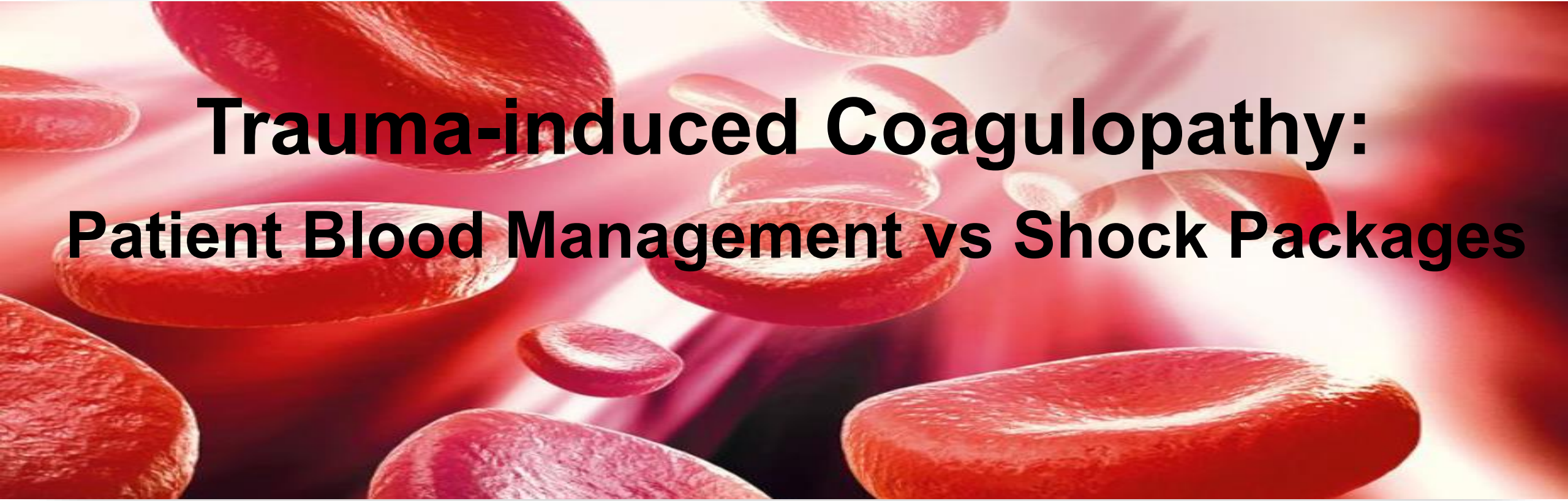

Trauma-induced Coagulopathy:
Patient Blood Management vs Shock Packages

Marc Maegele
Department for Trauma and Orthopedic Surgery
Cologne-Merheim Medical Center (CMMC)
Institute for Research in Operative Medicine (IFOM)
University Witten/Herdecke
Campus Cologne-Merheim

Breugel *et al. World Journal of Emergency Surgery* (2020) 15:55
https://doi.org/10.1186/s13017-020-00330-3

Epidemiology of trauma

Major-“Killers“ after trauma: TBI and uncontrolled bleeding

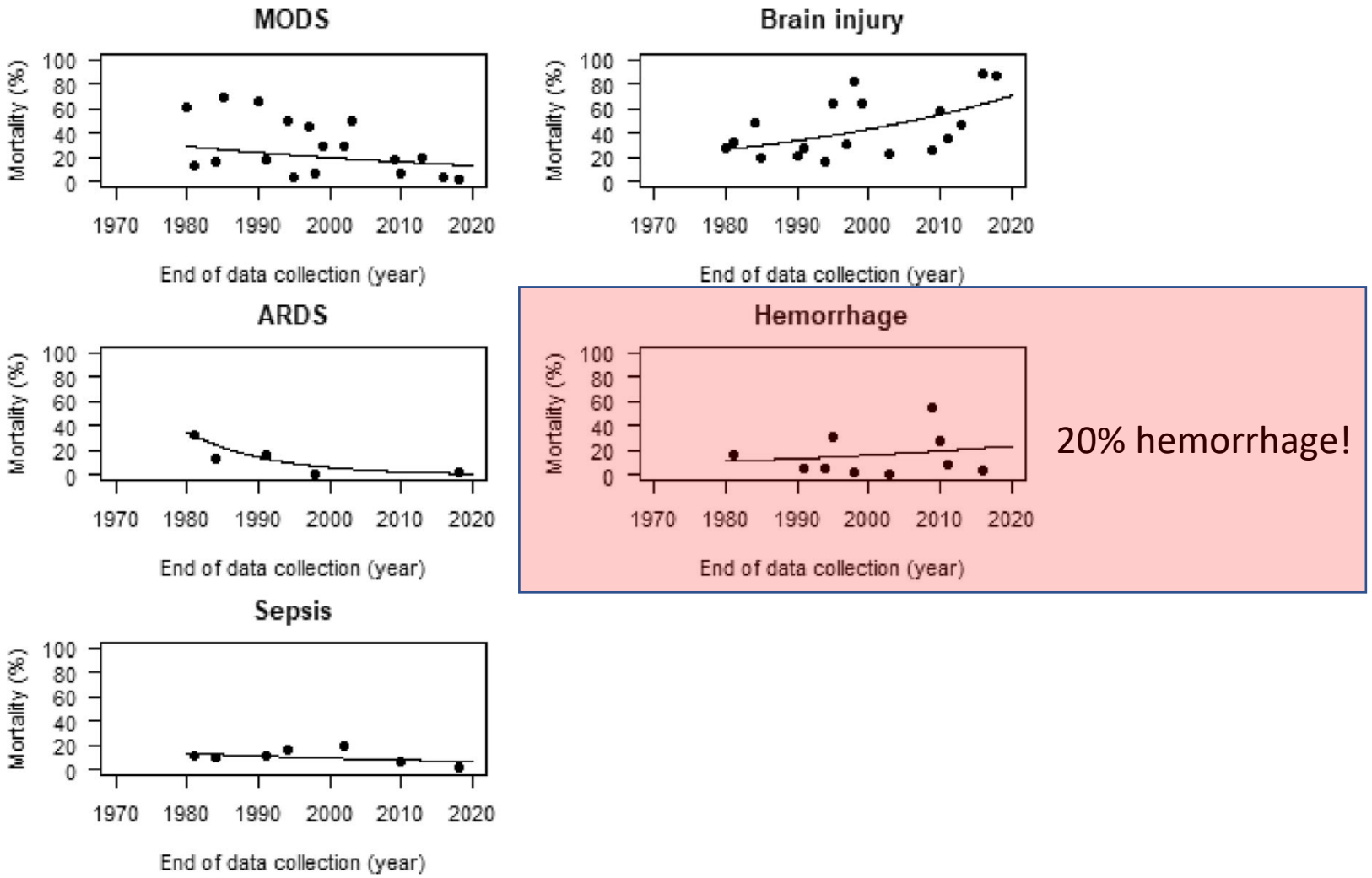

Fig. 3 Relative contribution of cause-specific mortality to all-cause mortality in polytrauma patients admitted to the ICU since 1966. Different panels show the relative contribution of different causes of death

Frequency of (evolvoing) hemostatic failure upon ED admission (major contributing factor)

25% of all severely injured and bleeding patients display laboratory signs of coagulopathy

European Journal of Trauma and Emergency Surgery
https://doi.org/10.1007/s00068-017-0884-5

ORIGINAL ARTICLE

Trauma-induced coagulopathy upon emergency room arrival: still a significant problem despite increased awareness and management?

Matthias Fröhlich[1,2] · Manuel Mutschler[1] · Michael Caspers[1,2] · Ulrike Nienaber[3] · Vera Jäcker[1] · Arne Driessen[4] · Bertil Bouillon[1] · Marc Maegele[1,2] · The TraumaRegister DGU[5]

Received: 3 August 2017 / Accepted: 20 November 2017
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Patients and methods Between 2002 and 2013, 61,212 trauma patients derived from the TraumaRegister DGU® had a full record of coagulation parameters and were assessed for the presence of coagulopathy. Coagulopathy was defined by a Quick's value < 70% and/or platelet counts < 100,000/µl upon ER admission. For each year, the incidence of coagulopathy, the amount of pre-hospital administered i.v.-fluids and transfusion requirements were assessed.

Results Coagulopathy upon ER admission was present in 24.5% of all trauma patients.

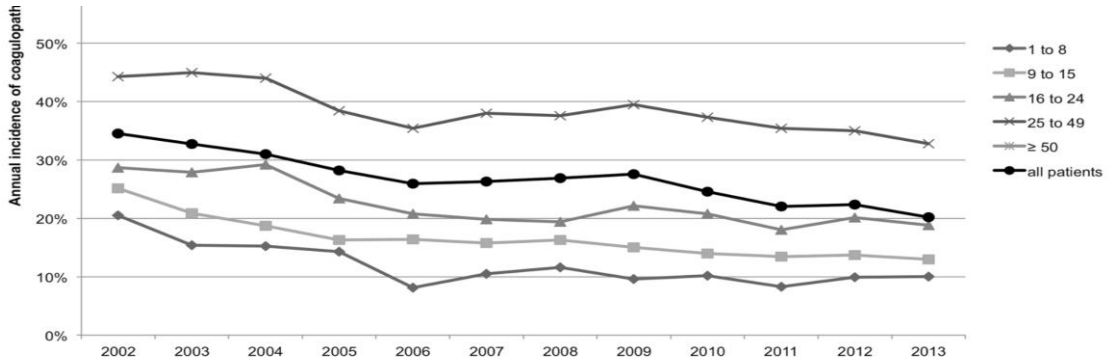


Fig. 2 Annually incidence rate of coagulopathy in subgroups according to injury severity over the years 2002–2013 (ISS, five groups; $n = 61{,}212$; decrease significant, $p < 0.001$ for all groups)

Table 7: Data from the TR-DGU on emergency room and surgery. Information for primary admitted patients

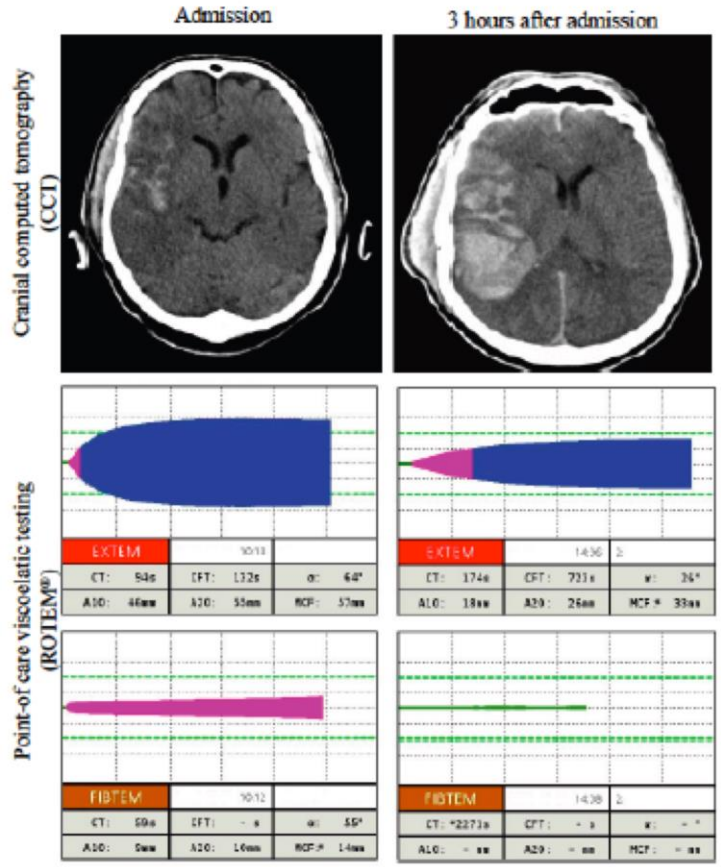
Time point B: Emergency room / surgery	TR-DGU 2023		TR-DGU 10 years	
Primary admitted patients (n) (%-ratio of the basic group)	28,718 (92 %)		293,047 (91 %)	
Hemostasis therapy**	**24.3 %**	4,207	**20.8 %**	29,566

¼ TR-DGU patients needs hemostatic therapy!

universität Witten/Herdecke

Frequency of (evolving) hemostatic failure upon ED admission

Evolving hemostatic failure after admission



Haemoglobin	12.6 g/dL	Haemoglobin	6.6g/dL ↓
Platelets	174.000/µL	Platelets	55.000/µL ↓
pH	7.332	pH	7.22 ↓
BE	-2.7 mmol/L	BE	-8.7 mmol/L ↓
Lactate	0.99(mmol/L	Lactate	6.99 mmol/L ↑
Quicks (PTr)	60%	Quicks (PTr)	15% ↓
PT	16.3 sec	PT	45,3 sec ↑
aPTT	40 sec	aPTT	161 sec ↑
Fibrinogen	135 mg/dL	Fibrinogen	81 mg/dL ↓

Traumatic brain injury 2

Lancet Neurol 2017; 16: 630–47

Coagulopathy and haemorrhagic progression in traumatic brain injury: advances in mechanisms, diagnosis, and management

Marc Maegele, Herbert Schöchl, Tomas Menovsky, Hugues Maréchal, Niklas Marklund, Andras Buki, Simon Stanworth

Greuters et al., Crit Care 2011

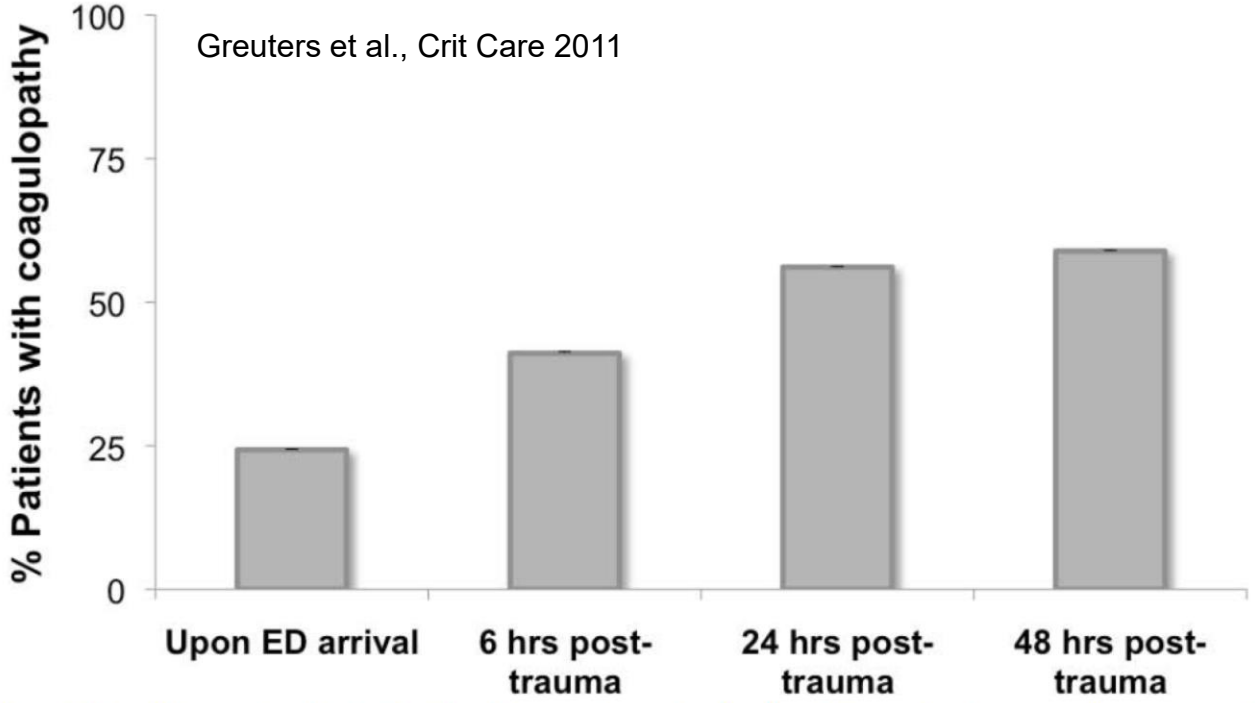
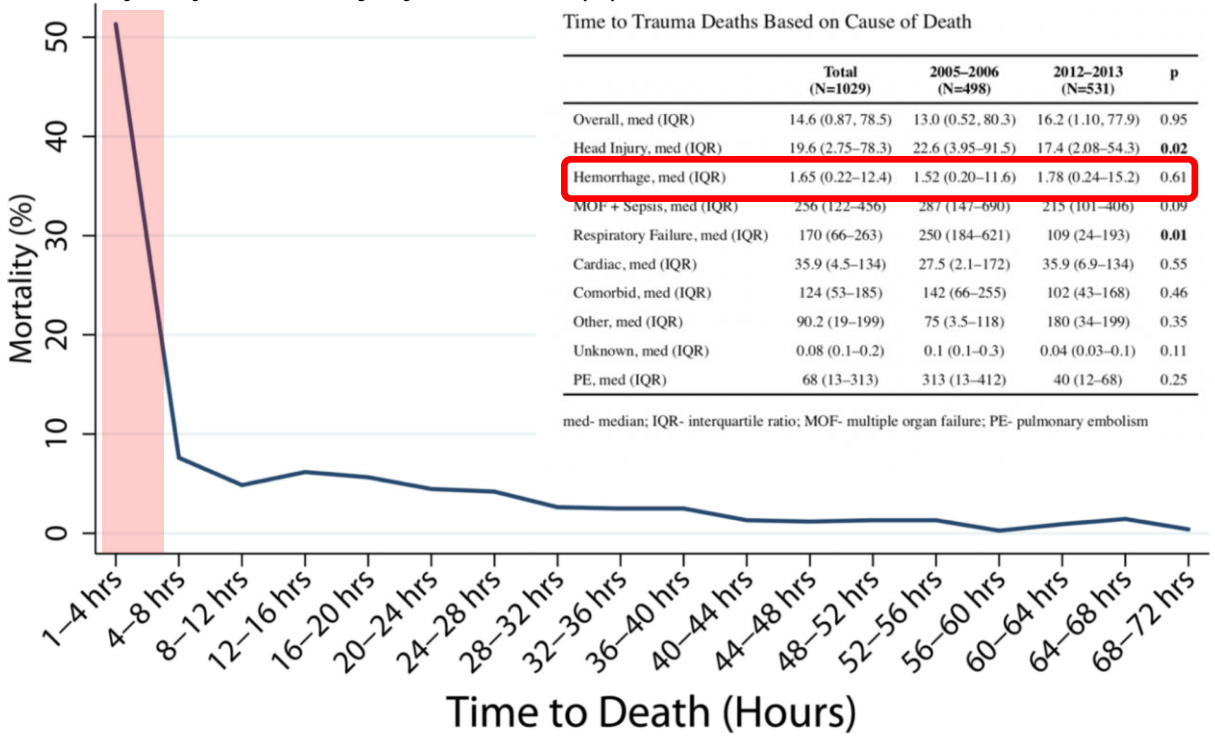


Figure 1 The relative number of patients with a diagnosis of coagulopathy. The relative number of patients with a diagnosis of coagulopathy upon emergency department arrival and at 6, 24 and 48 hours post-trauma.

