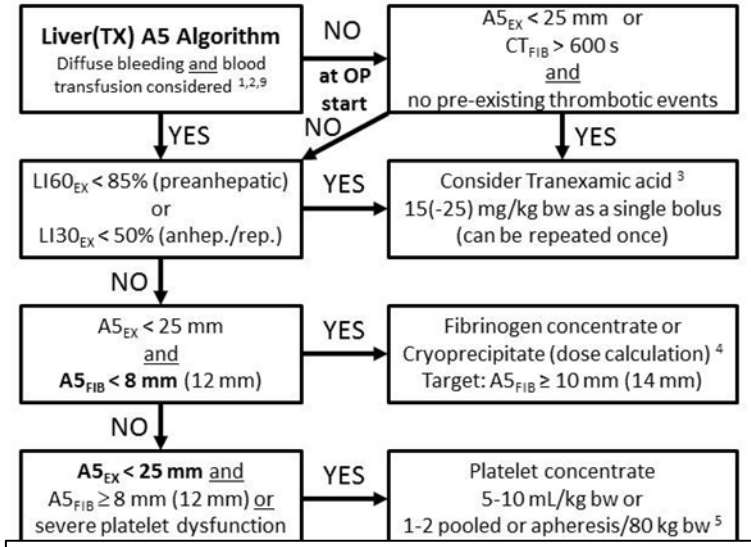


POD 3: cut-off >23 mm,
0.779 (0.097), *P=0.004*

POD 7: cut-off >28 mm,
0.706 (0.089), *P=0.020*

Case #7: POD3 after LTX





FIBTEM A5 = 26 mm

FIBTEM A10 = 27 mm

FIBTEM MCF* = 28 mm

EXTEM A5 = 54 mm

PLTEM A5 = 28 mm

EXTEM A10 = 63 mm

EXTEM MCF* = 63 mm

EXTEM CT = 48 s

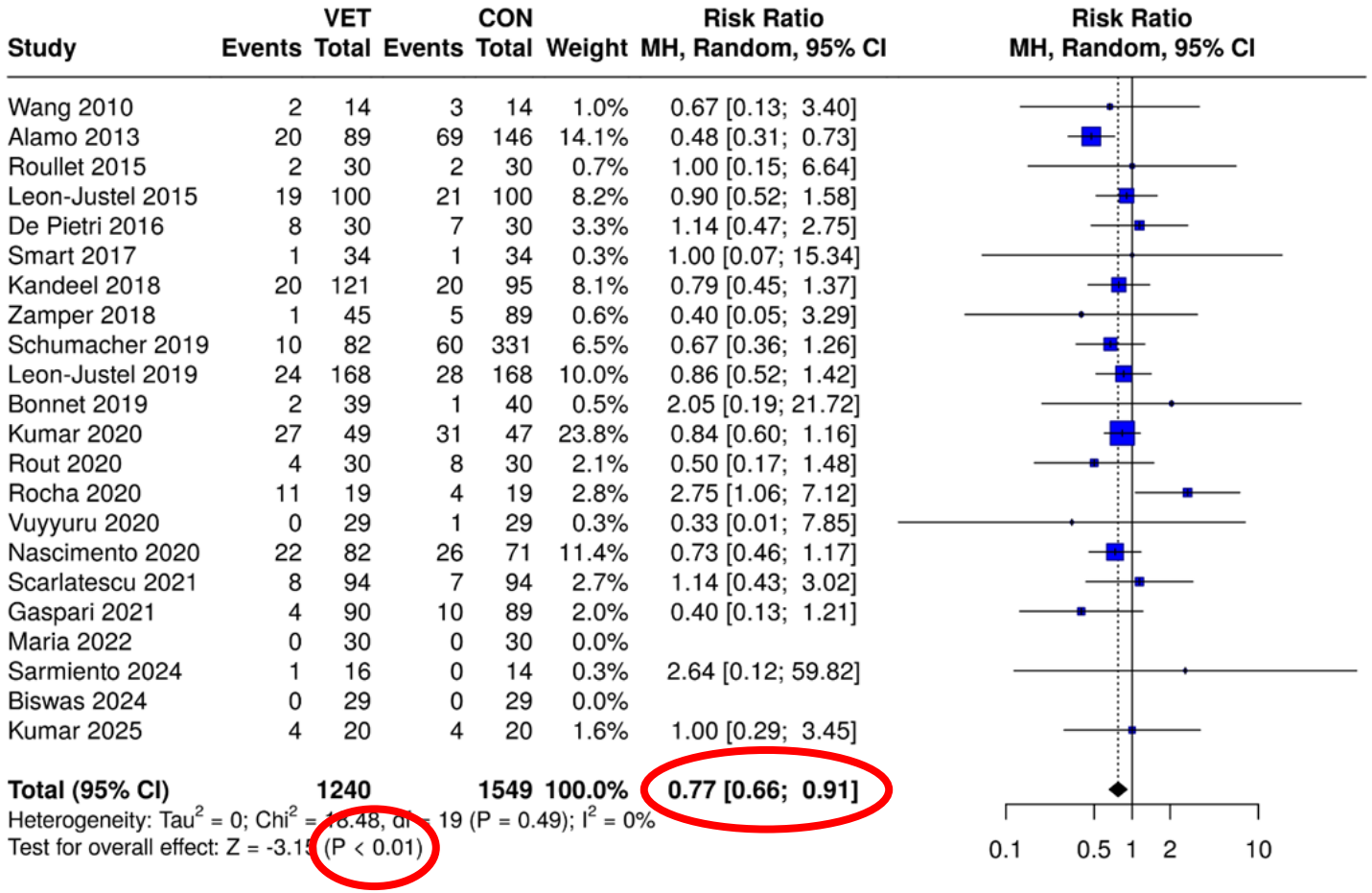
INTEM CT = 174 s

Patients' Outcome

NATA25; April 24-26, 2025, Munich, Germany. https://nataonline.com/nata25-abstract-book/.

Effect of Viscoelastic Testing on Mortality in Liver Transplantation and Cirrhotic Patients undergoing invasive Procedures: A Meta-Analysis

Görlinger K, Gandhi A, Perez-Calatayud AA, Yassen KA, Bezinover D, Saner FH.



Seven studies used TEG, 15 studies used ROTEM, and no study used Quantra, Medcaptain or ClotPro.

KEEP CALM AND STOP BLEEDING

kgoerlinger@werfen.com

… BUT AVOID TACO, TRALI, TRIM, AND THROMBOSIS