Clinical significance

Death from uncontrolled bleeding and hemostatic failure occurs quickly

Oyeniyi et al., Injury 2017; 48(1): 5-12



Time to Trauma Deaths Based on Cause of Death

	Total (N=1029)	2005–2006 (N=498)	2012–2013 (N=531)	p
Overall, med (IQR)	14.6 (0.87, 78.5)	13.0 (0.52, 80.3)	16.2 (1.10, 77.9)	0.95
Head Injury, med (IQR)	19.6 (2.75–78.3)	22.6 (3.95–91.5)	17.4 (2.08–54.3)	**0.02**
Hemorrhage, med (IQR)	1.65 (0.22–12.4)	1.52 (0.20–11.6)	1.78 (0.24–15.2)	0.61
MOF + Sepsis, med (IQR)	256 (122–456)	287 (147–690)	215 (101–406)	0.09
Respiratory Failure, med (IQR)	170 (66–263)	250 (184–621)	109 (24–193)	**0.01**
Cardiac, med (IQR)	35.9 (4.5–134)	27.5 (2.1–172)	35.9 (6.9–134)	0.55
Comorbid, med (IQR)	124 (53–185)	142 (66–255)	102 (43–168)	0.46
Other, med (IQR)	90.2 (19–199)	75 (3.5–118)	180 (34–199)	0.35
Unknown, med (IQR)	0.08 (0.1–0.2)	0.1 (0.1–0.3)	0.04 (0.03–0.1)	0.11
PE, med (IQR)	68 (13–313)	313 (13–412)	40 (12–68)	0.25

med- median; IQR- interquartile ratio; MOF- multiple organ failure; PE- pulmonary embolism

Earlier time to hemostasis is associated with decreased mortality and rate of complications: Results from the Pragmatic Randomized Optimal Platelet and Plasma Ratio trial

Ronald Chang, MD, Jeffrey D. Kerby, MD, PhD, Kyle J. Kalkwarf, MD, Gerald Van Belle, PhD, Erin E. Fox, PhD, Bryan A. Cotton, MD, MPH, Mitchell J. Cohen, MD, Martin A. Schreiber, MD, Karen Brasel, MD, MPH, Eileen M. Bulger, MD, Kenji Inaba, MD, Sandro Rizoli, MD, Jeanette M. Podbielski, BSN, Charles E. Wade, PhD, John B. Holcomb, MD, *and* PROPPR Study Group, *Houston, Texas*

J Trauma Acute Care Surg. 2019;87: 342–349

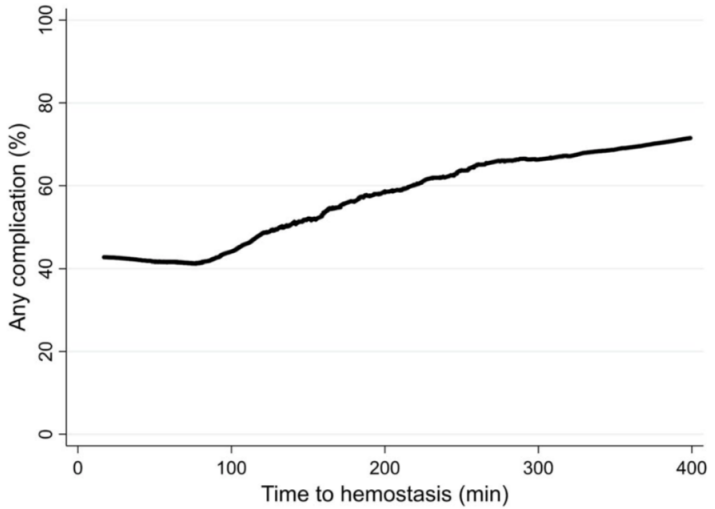
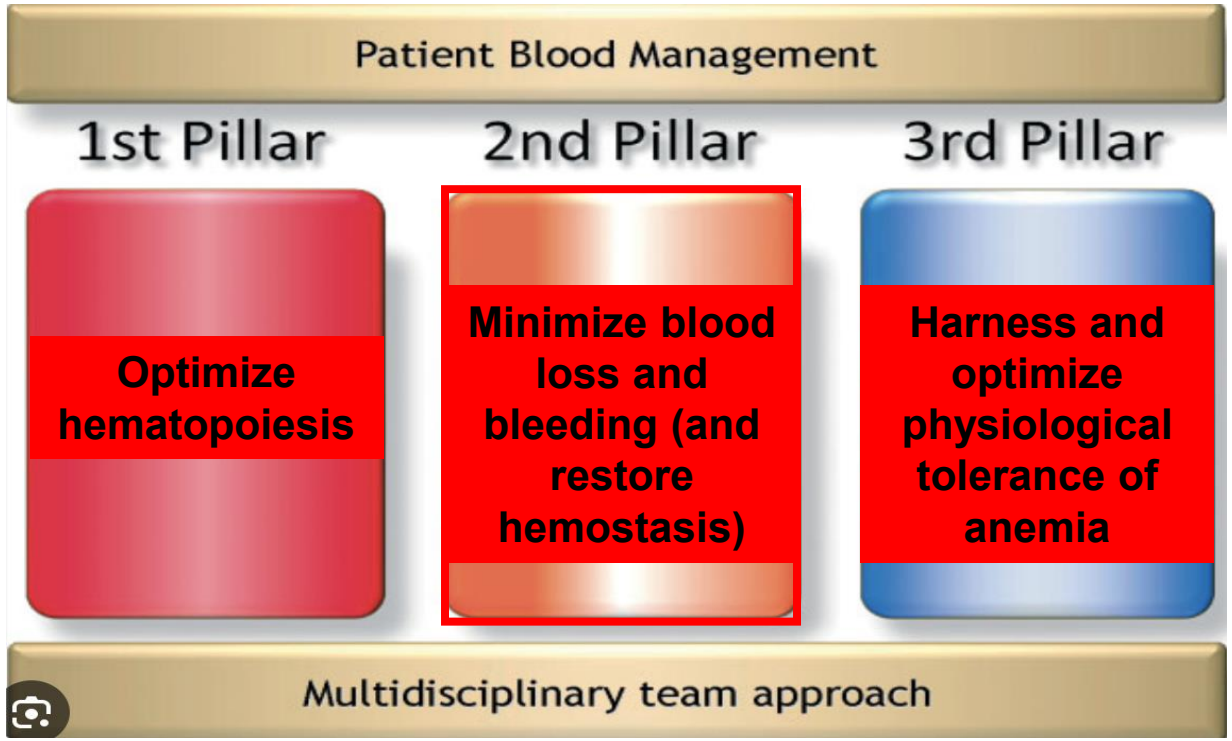


Figure 3. LOWESS regression of incidence of any complication (mortality, AKI, ARDS, MOF, sepsis, or VTE) versus time to hemostasis.

Of 680 enrolled patients, 468 (69%) underwent an emergent procedure. Patients with decreased time to hemostasis were less severely injured, had less deranged base excess on admission, and lower incidence of blunt trauma (all $p < 0.05$). In 408 (87%) patients in whom hemostasis was achieved, every 15-minute decrease in time to hemostasis was associated with decreased 30-day mortality (RR, 0.97; 95% confidence interval [CI], 0.94–0.99), AKI (RR, 0.97; 95% CI, 0.96–0.98), ARDS (RR, 0.98; 95% CI, 0.97–0.99), MOF (RR, 0.94; 95% CI, 0.91–0.97), and sepsis (RR, 0.98; 95% CI, 0.96–0.99), but not venous thromboembolism (RR, 0.99; 95% CI, 0.96–1.03).

Treat the bleeding is to stop the bleeding
and to restore hemostasis!

Guidance provided by Patient Blood Management Program and AND European Trauma Guideline



GUIDELINES Open Access

The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition

Rolf Rossaint[1*], Arash Afshari[2], Bertil Bouillon[3], Vladimir Cerny[4,5], Diana Cimpoesu[6], Nicola Curry[7,8], Jacques Duranteau[9], Daniela Filipescu[10], Oliver Grottke[1], Lars Grønlykke[11], Anatole Harrois[9], Beverley J. Hunt[12], Alexander Kaserer[13], Radko Komadina[14], Mikkel Herold Madsen[2], Marc Maegele[15], Lidia Mora[16], Louis Riddez[17], Carolina S. Romero[18], Charles-Marc Samama[19], Jean-Louis Vincent[20], Sebastian Wiberg[11] and Donat R. Spahn[13]

Rossaint *et al. Critical Care* (2023) 27:80
https://doi.org/10.1186/s13054-023-04327-7

Results This guideline comprises 39 clinical practice recommendations that follow an approximate temporal path for management of the bleeding trauma patient, with recommendations grouped behind key decision points. While approximately one-third of patients who have experienced severe trauma arrive in hospital in a coagulopathic state, a systematic diagnostic and therapeutic approach has been shown to reduce the number of preventable deaths attributable to traumatic injury.

3 Key interventions to reduce mortality in trauma

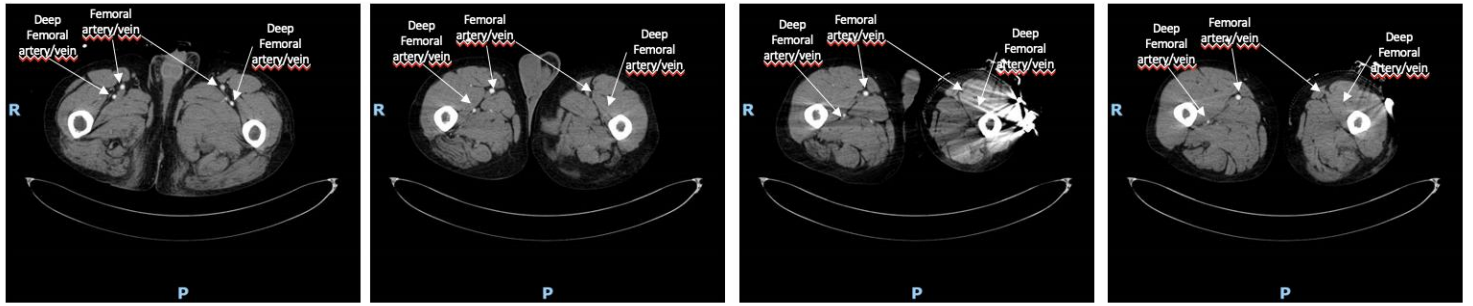
March 27, 2019

Use of Combat Casualty Care Data to Assess the US Military Trauma System During the Afghanistan and Iraq Conflicts, 2001-2017

Jeffrey T. Howard, PhD[1,2]; Russ S. Kotwal, MD, MPH[2,3,4]; Caryn A. Stern, DrPH[2]; et al

» Author Affiliations

JAMA Surg. 2019;154(7):600-608. doi:10.1001/jamasurg.2019.0151



Retrospective study (2001-2017)

n = 56 763 military casualties

Survival 3-fold ↑

3 Key interventions (touniquets, access to Blood products and prehospital time 60 min) Associated with 44% mortality reduction

Design, Setting, and Participants Retrospective analysis of all available aggregate and weighted individual administrative data compiled from Department of Defense databases on all 56 763 US military casualties injured in battle in Afghanistan and Iraq from October 1, 2001, through December 31, 2017. Casualty outcomes were compared with period-specific ratios of the use of tourniquets, blood transfusions, and transport to a surgical facility within 60 minutes.

Findings This analysis of all US military casualties from October 2001 through December 2017 found that survival among the most critically injured casualties increased 3-fold during the course of the conflicts and that 3 key interventions (tourniquets, blood transfusions, and prehospital transport within 60 minutes) were associated with 44% of mortality reduction.

Surgical bleeding control

CURRENT OPINION
Effective approaches to address noncompressible torso hemorrhage
Curr Opin Crit Care 2024, 30:202–208
DOI:10.1097/MCC.0000000000001141

Marc Maegele[a,b]

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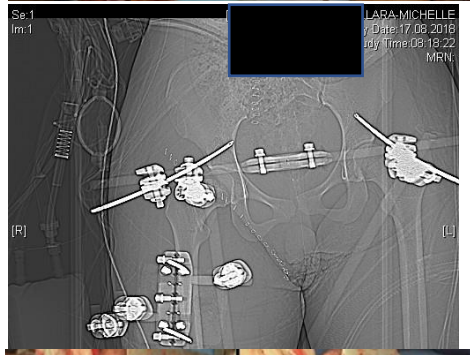
Rolf Rossaint[1*], Arash Afshari[2], Bertil Bouillon[3], Vladimir Cerny[4,5], Diana Cimpoesu[6], Nicola Curry[7,8], Jacques Duranteau[9], Daniela Filipescu[10], Oliver Grottke[1], Lars Grønlykke[11], Anatole Harrois[9], Beverley J. Hunt[12], Alexander Kaserer[13], Radko Komadina[14], Mikkel Herold Madsen[2], Marc Maegele[15], Lidia Mora[16], Louis Riddez[17], Carolina S. Romero[18], Charles-Marc Samama[19], Jean-Louis Vincent[20], Sebastian Wiberg[11] and Donat R. Spahn[13]

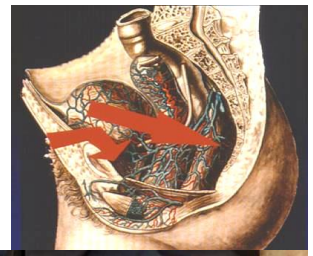
Rossaint et al. Critical Care (2023) 27:80
https://doi.org/10.1186/s13054-023-04327-7

Local management, „Damage control“ and Endovasular Control

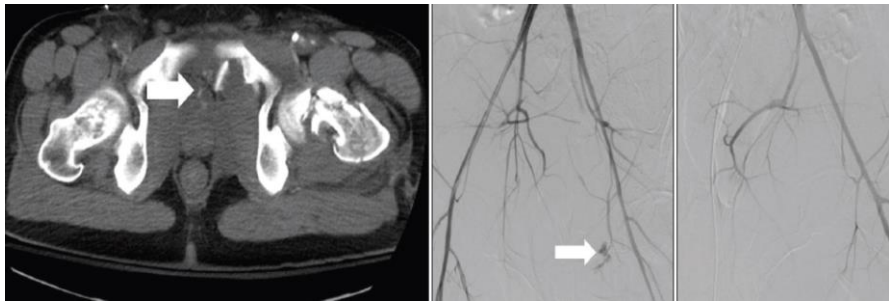
Local compression, tourniquet and pelvic binder!

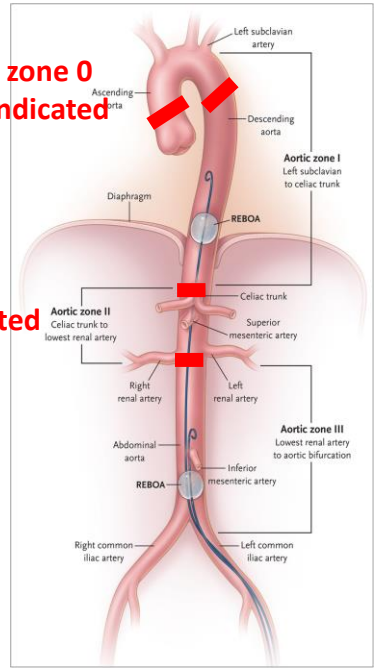
Damage control surgery!





Embolisation and endovascular control (REBOA)!





Restore Hemostasis!
universität
Witten/Herdecke

Current understanding of hemostatic failure/trauma-induced coagulopathy

Pathophysiology of Trauma-Induced Coagulopathy

Herbert Schöchl[1] Felix C.F. Schmitt[2] Marc Maegele[3,4]

Hamostaseologie 2024;44:31–39.

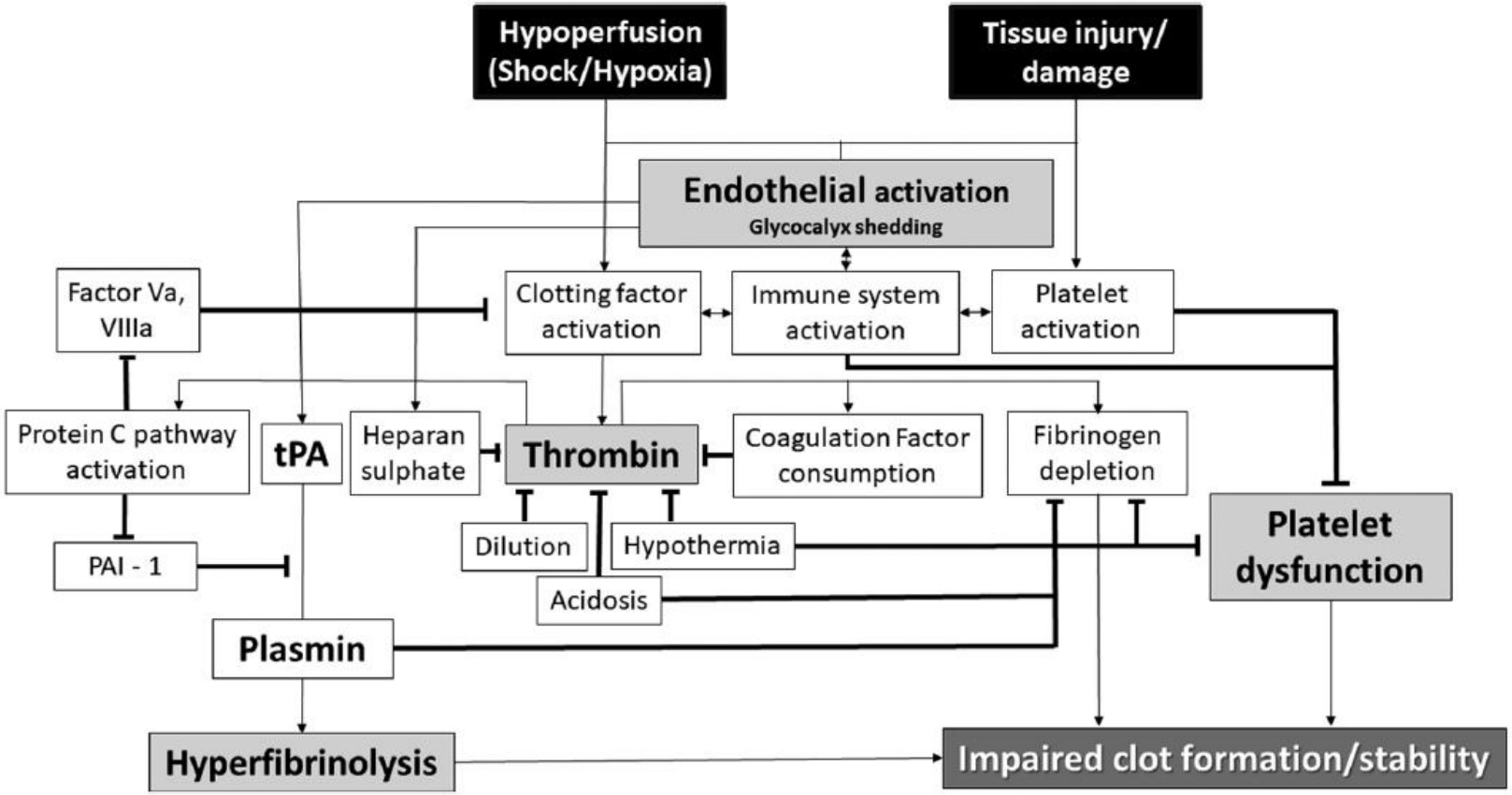


Fig. 1 Schematic overview of potential drivers of trauma-induced coagulopathy. t-PA, tissue plasminogen activator; PAI-1, plasminogen activator inhibitor 1. Activators; inhibitors.

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GUIDELINES Open Access

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Rolf Rossaint[1*], Arash Afshari[2], Bertil Bouillon[3], Vladimir Cerny[4,5], Diana Cimpoesu[6], Nicola Curry[7,8], Jacques Duranteau[9], Daniela Filipescu[10], Oliver Grottke[1], Lars Grønlykke[11], Anatole Harrois[9], Beverley J. Hunt[12], Alexander Kaserer[13], Radko Komadina[14], Mikkel Herold Madsen[2], Marc Maegele[15], Lidia Mora[16], Louis Riddez[17], Carolina S. Romero[18], Charles-Marc Samama[19], Jean-Louis Vincent[20], Sebastian Wiberg[11] and Donat R. Spahn[13]

Rossaint et al. Critical Care (2023) 27:80
https://doi.org/10.1186/s13054-023-04327-7

Summary recommendations
V. Initial management of bleeding & coagulopathy

ABC Advanced Bleeding Care

V.
Initial management of bleeding & coagulopathy

R23
Antifibrinolytic agents

***

Tranexamic acid should be administered to the trauma patient who is bleeding or at risk of significant bleeding as soon as possible, en route to the hospital if feasible, and within 3 h at a loading dose of 1 g infused over 10 min, followed by an intravenous infusion of 1 g over 8 h. Tranexamic acid administration should not await viscoelastic assessment results.

R24
Coagulation support

***

Monitoring and measures to support coagulation should be initiated immediately upon hospital admission.

R25
Initial coagulation resuscitation

***

The initial coagulation resuscitation strategy for patients with expected massive haemorrhage should comprise either:
fibrinogen concentrate or cryoprecipitate and pRBC
OR
FFP or pathogen-inactivated FFP in a FFP:pRBC ratio of at least 1:2 as needed.
A high platelet:pRBC ratio may be applied.

Ratio-based strategies

J Trauma Acute Care Surg. 2014 Mar;76(3):561-7; discussion 567-8. doi: 10.1097/TA.0000000000000146.

Hemostatic resuscitation is neither hemostatic nor resuscitative in trauma hemorrhage.

Khan S[1], Brohi K, Chana M, Raza I, Stanworth S, Gaarder C, Davenport R; International Trauma Research Network (INTRN).

RESULTS: Of the 106 study patients receiving at least 4 U of PRBC, 27 received 8 U to 11 U of PRBC and 31 received more than 12 U of PRBC. Average admission lactate was 6.2 mEq/L. Patients with high lactate (≥5 mEq/L) on admission did not clear lactate until hemorrhage control was achieved, and no further PRBC units were required. On admission, 43% of the patients were coagulopathic (clot amplitude at 5 minutes ≤ 35 mm). This increased to 49% by PRBC 4; 62% by PRBC 8 and 68% at PRBC 12. The average fresh frozen plasma/PRBC ratio between intervals was 0.5 for 0 U to 4 U of PRBC, 0.9 for 5 U to 8 U of PRBC, 0.7 for 9 U to 12 U of PRBC. There was no improvement in any ROTEM parameter during ongoing bleeding.

CONCLUSION: While hemostatic resuscitation offers several advantages over historical strategies, it still does not achieve correction of hypoperfusion or coagulopathy during the acute phase of trauma hemorrhage. Significant opportunities still exist to improve management and improve outcomes for bleeding trauma patients.

Intensive Care Med. 2015 Feb;41(2):239-47. doi: 10.1007/s00134-014-3584-1. Epub 2014 Dec 2.

Damage control resuscitation using blood component therapy in standard doses has a limited effect on coagulopathy during trauma hemorrhage.

Khan S[1], Davenport R, Raza I, Glasgow S, De'Ath HD, Johansson PI, Curry N, Stanworth S, Gaarder C, Brohi K.

RESULTS: One hundred six patients who received at least four PRBC units were included. Thirty-four patients (32 %) required a massive transfusion. On admission 40 % of patients were coagulopathic (ROTEM CA5 ≤ 35 mm). This increased to 58 % after four PRBCs and 81 % after eight PRBCs. On average all functional coagulation parameters and procoagulant factor concentrations deteriorated during hemorrhage. There was no clear benefit to high-dose FFP therapy in any parameter. Only combined high-dose FFP, cryoprecipitate and platelet therapy with a high total fibrinogen load appeared to produce a consistent improvement in coagulation.

CONCLUSIONS: Damage control resuscitation with standard doses of blood components did not consistently correct trauma-induced coagulopathy during hemorrhage. There is an important opportunity to improve TIC management during damage control resuscitation.

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Ratio-based strategies

Ratio-based concepts: Problems

- takes time to achieve hemostasis!

  1:1 took 14.8 hrs to correct standard coagulation assays (INR < 1.5)

  Gonzales et al., J Trauma 2007

- also leads to dilution!

  Armand and Hess, Transfusion Med Rev 2003

- is associated with immunological patterns/ derange-ments

  volume loading

  immunological reactions/infection risk

Component Therapy vs What we bleed

So Component Therapy Gives You

1U PRBC + 1U PLT + 1U FFP

- *Hct 29%*
- *Plt 87K*
- *Coag activity 65%*
- *850 mg fibrinogen*

Armand & Hess, Transfusion Med. Rev., 2003

New RCTs on empiric treatment… not effective!

Resuscitation with blood products in patients with trauma-related haemorrhagic shock receiving prehospital care (RePHILL): a multicentre, open-label, randomised, controlled, phase 3 trial

*Nicholas Crombie, Heidi A Doughty, Jonathan R B Bishop, Amisha Desai, Emily F Dixon, James M Hancox, Mike J Herbert, Caroline Leech, Simon J Lewis, Mark R Nash, David N Naumann, Gemma Slinn, Hazel Smith, Iain M Smith, Rebekah K Wale, Alastair Wilson, Natalie Ives, Gavin D Perkins, on behalf of the RePHILL collaborative group**

Lancet Haematol 2022

Published Online
March 7, 2022
https://doi.org/10.1016/
S2352-3026(22)00040-0

Interpretation The trial did not show that prehospital PRBC–LyoPlas resuscitation was superior to 0·9% sodium chloride for adult patients with trauma related haemorrhagic shock. Further research is required to identify the characteristics of patients who might benefit from prehospital transfusion and to identify the optimal outcomes for transfusion trials in major trauma. The decision to commit to routine prehospital transfusion will require careful consideration by all stakeholders.

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Efficacy and Safety of Early Administration of 4-Factor Prothrombin Complex Concentrate in Patients With Trauma at Risk of Massive Transfusion
The PROCOAG Randomized Clinical Trial

JAMA. doi:10.1001/jama.2023.4080
Published online March 21, 2023.

Pierre Bouzat, MD, PhD; Jonathan Charbit, MD; Paer-Selim Abback, MD; Delphine Huet-Garrigue, MD; Nathalie Delhaye, MD; Marc Leone, MD, PhD; Guillaume Marcotte, MD; Jean-Stéphane David, MD, PhD; Albrice Levrat, MD; Karim Asehnoune, MD, PhD; Julien Pottecher, MD, PhD; Jacques Duranteau, MD, PhD; Elie Courvalin, MD; Anais Adolle, MSc; Dimitri Sourd, MSc; Jean-Luc Bosson, MD, PhD; Bruno Riou, MD, PhD; Tobias Gauss, MD; Jean-François Payen, MD, PhD; for the PROCOAG Study Group

CONCLUSIONS AND RELEVANCE Among patients with trauma at risk of massive transfusion, there was no significant reduction of 24-hour blood product consumption after administration of 4F-PCC, but thromboembolic events were more common. These findings do not support systematic use of 4F-PCC in patients at risk of massive transfusion.

CRYOSTAT-2
EARLY CRYOPRECIPITATE IN TRAUMA

STUDY DESIGN

Randomised, un-blinded, controlled trial

Study groups
- 3 pools of cryoprecipitate (~6g fibrinogen) plus MHP
- Standard MHP alone

1568 patients in UK and USA

PRIMARY OUTCOME = 28 day mortality

CENTRE FOR TRAUMA SCIENCES

NHS National Institute for Health Research

NHS Blood and Transplant

Karim Brohi ✓
@karimbrohi

CRYOSTAT2 results #ccr23:

- Early *empiric* administration of high-dose cryoprecipitate to trauma patients activating the major haemorrhage protocol did not improve 28-day mortality.

- possible evidence of harm if given very early or in penetrating trauma patients…

Post übersetzen

12:14 nachm. · 16. Juni 2023 · **98.825** Mal angezeigt

Restore haemostasis and coagulation support: Guidelines

GUIDELINES Open Access

The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition

Rolf Rossaint[1*], Arash Afshari[2], Bertil Bouillon[3], Vladimir Cerny[4,5], Diana Cimpoesu[6], Nicola Curry[7,8], Jacques Duranteau[9], Daniela Filipescu[10], Oliver Grottke[1], Lars Grønlykke[11], Anatole Harrois[9], Beverley J. Hunt[12], Alexander Kaserer[13], Radko Komadina[14], Mikkel Herold Madsen[2], Marc Maegele[15], Lidia Mora[16], Louis Riddez[17], Carolina S. Romero[18], Charles-Marc Samama[19], Jean-Louis Vincent[20], Sebastian Wiberg[11] and Donat R. Spahn[13]

Rossaint *et al. Critical Care* (2023) 27:80
https://doi.org/10.1186/s13054-023-04327-7

Coagulation monitoring

Recommendation 11 We recommend the early and repeated monitoring of haemostasis, using either a traditional laboratory determination such as prothrombin time (PT)/international normalised ratio (INR), Clauss fibrinogen level and platelet count and/or point-of-care (POC) PT/INR and/or a viscoelastic method (Grade 1C).

Recommendation 26 We recommend that resuscitation measures be continued using a goal-directed strategy, guided by standard laboratory coagulation values and/or VEM (Grade 1B).

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

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

Second update 2022

Sibylle Kietaibl, Aamer Ahmed, Arash Afshari, Pierre Albaladejo, Cesar Aldecoa, Giedrius Barauskas, Edoardo De Robertis, David Faraoni, Daniela C. Filipescu, Dietmar Fries, Anne Godier, Thorsten Haas, Matthias Jacob, Marcus D. Lancé, Juan V. Llau, Jens Meier, Zsolt Molnar, Lidia Mora, Niels Rahe-Meyer, Charles M. Samama, Ecaterina Scarlatescu, Christoph Schlimp, Anne J. Wikkelsø and Kai Zacharowski

Which patients should be optimised before surgery and how?

We suggest VHA-guided, goal-directed procoagulant treatment of peri-operatively acquired coagulopathic bleeding avoiding overcorrection. 2C

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Nächste Überprüfung geplant: 12/2027
AWMF Register-Nr.: 187-023
Klasse: S3

Polytrauma/Schwerverletzten-Behandlung

S3-Leitlinie

der

Deutschen Gesellschaft für Unfallchirurgie e.V.

DEUTSCHE GESELLSCHAFT FÜR UNFALLCHIRURGIE

2.4.14	Recommendation	New 2022
Recommendation Level A↑↑	Coagulation diagnostics and therapy should be guided by viscoelastic testing. **When available has been deleted!**	

universität Witten/Herdecke

Support of coagulation function

Schöchl et al. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine 2012, 20:15
http://www.sjtrem.com/content/20/1/15

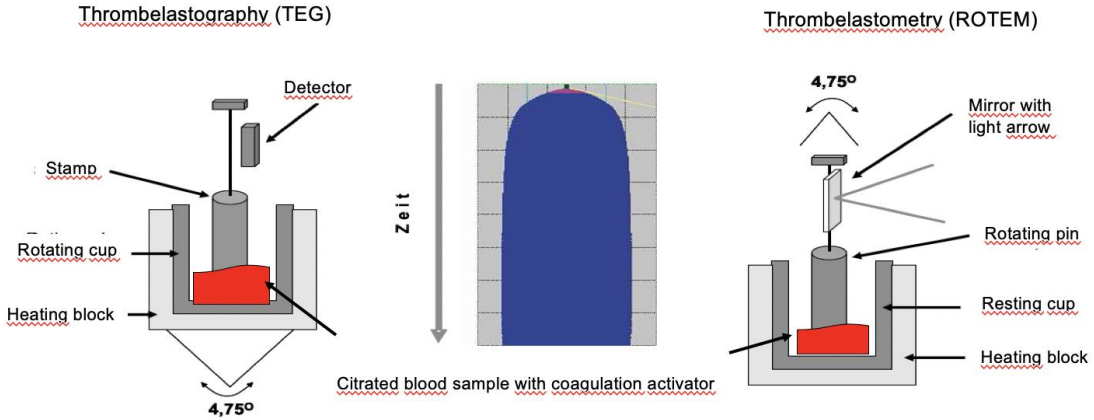
SCANDINAVIAN JOURNAL OF trauma, resuscitation & emergency medicine

REVIEW Open Access

Early and individualized goal-directed therapy for trauma-induced coagulopathy

Herbert Schöchl[1,2*], Marc Maegele[3], Cristina Solomon[1], Klaus Görlinger[4] and Wolfgang Voelckel[2]

Viscoelastic (functional) tests to assess coagulation function



Ex vivo-initiation of the clotting process via adding a coagulation activator (e.g. tissue factor)

Clotting within the cup increases resistance against the rotating cup (TEG)/ the rotating pin (ROTEM)

Translation of the resistance into a signal and visualization as a trace on the screen

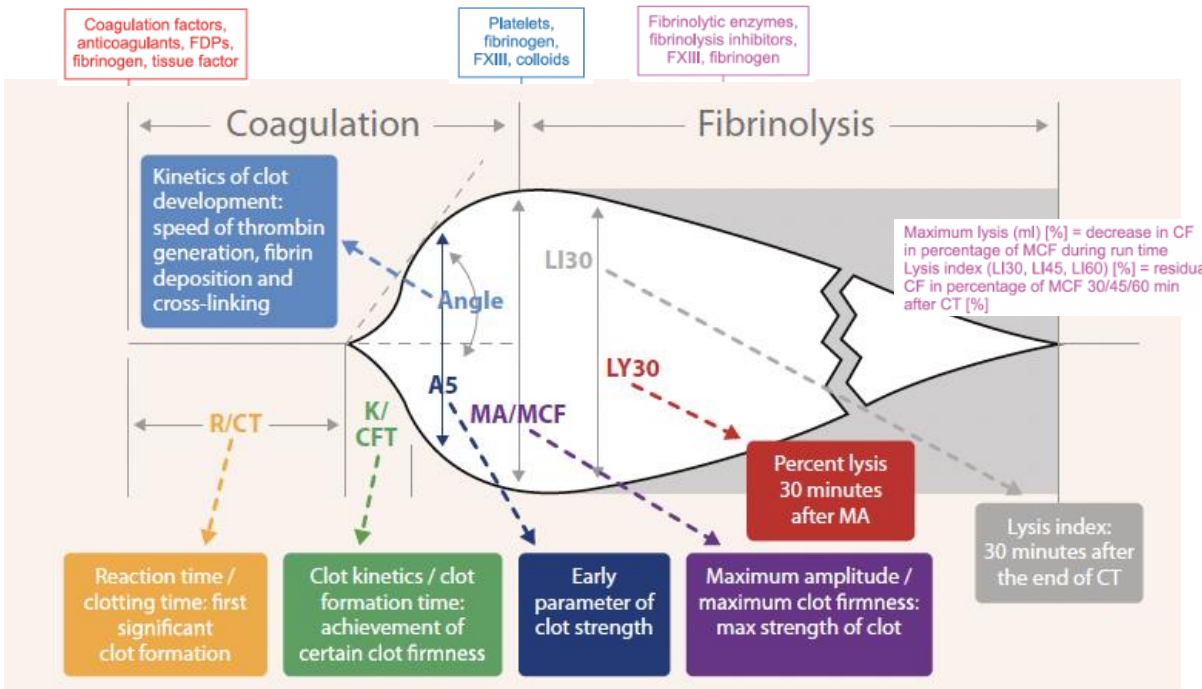
Rapid results > „Point-of-Care“ (POC)

Information on

- Clot initiation („clotting time“)
- Dynamics of clotting
- Quality of clotting (stability/firmness)

Table I. Most commonly used parameters derived from viscoelastic tracing and their signification.

Measurement	TEG® nomenclature	ROTEM® nomenclature	Signification
Time to an amplitude of 2 mm	Reaction time or R time	Clotting time (CT)	Informs about thrombin generation. Prolongation is associated with clotting factor deficiency, inhibitors or anticoagulant.
Time from 2 mm to 20 mm	K time	Clot Formation Time (CFT)	Depicts how fast a visible clot is formed. Depends on thrombin, thrombin generation, fibrinogen and platelets.
Angle formed by a tangential line to the curve starting from the split point.	α-Angle	α-Angle	Closely related to the K time but more precise because it can be determined even when the split does not reach 20 mm of amplitude
Greater width of the tracing	Maximal Amplitude (MA)	Maximal Clot Firmness (MCF)	Mainly affected by platelets and the fibrinogen level.
Per cent reduction of area under the curve (TEG®) or per cent of MCF (ROTEM®) 30 and 60 min after CT.	CLI30 and CL60	LY30 and LY60	Useful in the diagnosis of hyperfibrinolytic states.



Best practice: Local implementation of a trauma algorithm

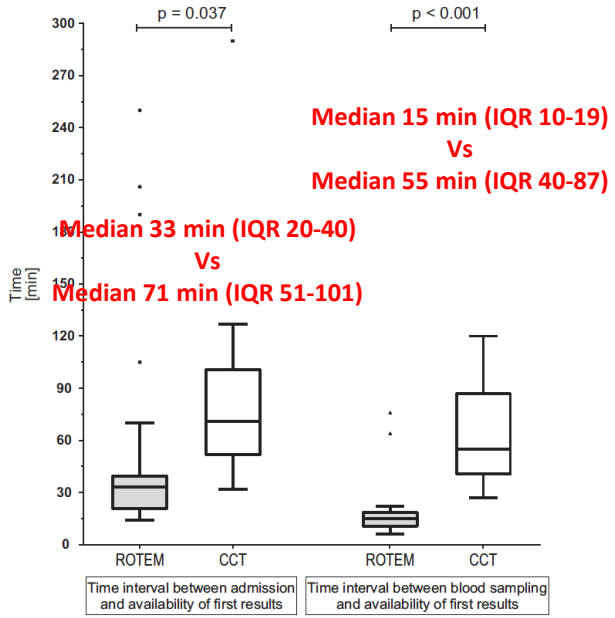
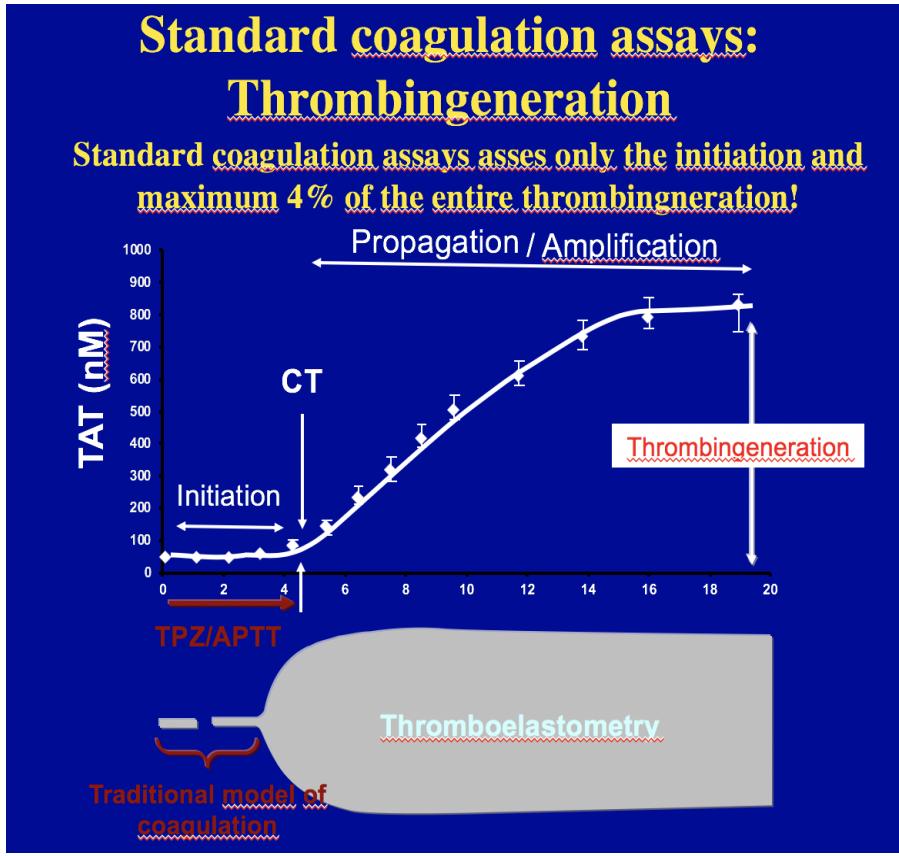


Figure 2 Comparison of time from admission and from blood sampling to availability of rotational thromboelastometry results (n = 32) and conventional coagulation test results (CCT) (n = 21). Tukey box plots with whiskers of length 1.5 × IQR and outliers are shown.

Protocolised thromboelastometric-guided haemostatic management in patients with traumatic brain injury: a pilot study.

Gratz J, Güting H, Thorn S, Brazinova A, Görlinger K, Schäfer N, Schöchl H, Stanworth S, Maegele M.

Anaesthesia. 2019 Jul;74(7):883-890. doi: 10.1111/anae.14670. Epub 2019 Apr 29.



Crit Care Med. 2011 Dec;39(12):2652-8. doi: 10.1097/CCM.0b013e3182281af5.

Functional definition and characterization of acute traumatic coagulopathy.

Davenport R, Manson J, De'Ath H, Platton S, Coates A, Allard S, Hart D, Pearse R, Pasi KJ, MacCallum P, Stanworth S, Brohi K.

Trauma Sciences, Blizard Institute of Cell and Molecular Science, Bart's and the London School of Medicine and Dentistry, Queen Mary University of London, UK.

compared to central laboratory monitoring. Test results were obtained in less than 5 minutes when performed using the POC device versus a median turnaround time of 88 minutes (range: 29-235 minutes) when blood collection tubes were sent to the central laboratory.

Thromb Haemost. 2009 Feb;101(2):394-401.

Point-of-care versus central laboratory coagulation testing during haemorrhagic surgery. A multicenter study.

Toulon P[1], Ozier Y, Ankri A, Fléron MH, Leroux G, Samama CM.

MAIN RESULTS: Three hundred patients were included in the study. Laboratory prothrombin time results were available at a median of 78 (62-103) mins. Point-of-care prothrombin time ratio had reduced agreement with laboratory prothrombin time ratio in patients with acute traumatic

KJA
Korean Journal of Anesthesiology

Review Article
pISSN 2005-6419 • eISSN 2005-7563

The role of evidence-based algorithms for rotational thromboelastometry-guided bleeding management

Klaus Görlinger[1,2], Antonio Pérez-Ferrer[3], Daniel Dirkmann[1], Fuat Saner[4], Marc Maegele[5,6], Ángel Augusto Pérez Calatayud[7], and Tae-Yop Kim[8]

[1]Department of Anesthesiology and Intensive Care Medicine, University Hospital Essen, University Duisburg-Essen, Essen, [2]Tem Innovations, Munich, Germany, [3]Department of Anesthesiology, Infanta Sofia University Hospital, San Sebastián de los Reyes, Madrid, Spain, [4]Department of General, Visceral and Transplant Surgery, University Hospital Essen, University Duisburg-Essen, Essen, Germany, [5]Department for Trauma and Orthopedic Surgery, Cologne-Merheim Medical Center (CMMC), Cologne, Germany, [6]Institute for Research in Operative Medicine (IFOM), University Witten/Herdecke (UW/H), Campus Cologne-Merheim, Cologne, Germany, [7]Terapia Intensiva Adultos, Hospital de Especialidades del Niño y la Mujer, Coordinador Grupo Mexicano para el Estudio de la Medicina Intensiva, Colegio Mexicano de Especialistas en Obstetrica Critica (COMEOC), Queretarco, Mexico, [8]Department of Anesthesiology, Konkuk University Medical Center, Konkuk University School of Medicine, Seoul, Korea

Korean J Anesthesiol 2019 August 72(4): 297-322

Table 2. FIBTEM-guided Fibrinogen Substitution

Targeted increase in FIBTEM A5 (A10) (mm)	Fibrinogen dose (mg/kg bw)	Fibrinogen concentrate (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)

Therapeutic focus

Severe trauma

Trauma A5 algorithm
Diffuse bleeding and blood transfusion considered [1,7]

Check

Upon emergency room admission:
BE < −6 mmol/L or
Hb < 10 g/dL or
ISS ≥ 25 or
TASH-score ≥ 15

Yes

No

Yes

Lysis

$A5_{EX}$ < 35 mm or
CT_{FIB} > 600 s or
ML ≥ 5% (within 60 min)

Yes

Tranexamic acid[2]
(15−) 25 mg/kg as a single bolus
(if not already given prophylactically)

Done

No

Stability

$A5_{EX}$ < 35 mm
and
$A5_{FIB}$ < 9 mm

Yes

Fibrinogen concentrate or
cryoprecipitate (dose calculation)[3]
Target: $A5_{FIB}$ ≥ 12 mm

No

$A5_{EX}$ < 35 mm and
$A5_{FIB}$ ≥ 9 mm
or platelet dysfunction
(TRAPTEM < 50 and/or
ADPTEM < 40 Ω·min)

Yes

Platelet concentrate[4]
5−10 ml/kg bw
(1−2 pooled or apheresis/80 kg)

No

Initiation

CT_{EX} > 80 s
and
$A5_{FIB}$ ≥ 9 mm

Yes

4F-PCC 15−25 IU/kg bw[5]
or FFP 10−15 ml/kg bw

No

CT_{IN} > 240 s

Yes

CT_{IN}/CT_{HEP} ≥ 1.25

No

Consider FFP
10 ml/kg bw

Yes

Consider protamine[6]
(0.3)−0.5 mg/kg bw
(25−50 mg/80 kg; 2.5−5 ml/80 kg) in severe bleeding

No

Ongoing bleeding

Yes

Re-check after 10−15 min
using a new blood sample

Tranexamic acid (TXA): Refining ist use!

"There are no magic bullets when it comes to drugs for stopping bleeding."

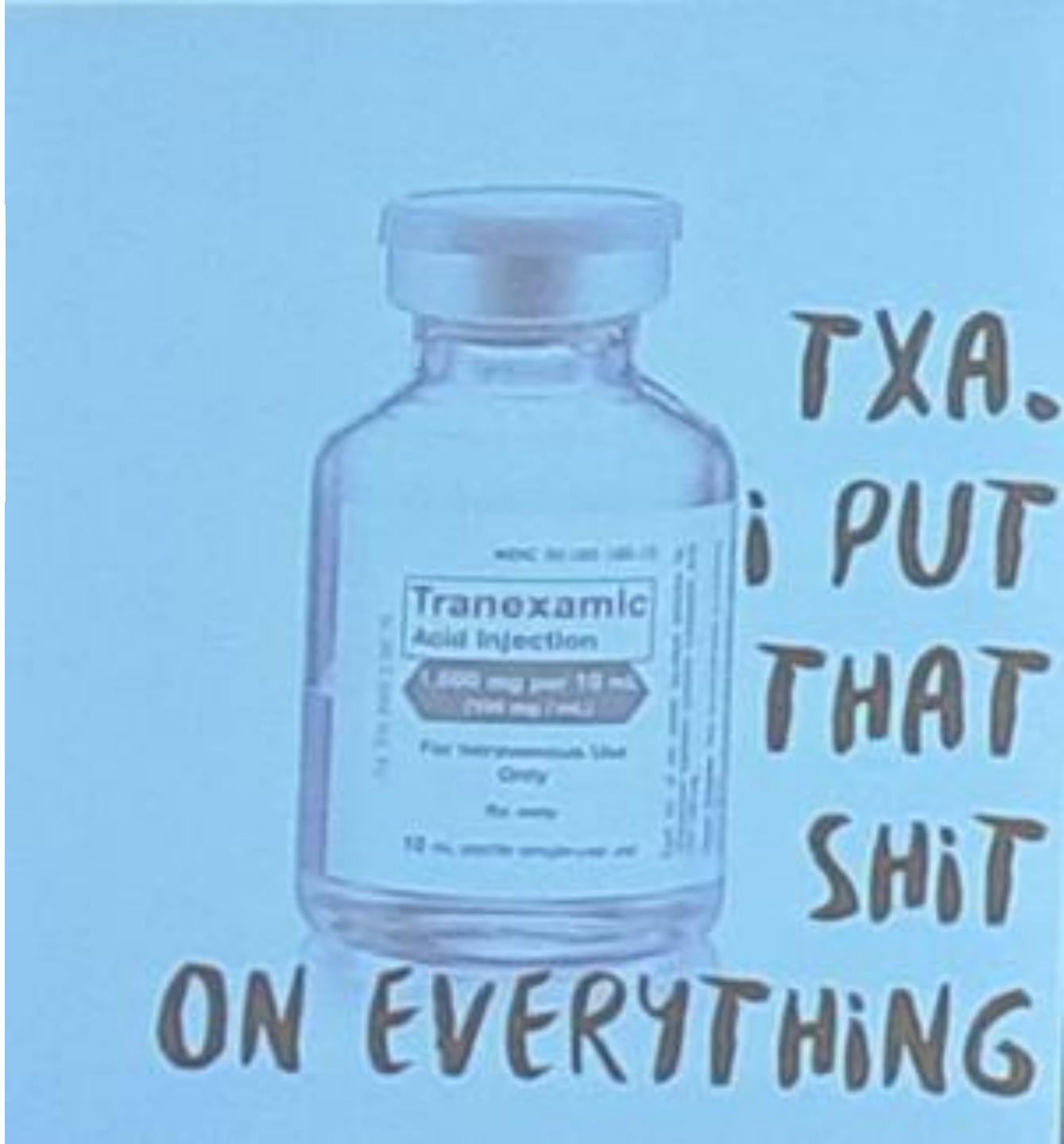
M. Schreiber 2010

Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): a randomised, placebo-controlled trial

*CRASH-2 trial collaborators**

Effects of tranexamic acid on death, disability, vascular occlusive events and other morbidities in patients with acute traumatic brain injury (CRASH-3): a randomised, placebo-controlled trial

*The CRASH-3 trial collaborators**



Tranexamic acid as prehospital intervention in patients with hemorrhagic shock

JAMA Surg. doi:10.1001/jamasurg.2020.4350
Published online October 5, 2020.

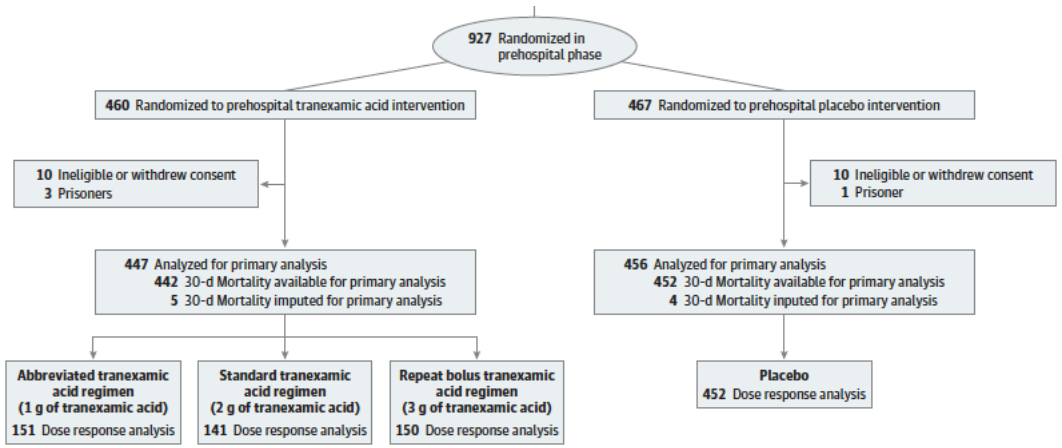
JAMA Surgery | Original Investigation

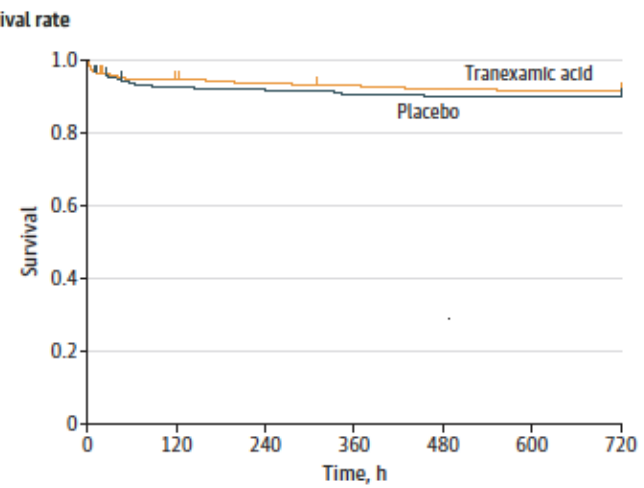
Tranexamic Acid During Prehospital Transport in Patients at Risk for Hemorrhage After Injury

A Double-blind, Placebo-Controlled, Randomized Clinical Trial

Francis X. Guyette, MD, MPH; Joshua B. Brown, MD, MSc; Mazen S. Zenati, MD, PhD; Barbara J. Early-Young, BSN; Peter W. Ad
Brian J. Eastridge, MD; Raminder Nirula, MD, MPH; Gary A. Vercruysse, MD; Terence O'Keeffe, MD; Bellal Joseph, MD; Louis H
Clifton W. Callaway, MD, PhD; Brian S. Zuckerbraun, MD; Matthew D. Neal, MD; Raquel M. Forsythe, MD; Matthew R. Rosenga
Timothy R. Billiar, MD; Donald M. Yealy, MD; Andrew B. Peitzman, MD; Jason L. Sperry, MD, MPH; and the STAAMP Study Gro

DESIGN, SETTING, AND PARTICIPANTS This pragmatic, phase 3, multicenter, double-blind, placebo-controlled, superiority randomized clinical trial included injured patients with prehospital hypotension (systolic blood pressure ≤90 mm Hg) or tachycardia (heart rate ≥110/min) before arrival at 1 of 4 US level 1 trauma centers, within an estimated 2 hours of injury, from May 1, 2015, through October 31, 2019.

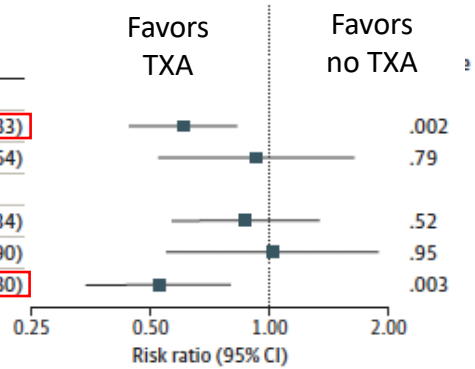




At 30 days after randomization, 36 deaths (8%) had occurred in the tranexamic acid intervention arm and 45 deaths (10%) in the placebo arm. After multiple imputation for the 9 patients missing the primary outcome (5 in the tranexamic acid arm and 4 in the placebo arm), patients who received tranexamic acid compared with placebo did not differ in 30-day mortality (8.1% vs 9.9%; difference, −1.8; 95% CI, −5.6% to 1.9%; P = .17). Sensitivity analysis assuming all patients with miss-

B Mortality risk by time from injury and shock severity

Subgroup	No./total No. (%) of patients: Placebo	Tranexamic acid	Risk ratio (95% CI)	
Time from injury, h				
≤1	18/238 (7.6)	10/219 (4.6)	0.60 (0.44-0.83)	.002
>1	27/214 (12.6)	26/223 (11.7)	0.92 (0.52-1.64)	.79
Shock severity				
Tachycardia only	21/320 (6.6)	18/316 (5.7)	0.87 (0.56-1.34)	.52
SBP <90 mm Hg	13/101 (12.9)	13/99 (13.1)	1.02 (0.55-1.90)	.95
SBP <70 mm Hg	11/31 (35.5)	5/27 (18.5)	0.52 (0.34-0.80)	.003



universität Witten/Herdecke

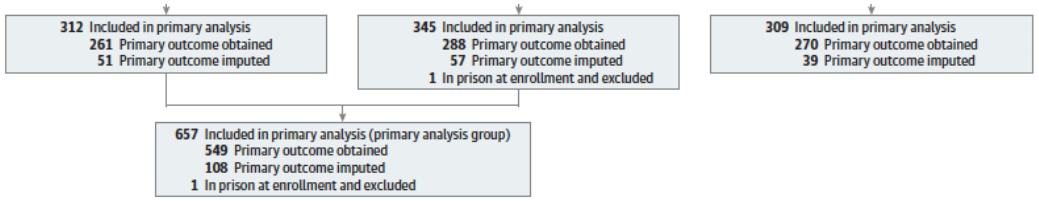
Optimization of prehospital TXA: Higher dosing (2g Bolus) and within 90 min of trauma/bleeding onset?

JAMA | Original Investigation

Effect of Out-of-Hospital Tranexamic Acid vs Placebo on 6-Month Functional Neurologic Outcomes in Patients With Moderate or Severe Traumatic Brain Injury

JAMA. 2020;324(10):961-974. doi:10.1001/jama.2020.8958

Susan E. Rowell, MD, MBA; Eric N. Meier, MS; Barbara McKnight, PhD; Delores Kannas, RN, MS, MHA; Susanne May, PhD; Kellie Sheehan, RN; Eileen M. Bulger, MD; Ahamed H. Idris, MD; Jim Christenson, MD; Laurie J. Morrison, MD; Ralph J. Frascone, MD; Patrick L. Bosarge, MD; M. Riccardo Colella, DO, MPH; Jay Johannigman, MD; Bryan A. Cotton, MD; Jeannie Callum, MD; Jason McMullan, MD; David J. Dries, MD; Brian Tibbs, MD; Neal J. Richmond, MD; Myron L. Weisfeldt, MD; John M. Tallon, MD, MSc; John S. Garrett, MD; Martin D. Zielinski, MD; Tom P. Aufderheide, MD; Rajesh R. Gandhi, MD, PhD; Rob Schlamp; Bryce R. H. Robinson, MD; Jonathan Jui, MD, MPH; Lauren Klein, MD, MS; Sandro Rizoli, MD; Mark Gamber, DO; Michael Fleming, BA; Jun Hwang, MS; Laura E. Vincent, RN; Carolyn Williams, RN; Audrey Hendrickson, MPH; Robert Simonson, DO; Patricia Klotz, RN; George Sopko, MD; William Witham, MD; Michael Ferrara, MS; Martin A. Schreiber, MD



Outcome	Treatment group, No. (%)[a] Combined tranexamic acid group (n = 657)	Placebo (n = 309)	Adjusted difference (95% CI)[b,c] Combined tranexamic acid group vs placebo	*P* value
Primary outcome				
6-mo Glasgow Outcome Scale-Extended score >4[d]	425 (65)	192 (62)	3.5% (−0.9% to 10.2%)[c]	.16 (benefit); .84 (harm)

Secondary outcomes (exploratory)

Outcome	Treatment group, No. (%)[a] Bolus maintenance	Bolus only	Placebo	Adjusted difference (95% CI)[b] Bolus maintenance vs placebo	Bolus only vs placebo	Bolus only vs bolus maintenance
Secondary outcomes (exploratory)	**(n = 312)**	**(n = 345)**	**(n = 309)**			
6-mo Glasgow Outcome Scale-Extended score >4[c]	198 (63)	226 (66)	192 (62)	2.0 (−5.8 to 9.8)	4.8 (−2.9 to 12.5)	2.8 (−4.6 to 10.2)
28-d mortality[c]	53 (17)	41 (12)	53 (17)	−0.09 (−6.1 to 5.9)	−5.4 (−10.9 to 0.05)	−5.3 (−10.8 to 0.1)
6-mo Disability Rating Scale score, median (IQR)[c]	2 (0 to 7)	1 (0 to 5)	1 (0 to 8)	−0.2 (−2.1 to 1.7)	−1.5 (−3.3 to 0.3)	−1.4 (−3.1 to 0.4)
Progression of intracranial hemorrhage[d,e]	26 (17) (n = 154)	27 (15) (n = 178)	30 (20) (n = 148)	−4.2 (−13.0 to 4.6)	−6.3 (−14.4 to 1.7)	−2.2 (−9.9 to 5.6)
Intracranial hemorrhage on initial computed tomographic imaging[f]	(n = 177)	(n = 197)	(n = 171)			
6-mo Glasgow Outcome Scale-Extended score >4[e]	83 (47)	108 (55)	86 (50)	−3.9 (−13.0 to 5.2)	4.8 (−4.4 to 14.0)	8.7 (−0.3 to 17.8)
28-d mortality[e]	45 (26)	35 (18)	47 (27)	0.8 (−7.0 to 8.7)	−8.2 (−15.6 to −0.8)	−9.0 (−16.1 to −1.8)
6-mo Disability Rating Scale score, median (IQR)[e]	2 (0 to 30)	2 (0 to 11)	4 (0 to 30)	−0.06 (−2.3 to 2.1)	−2.2 (−4.3 to −0.1)	−2.2 (−4.2 to −0.08)

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

DOI: 10.1056/NEJMoa2215457

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Prehospital Tranexamic Acid for Severe Trauma

The PATCH-Trauma Investigators and the ANZICS Clinical Trials Group*

Tranexamic Acid Timing and Mortality Impact After Trauma

Adnan Ali, MBBS, PhD; Russell L. Gruen, MBBS, PhD*; Stephen A. Bernard, MBBS, MD; Brian Burns, MB BCh, MRCS; Andrew B. Forbes, PhD; Dashiell C. Gantner, MBBS, PhD; Colin J. McArthur, MBChB; Marc Maegele, MD; Biswadev Mitra, MBBS, PhD; on behalf of the PATCH trial investigators

Figure 3: Effect of time from injury to first dose of TXA or placebo on death within 28 days.

Estimated treatment effect (solid black line) with 95% CI (dashed lines) is shown for death within 28 days. A risk ratio below 1 (solid grey line) favours tranexamic acid over placebo.

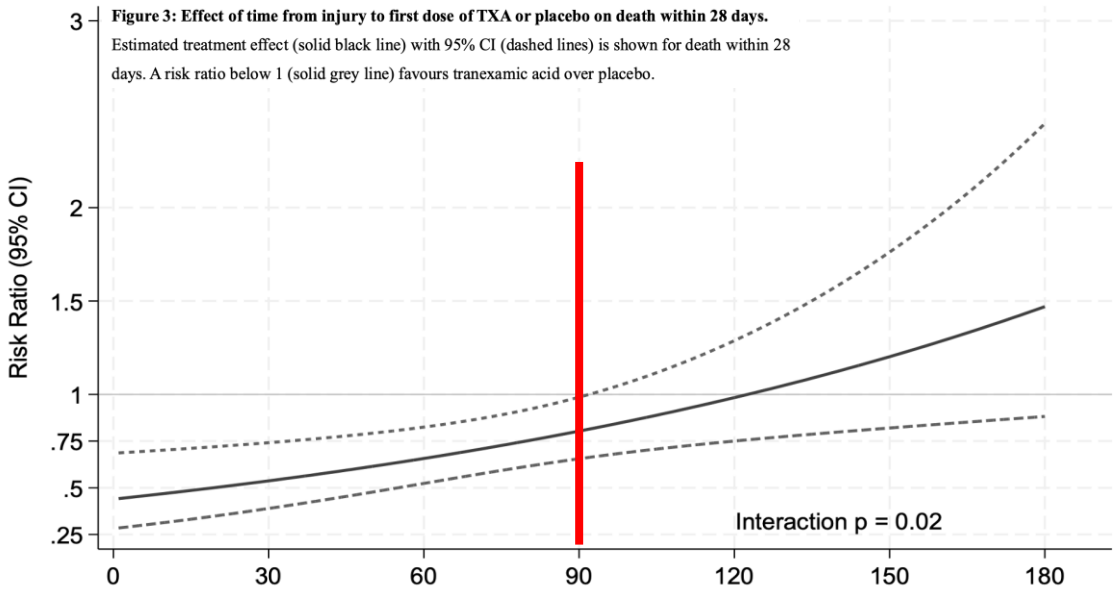
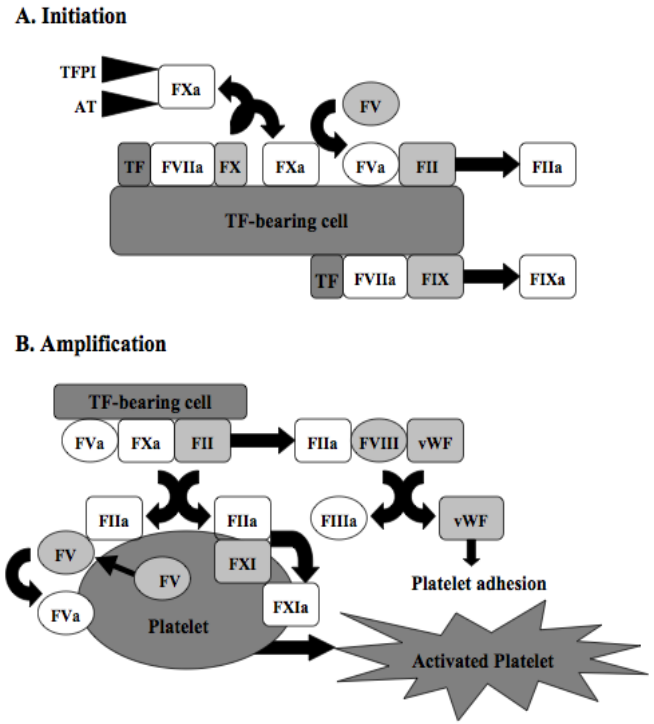


Table 2: Outcomes in subgroups by time to first dose of tranexamic acid or placebo

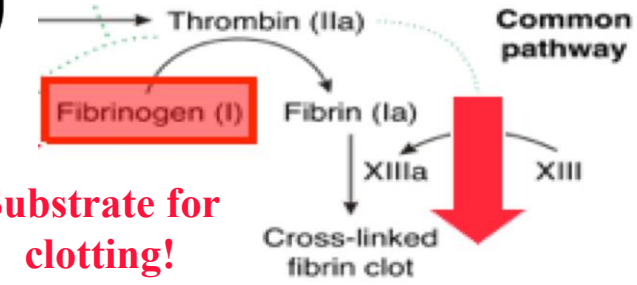
	TXA	Placebo	Unadjusted	Adjusted*
	No. of events/No. of total patients (%)		RR (95% CI)	RR (95% CI)
Death within 28 days				
<90 minutes	67/393 (17%)	91/363 (25%)	0.68 (0.51 – 0.90)	0.64 (0.50 – 0.82)
≥90 minutes	46/259 (18%)	47/272 (17%)	1.03 (0.71 – 1.49)	1.04 (0.74 – 1.47)
Overall	113/652 (17%)	138/635 (22%)	0.80 (0.64 – 1.00)	0.78 (0.64 - 0.95)

Ann Emerg Med. 2025 Aug 1:S0196-0644(25)00989-8. doi: 10.1016/j.annemergmed.2025.06.609.

Fibrinogen



Maegele, Textbook of Surgery 2017



Substrate for clotting!

Am J Clin Pathol. 2011 Sep;136(3):364-70. doi: 10.1309/AJCPH16YXJEFSHEO.

Frequency and characteristics of coagulopathy in trauma patients treated with a low- or high-plasma-content massive transfusion protocol.

Chambers LA[1], Chow SJ, Shaffer LE.

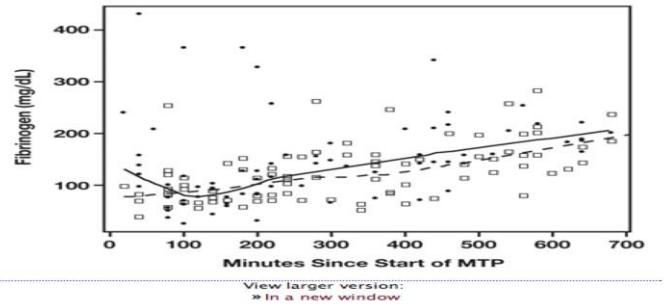
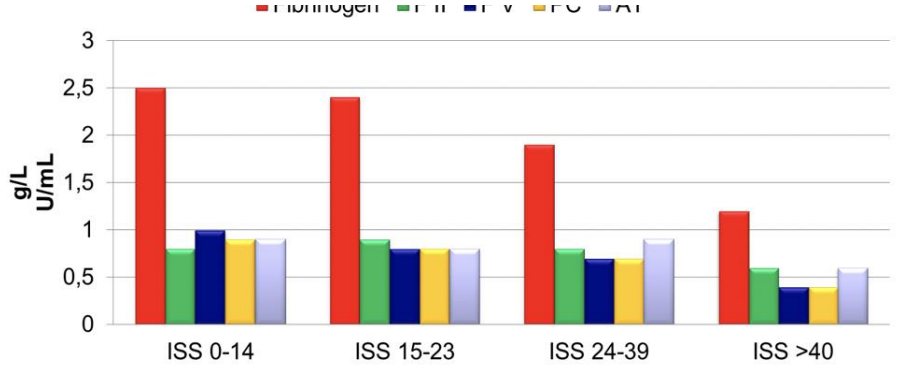


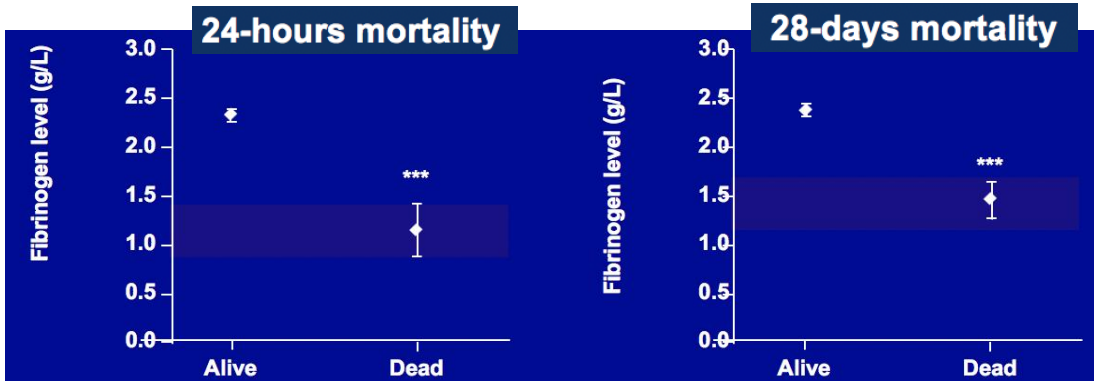
Figure 2

Fibrinogen levels (mg/dL) over time for the 25 patients treated under the original protocol (dots and solid line) and 27 patients treated under the new protocol (boxes and dashed line) who survived at least 12 hours. To convert fibrinogen values to Système International units (μmol/L), multiply by 0.0294. MTP, massive transfusion protocol.



Floccard et al., Injury 2012

Rourke et al., J Thromb Haemost 2012



Fibrinogen

Effect on clot stability

J Thromb Haemost. 2019 Jan 4. doi: 10.1111/jth.14378. [Epub ahead of print]

Towards patient-specific management of trauma hemorrhage: the effect of resuscitation therapy on parameters of thromboelastometry.

Juffermans NP[1], Wirtz MR[1], Balvers K[1,2], Baksaas-Aasen K[3,4], van Dieren S[1], Gaarder C[3], Naess PA[3], Stanworth S[5], Johansson PI[6], Stensballe J[6], Maegele M[7], Goslings JC[2], Brohi K[8]; TACTIC partners[1].

Author information

Abstract

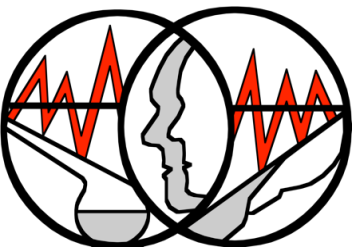
BACKGROUND: Rotational Thromboelastometry (ROTEM®) can detect trauma-induced coagulopathy (TIC) and is used in transfusion algorithms. The response of ROTEM® to transfusion therapy is unknown.

OBJECTIVES: To determine the response of ROTEM profiles to therapy in bleeding trauma patients.

PATIENTS/METHODS: Prospective multicentre study in bleeding trauma patients (receiving ≥ 4 red blood cell units). Blood was drawn on the emergency department, after administration of 4, 8 and 12 RBCs and 24 hours post injury. The response of ROTEM to plasma, platelets (PLTs), tranexamic acid (TXA) and fibrinogen products was evaluated in the whole cohort as well as in the subgroup of patients with ROTEM values indicative of TIC.

RESULTS: 309 bleeding and shocked patients were included. A mean dose of 3.8 grams of fibrinogen increased FIBTEMCA5 with 5.2 mm (4.1-6.3). TXA administration decreased lysis by 5.4%(4.3-6.5). PLT transfusion prevented further derangement of parameters of clot formation. The effect of PLTs on EXTEMCA5 values was more pronounced in patients with a ROTEM value indicative of TIC compared to the whole cohort. Plasma transfusion decreased EXTEM CT with 3.1 sec (-10-3.9) in the whole cohort and with 10.6 sec (-45-24) in the subgroup of patients with a ROTEM value indicative of TIC.

CONCLUSION: Effects of therapy on ROTEM values were small, but prevented further derangement of test results. In patients with ROTEM values corresponding to TIC, efficacy of PLT and plasma to correct deranged ROTEM parameters is possibly more robust. This article is protected by copyright. All rights reserved.



versität
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Synergistic effect of TXA and fibrinogen

ONLINE FIRST

Association of Cryoprecipitate and Tranexamic Acid With Improved Survival Following Wartime Injury

Findings From the MATTERs II Study

Arch Surg. Published online November 19, 2012
doi:10.1001/jamasurg.2013.764

Jonathan J. Morrison, MB, ChB, MRCS; James D. Ross, PhD; Joseph J. Dubose, MD; Jan O. Jansen, FRCS, FFICM; Mark J. Midwinter, BMedSci, MD, FRCS; Todd E. Rasmussen, MD

Objective: To quantify the impact of fibrinogen-containing cryoprecipitate in addition to the antifibrinolytic tranexamic acid on survival in combat injured.

Design: Retrospective observational study comparing the mortality of 4 groups: tranexamic acid only, cryoprecipitate only, tranexamic acid and cryoprecipitate, and neither tranexamic acid nor cryoprecipitate.

Main Outcome Measure: In-hospital mortality.

Patients: A total of 1332 patients were identified from prospectively collected UK and US trauma registries who required 1 U or more of packed red blood cells and composed the following groups: tranexamic acid (n=148), cryoprecipitate (n=168), tranexamic acid/cryoprecipitate (n=258), and no tranexamic acid/cryoprecipitate (n=758).

Conclusions: Cryoprecipitate may independently add to the survival benefit of tranexamic acid in the seriously injured requiring transfusion. Additional study is necessary to define the role of fibrinogen in resuscitation from hemorrhagic shock.

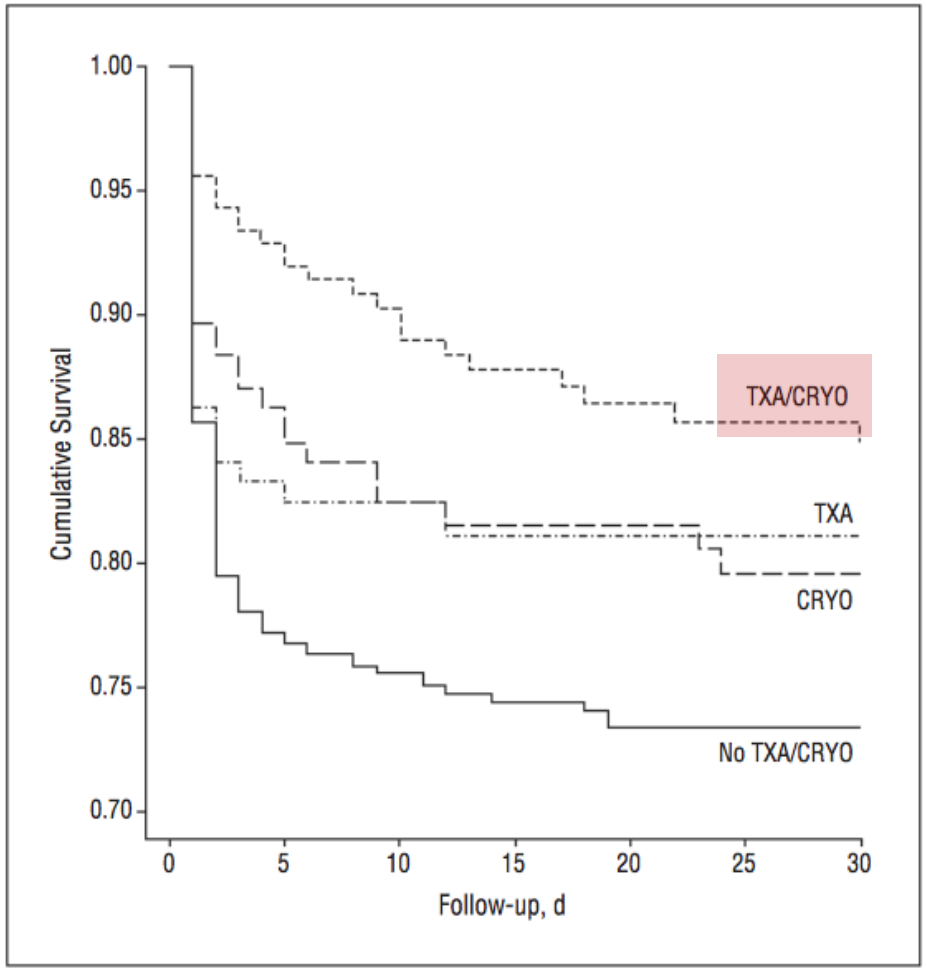
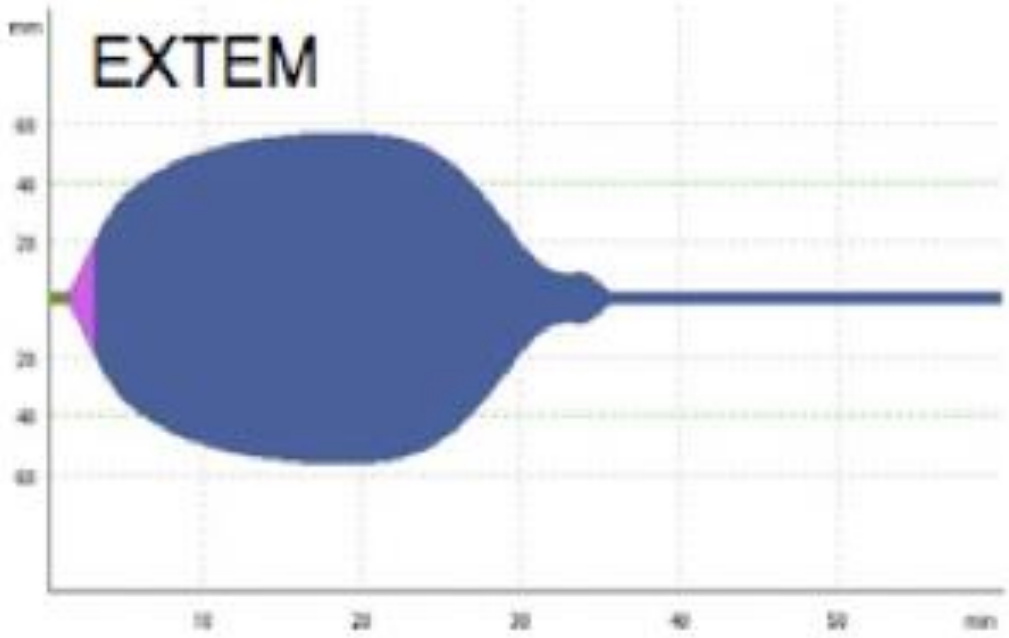


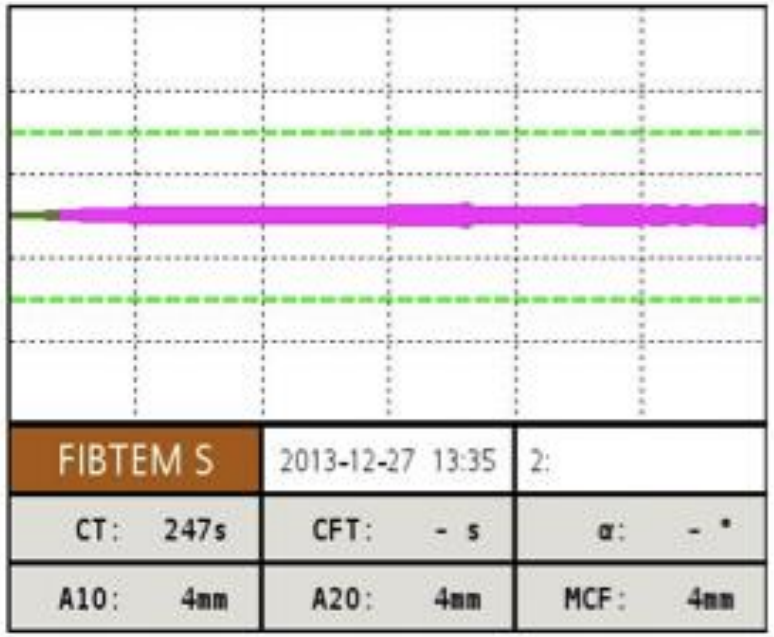
Figure. Survival plot of patients who received tranexamic acid and cryoprecipitate (TXA/CRYO), tranexamic acid alone (TXA), cryoprecipitate alone (CRYO), or neither product (no TXA/CRYO) as part of a component-based hemostatic resuscitation following combat injury.

Synergistic effect of TXA and fibrinogen

Block lysis first…



….then add substrate!



Clinical use of TEG/ROTEM: Meta-analysis

2020 EAST Podium Paper

Thromboelastography and rotational thromboelastometry in bleeding patients with coagulopathy: Practice management guideline from the Eastern Association for the Surgery of Trauma

Nikolay Bugaev, MD, John J. Como, MD, MPH, Guy Golani, MD, Jennifer J. Freeman, MD, Jaswin S. Sawhney, MD, Cory J. Vatsaas, MD, Brian K. Yorkgitis, DO, Laura A. Kreiner, MD, Nicole M. Garcia, MD, Hiba Abdel Aziz, MD, FACS, Peter A. Pappas, MD, Eric J. Mahoney, MD, Zachary W. Brown, DO, *and* **George Kasotakis, MD, MPH**, *Boston, Massachusetts*

METHODS: Systematic review and meta-analyses of manuscripts comparing TEG/ROTEM with non–TEG/ROTEM-guided blood products transfusions strategies were performed. The Grading of Recommendations Assessment, Development and Evaluation methodology was applied to assess the level of evidence and create recommendations for TEG/ROTEM-guided blood product transfusions in adult trauma, surgical, and critically ill patients.

J Trauma Acute Care Surg. 2020 Dec;89(6):999-1017.

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Clinical use of TEG/ROTEM: Meta-analysis

1. PICO 1
   In adult trauma patients with ongoing hemorrhage and concern for coagulopathy (P), should a TEG/ROTEM-guided transfusion strategy (I) versus a non-TEG/ROTEM transfusion strategy (C) be used to reduce mortality, blood product transfusions, and the need for additional hemostatic (angioembolic, endoscopic, or surgical) interventions (O)?
2. PICO 2
   In adult surgical patients with ongoing hemorrhage and concern for coagulopathy (P), should a TEG/ROTEM-guided transfusion strategy (I) versus a non-TEG/ROTEM transfusion strategy (C) be used to reduce mortality, blood product transfusions, and the need for additional hemostatic (angioembolic, endoscopic, or surgical) interventions (O)?
3. PICO 3
   In adult critically ill patients with ongoing hemorrhage and concern for coagulopathy (P), should a TEG/ROTEM-guided transfusion strategy (I) versus a non-TEG/ROTEM transfusion strategy (C) be used to reduce mortality, blood product transfusions, and the need for additional hemostatic (angioembolic, endoscopic, or surgical) interventions (O)?

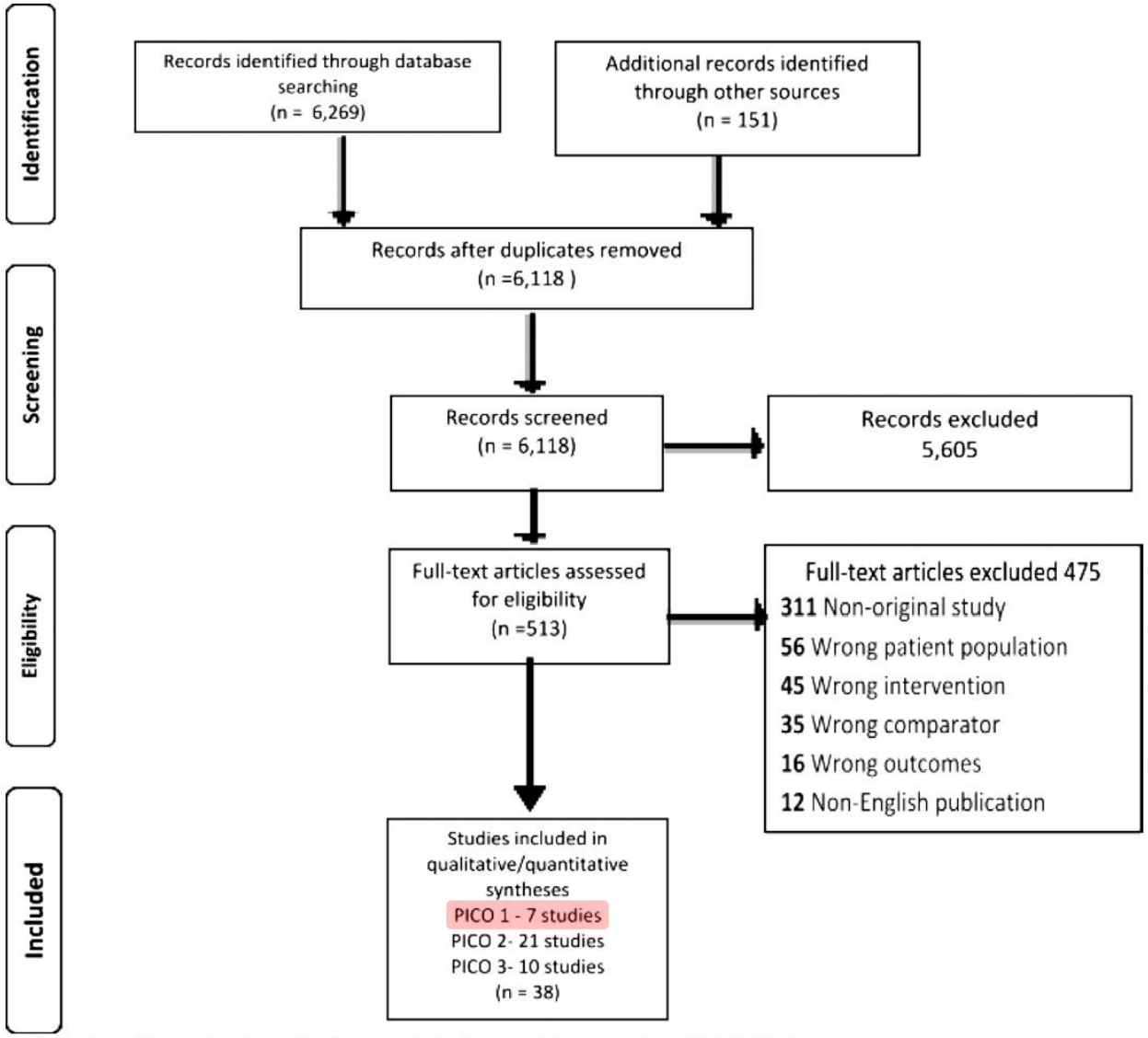

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) chart.

J Trauma Acute Care Surg. 2020 Dec;89(6):999-1017.

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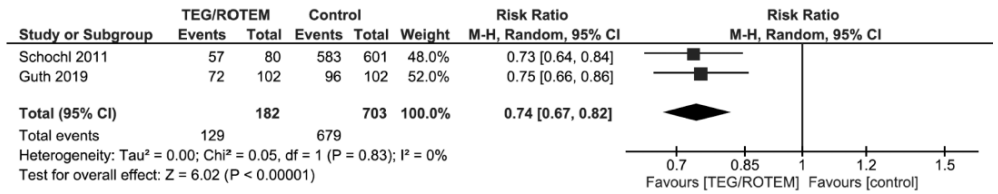
„Goal-directed therapy“: Evidence

A Number of patients transfused with PRBC

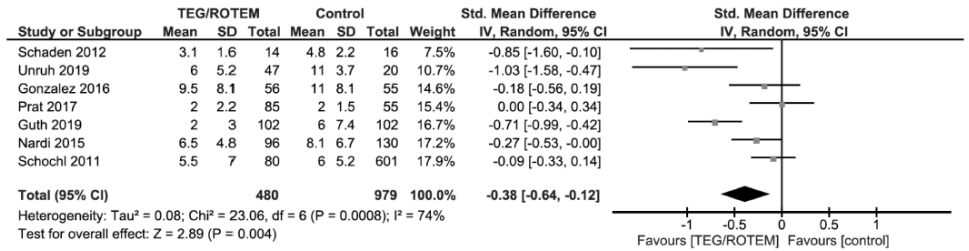


Study or Subgroup	TEG/ROTEM Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Schochl 2011	57	80	583	601	48.0%	0.73 [0.64, 0.84]
Guth 2019	72	102	96	102	52.0%	0.75 [0.66, 0.86]
Total (95% CI)		**182**		**703**	**100.0%**	**0.74 [0.67, 0.82]**
Total events	129		679			

Heterogeneity: Tau² = 0.00; Chi² = 0.05, df = 1 (P = 0.83); I² = 0%
Test for overall effect: Z = 6.02 (P < 0.00001)

Risk Ratio M-H, Random, 95% CI
0.7 0.85 1 1.2 1.5
Favours [TEG/ROTEM] Favours [control]

B Number of transfused PRBC units/patient

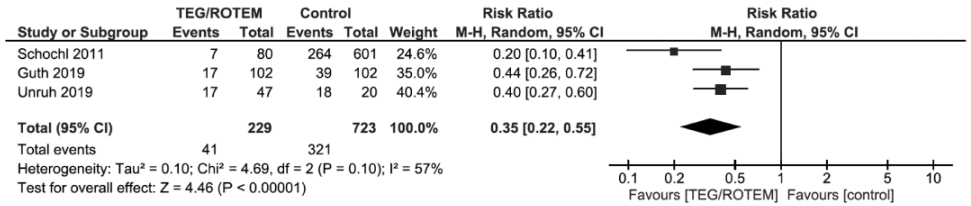


Study or Subgroup	TEG/ROTEM Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Schaden 2012	3.1	1.6	14	4.8	2.2	16	7.5%	-0.85 [-1.60, -0.10]
Unruh 2019	6	5.2	47	11	3.7	20	10.7%	-1.03 [-1.58, -0.47]
Gonzalez 2016	9.5	8.1	56	11	8.1	55	14.6%	-0.18 [-0.56, 0.19]
Prat 2017	2	2.2	85	2	1.5	55	15.4%	0.00 [-0.34, 0.34]
Guth 2019	2	3	102	6	7.4	102	16.7%	-0.71 [-0.99, -0.42]
Nardi 2015	6.5	4.8	96	8.1	6.7	130	17.2%	-0.27 [-0.53, -0.00]
Schochl 2011	5.5	7	80	6	5.2	601	17.9%	-0.09 [-0.33, 0.14]
Total (95% CI)			**480**			**979**	**100.0%**	**-0.38 [-0.64, -0.12]**

Heterogeneity: Tau² = 0.08; Chi² = 23.06, df = 6 (P = 0.0008); I² = 74%
Test for overall effect: Z = 2.89 (P = 0.004)

Std. Mean Difference IV, Random, 95% CI
-1 -0.5 0 0.5 1
Favours [TEG/ROTEM] Favours [control]

C Number of patients transfused with PLT

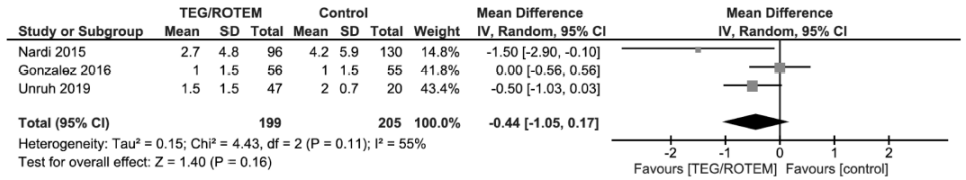


Study or Subgroup	TEG/ROTEM Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Schochl 2011	7	80	264	601	24.6%	0.20 [0.10, 0.41]
Guth 2019	17	102	39	102	35.0%	0.44 [0.26, 0.72]
Unruh 2019	17	47	18	20	40.4%	0.40 [0.27, 0.60]
Total (95% CI)		**229**		**723**	**100.0%**	**0.35 [0.22, 0.55]**
Total events	41		321			

Heterogeneity: Tau² = 0.10; Chi² = 4.69, df = 2 (P = 0.10); I² = 57%
Test for overall effect: Z = 4.46 (P < 0.00001)

Risk Ratio M-H, Random, 95% CI
0.1 0.2 0.5 1 2 5 10
Favours [TEG/ROTEM] Favours [control]

D Number of transfused PLTs units/patient

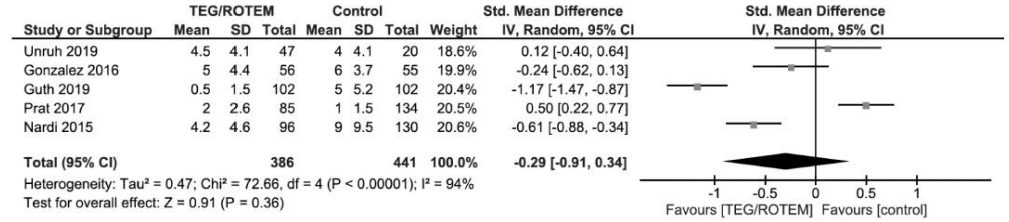


Study or Subgroup	TEG/ROTEM Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Nardi 2015	2.7	4.8	96	4.2	5.9	130	14.8%	-1.50 [-2.90, -0.10]
Gonzalez 2016	1	1.5	56	1	1.5	55	41.8%	0.00 [-0.56, 0.56]
Unruh 2019	1.5	1.5	47	2	0.7	20	43.4%	-0.50 [-1.03, 0.03]
Total (95% CI)			**199**			**205**	**100.0%**	**-0.44 [-1.05, 0.17]**

Heterogeneity: Tau² = 0.15; Chi² = 4.43, df = 2 (P = 0.11); I² = 55%
Test for overall effect: Z = 1.40 (P = 0.16)

Mean Difference IV, Random, 95% CI
-2 -1 0 1 2
Favours [TEG/ROTEM] Favours [control]

E Number of transfused FFP units/patient

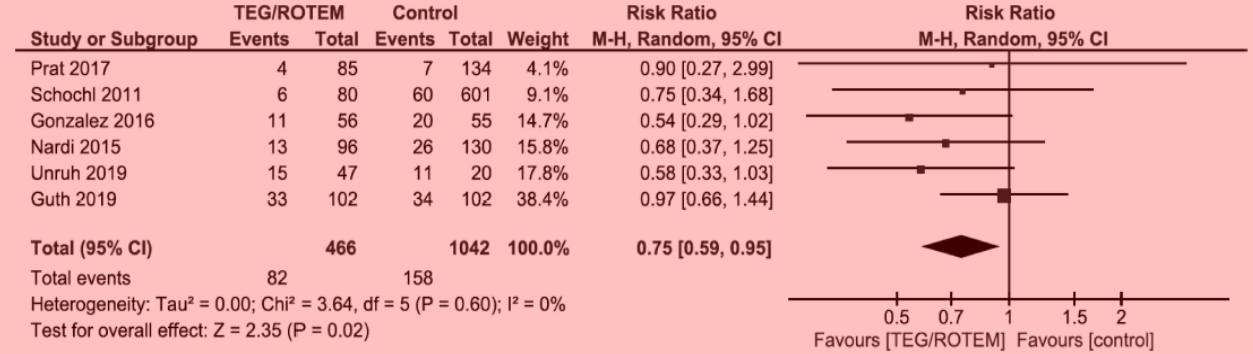


Study or Subgroup	TEG/ROTEM Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Unruh 2019	4.5	4.1	47	4	4.1	20	18.6%	0.12 [-0.40, 0.64]
Gonzalez 2016	5	4.4	56	6	3.7	55	19.9%	-0.24 [-0.62, 0.13]
Guth 2019	0.5	1.5	102	5	5.2	102	20.4%	-1.17 [-1.47, -0.87]
Prat 2017	2	2.6	85	1	1.5	134	20.5%	0.50 [0.22, 0.77]
Nardi 2015	4.2	4.6	96	9	9.5	130	20.6%	-0.61 [-0.88, -0.34]
Total (95% CI)			**386**			**441**	**100.0%**	**-0.29 [-0.91, 0.34]**

Heterogeneity: Tau² = 0.47; Chi² = 72.66, df = 4 (P < 0.00001); I² = 94%
Test for overall effect: Z = 0.91 (P = 0.36)

Std. Mean Difference IV, Random, 95% CI
-1 -0.5 0 0.5 1
Favours [TEG/ROTEM] Favours [control]

F Mortality



Study or Subgroup	TEG/ROTEM Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Prat 2017	4	85	7	134	4.1%	0.90 [0.27, 2.99]
Schochl 2011	6	80	60	601	9.1%	0.75 [0.34, 1.68]
Gonzalez 2016	11	56	20	55	14.7%	0.54 [0.29, 1.02]
Nardi 2015	13	96	26	130	15.8%	0.68 [0.37, 1.25]
Unruh 2019	15	47	11	20	17.8%	0.58 [0.33, 1.03]
Guth 2019	33	102	34	102	38.4%	0.97 [0.66, 1.44]
Total (95% CI)		**466**		**1042**	**100.0%**	**0.75 [0.59, 0.95]**
Total events	82		158			

Heterogeneity: Tau² = 0.00; Chi² = 3.64, df = 5 (P = 0.60); I² = 0%
Test for overall effect: Z = 2.35 (P = 0.02)

Risk Ratio M-H, Random, 95% CI
0.5 0.7 1 1.5 2
Favours [TEG/ROTEM] Favours [control]

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Clinical use of TEG/ROTEM: Meta-analysis > Conclusions and recommendations

TABLE 2A. Recommendations

PICOs	Recommendations
TEG/ROTEM-guided transfusion strategy in adult trauma patients with ongoing hemorrhage and concern for coagulopathy	We conditionally recommend using TEG/ROTEM-guided strategy vs. non–TEG/ROTEM-guided strategy in adult trauma patients with ongoing hemorrhage and concern for coagulopathy to reduce blood product transfusions.
TEG/ROTEM-guided transfusion strategy in adult surgical patients with ongoing hemorrhage and concern for coagulopathy	We conditionally recommend using a TEG/ROTEM-guided strategy vs. a non–TEG/ROTEM-guided strategy in adult surgical patients with ongoing hemorrhage and concern for coagulopathy, to reduce blood product transfusions.
TEG/ROTEM-guided transfusion strategy in adult critically ill patients with ongoing hemorrhage and concern for coagulopathy	We conditionally recommend using TEG/ROTEM-guided strategy vs. non–TEG/ROTEM-guided strategy in adult critically ill patients with ongoing hemorrhage and concern for coagulopathy to reduce blood product transfusions.

J Trauma Acute Care Surg. 2020 Dec;89(6):999-1017.

Recent meta-analysis

Effect of Viscoelastic Testing on Mortality in Bleeding Patients with Severe Trauma: A Meta-Analysis

Klaus Goerlinger[1,2], Marc Maegele[3], Heiko Lier[4], Donat R. Spahn[5]

[1] Department of Anesthesiology and Intensive Care Medicine, University Hospital Essen, University Duisburg-Essen, Essen, Germany
[2] Medical Department, TEM Innovations/Werfen PBM, Munich, Germany
[3] Department of Trauma and Orthopedic Surgery, Cologne-Merheim Medical Center (CMMC), University Witten/Herdecke, Cologne, Germany
[4] Department of Anesthesiology and Intensive Care Medicine, University of Cologne, University Hospital Cologne, Cologne, Germany
[5] Prof. Emeritus, University of Zurich, Zurich, Switzerland

BACKGROUND: It is still a matter of debate whether viscoelastic testing-guided bleeding management or a ratio-based transfusion approach is associated with lower mortality in bleeding patients with severe trauma.

METHODS: An Advanced PubMed Search with the search term ((ROTEM[Title/Abstract] OR TEG[Title/Abstract] OR thromboelastometry[Title/Abstract] OR thrombelastography[Title/Abstract] OR viscoelastic[Title/Abstract] OR FIBTEM[Title/Abstract]) AND (trauma[Title/Abstract] OR traumatic[Title/Abstract] OR Injury[Title/Abstract]) AND (mortality[Title/Abstract] OR survival[Title/Abstract])) provided 488 results on March 29, 2024. Twenty-four studies published between 2011 and 2024 reporting mortality in adult and pediatric bleeding trauma patients comparing viscoelastic testing-guided bleeding management with standard of care were included in this meta-analysis [1-24], and further five studies have been identified by other sources and included, too [25-29].

RESULTS: Overall, 29 studies with 11,006 participants and 2,096 events (overall mortality, 19.0%) have been included in this meta-analysis. This included three randomized controlled trials (N=600) and 26 cohort studies (N=10,406). Twenty-seven studies assessed the effect on civilian trauma (N=7467) and two studies on military trauma (N=3539). Twenty-six studies included adult (N=10,007) and three studies pediatric trauma patients (N=999). Seventeen studies used ROTEM (N=5,760), two studies used ROTEM or TEG (N=3,715), and 10 studies used TEG (N=1,531). None of the trauma studies reporting mortality used Quantra. The Risk Ratio for mortality (95% Confidence Interval) was 0.7890 (0.7014; 0.8877) with a P-value of 0.0003 in the random model (Figure). As markers of heterogeneity, Tau2 was 0.0201, Chi2 was 40.34, df was 28, I2 was 30.6% with a P-value of 0.06

CONCLUSIONS: Our meta-analysis demonstrates a significant reduction in mortality by viscoelastic testing (ROTEM/TEG)-guided bleeding management in bleeding patients with severe trauma.

REFERENCES: 1. Schöchl et al. Crit Care. 2011; 2. Tapia et al. J Trauma Acute Care Surg. 2013; 3. Yin et al. J Emerg Surg. 2014; 4. Gonzalez et al. Ann Surg. 2016; 5. Wang et al. J Clin Med Res. 2017; 6. Innerhofer et al. Lancet Haematol. 2017; 7. Stein et al. Anaesthesia. 2017; 8. Prat et al. J Trauma Acute Care Surg. 2017; 9. Aladegbami et al. J Emerg Trauma Shock. 2018; 10. Hota et al. Am Surg. 2019; 11. Guth et al. Anaesth Crit Care Pain Med. 2019; 12. Unruh et al. Am J Surg. 2019; 13. Lammers et al. J Trauma Acute Care Surg. 2020; 14. Rimaitis et al. Med Sci Monit. 2020; 15. Cochrane et al. Diagnostics (Basel). 2020; 16. Dudek et al. Injury. 2020; 17. Baksaas-Aasen et al. Intensive Care Med. 2021; 18. Pernod et al. Turk J Anaesthesiol Reanim. 2021; 19. Barquero Lopez et al. J Trauma Acute Care Surg. 2022; 20. Riehl et al. J Clin Med. 2022; 21. David et al. Crit Care. 2023; 22. Hannington et al. S Afr J Surg. 2023; 23. Salehi et al. World J Emerg Surg. 2023; 24. Liu et al. Transfus Med. 2024; 25. Nienaber et al. Injury. 2011; 26. Lendemans et al. DKOU. 2013; 27. Nardi et al. Crit Care. 2015; 28. Deng et al. J Int Med Res. 2018; 29. Campbell et al. Emerg Med Australas. 2021.

the ANESTESIOLOGY® 2024 annual meeting, PHILADELPHIA, PA, OCTOBER 18-22, 2024: ePoster A2047.

Study	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Schöchl 2011	6	80	60	601	1.6%	0.75 [0.34; 1.68]
Nienaber 2011	3	18	2	18	0.4%	1.50 [0.28; 7.93]
Tapia 2013	28	165	35	124	4.4%	0.60 [0.39; 0.93]
Lendemans 2013	19	91	31	81	3.8%	0.55 [0.34; 0.89]
Yin 2014	3	29	2	31	0.4%	1.60 [0.29; 8.92]
Nardi 2015	13	96	26	130	2.6%	0.68 [0.37; 1.25]
Gonzalez 2016	11	56	20	55	2.5%	0.54 [0.29; 1.02]
Wang 2017	10	86	15	80	1.9%	0.62 [0.30; 1.30]
Innerhofer 2017	5	50	2	44	0.5%	2.20 [0.45; 10.78]
Stein 2017	88	408	107	323	8.8%	0.65 [0.51; 0.83]
Prat 2017	4	85	7	134	0.8%	0.90 [0.27; 2.99]
Aladegbami 2018	4	23	1	54	0.3%	9.39 [1.11; 79.52]
Deng 2018	1	332	0	332	0.1%	3.00 [0.12; 73.38]
Hota 2019	10	54	13	64	1.9%	0.91 [0.43; 1.91]
Guth 2019	33	102	34	102	5.2%	0.97 [0.66; 1.44]
Unruh 2019	15	47	11	20	2.9%	0.58 [0.33; 1.03]
Lammers 2020	42	594	279	2726	6.8%	0.69 [0.51; 0.94]
Rimaitis 2020	18	69	15	65	2.8%	1.13 [0.62; 2.05]
Cochrane 2020	19	175	32	126	3.4%	0.43 [0.25; 0.72]
Dudek 2020	32	88	66	170	6.3%	0.94 [0.67; 1.31]
Campbell 2020	13	77	5	37	1.2%	1.25 [0.48; 3.24]
Baksaas-Aasen 2021	50	201	55	194	6.4%	0.88 [0.63; 1.22]
Pernod 2021	36	122	50	122	6.0%	0.72 [0.51; 1.02]
Barquero Lopez 2022	13	42	39	93	3.5%	0.74 [0.44; 1.23]
Riehl 2022	242	790	258	725	12.2%	0.86 [0.75; 0.99]
David 2023	78	215	71	215	8.2%	1.10 [0.85; 1.42]
Hannington 2023	15	48	7	36	1.7%	1.61 [0.73; 3.53]
Salehi 2023	9	43	7	21	1.5%	0.63 [0.27; 1.45]
Liu 2024	6	31	20	66	1.6%	0.64 [0.29; 1.43]
Total (95% CI)		**4217**		**6789**	**100.0%**	**0.79 [0.70; 0.89]**

Heterogeneity: $Tau^2 = 0.0201$; $Chi^2 = 40.34$, df = 28 (P = 0.06); $I^2 = 31\%$

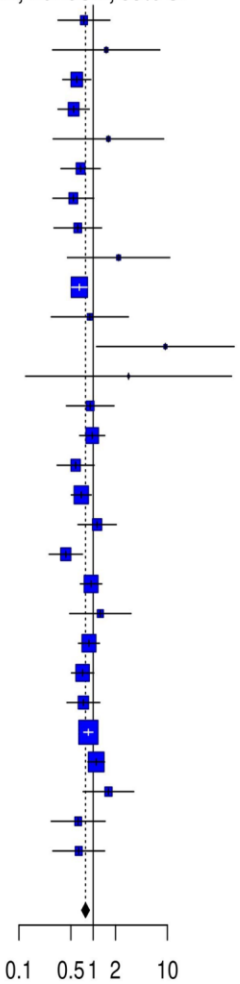


Figure: Meta-analysis on the effects of viscoelastic testing on mortality in bleeding patients with severe trauma (Forest plot, random model).

Best practice: Local implementation of a trauma algorithm

Protocolised thromboelastometric-guided haemostatic management in patients with traumatic brain injury: a pilot study

Anaesthesia. 2019 Jul;74(7):883-890. doi: 10.1111/anae.14670. Epub 2019 Apr 29.

J. Gratz,[1] H. Güting,[2] S. Thorn,[3] A. Brazinova,[4] K. Görlinger,[5,6] N. Schäfer,[2] H. Schöchl,[7,8] S. Stanworth[9] and M. Maegele[10,11]

Aim: Feasibility to implement a thromelastometry-guided treatment algorithm in centers initially naive to the assessment/technology

Outcome: Adherence to algorithm and turn around times for test results versus standard coagulation assays

Pats: 32 in 4 CENTER-TBI European trauma centers (GER,SP,HU,B)

Results: Complete adherence to algorithm in 20/32 cases
5/32 displayed coag abnormalities on standard assays
21/32 displayed coag abnormalities in ROTEM assays

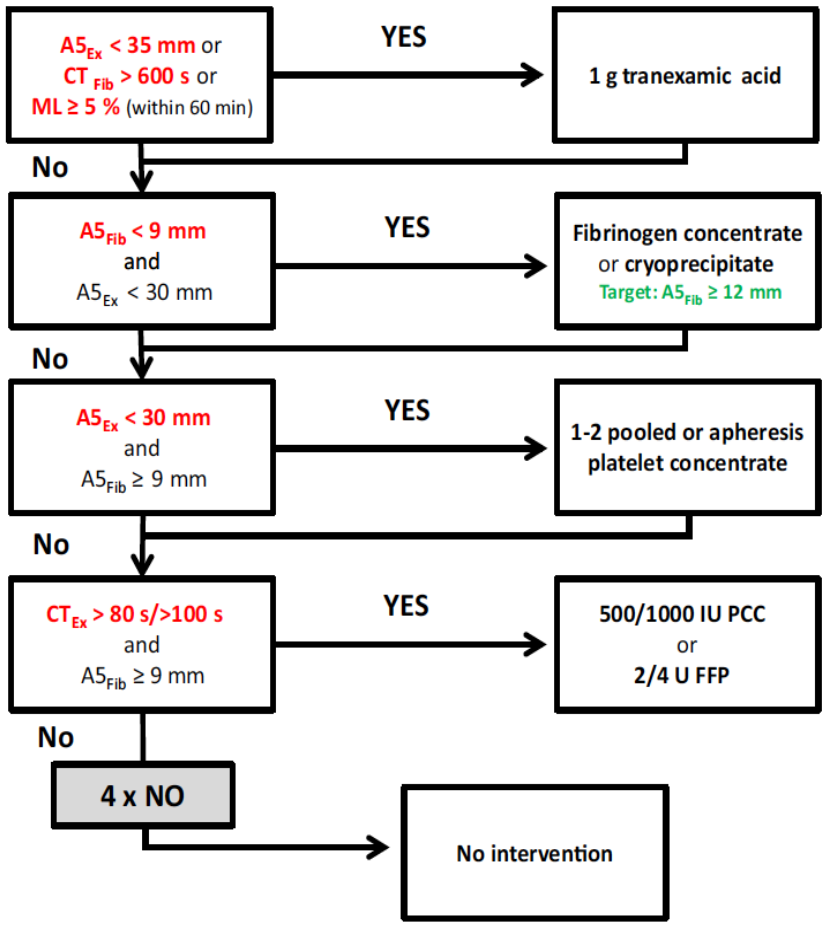


Figure 1 Rotational thromboelastometry (ROTEM)-guided coagulation management algorithm used in the study. Based on specific ROTEM results, it led the treating physician through coagulation-directed management step-by-step. $A5_{EX}$, clot amplitude 5 min after CT on EXTEM assay; CT_{FIB}, clotting time (CT) on FIBTEM assay; ML, maximum lysis; $A5_{FIB}$, clot amplitude 5 min after CT on FIBTEM assay; CT_{EX}, CT on EXTEM assay; PCC, prothrombin complex concentrate; FFP, fresh frozen plasma.

Best practice: Local implementation of a trauma algorithm

Protocolised thromboelastometric-guided haemostatic management in patients with traumatic brain injury: a pilot study

Anaesthesia. 2019 Jul;74(7):883-890. doi: 10.1111/anae.14670. Epub 2019 Apr 29.

J. Gratz,[1] H. Güting,[2] S. Thorn,[3] A. Brazinova,[4] K. Görlinger,[5,6] N. Schäfer,[2] H. Schöchl,[7,8] S. Stanworth[9] and M. Maegele[10,11]

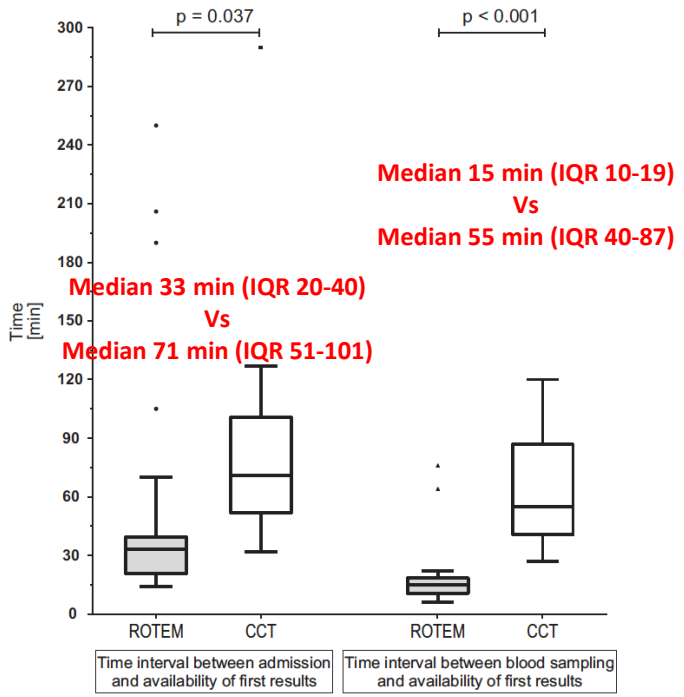


Figure 2 Comparison of time from admission and from blood sampling to availability of rotational thromboelastometry results (n = 32) and conventional coagulation test results (CCT) (n = 21). Tukey box plots with whiskers of length 1.5 × IQR and outliers are shown.

Adherence to algorithm was associated with

1. faster clot initiation (decreased CT time)

2. Better clot stability/firmness (increased amplitude)

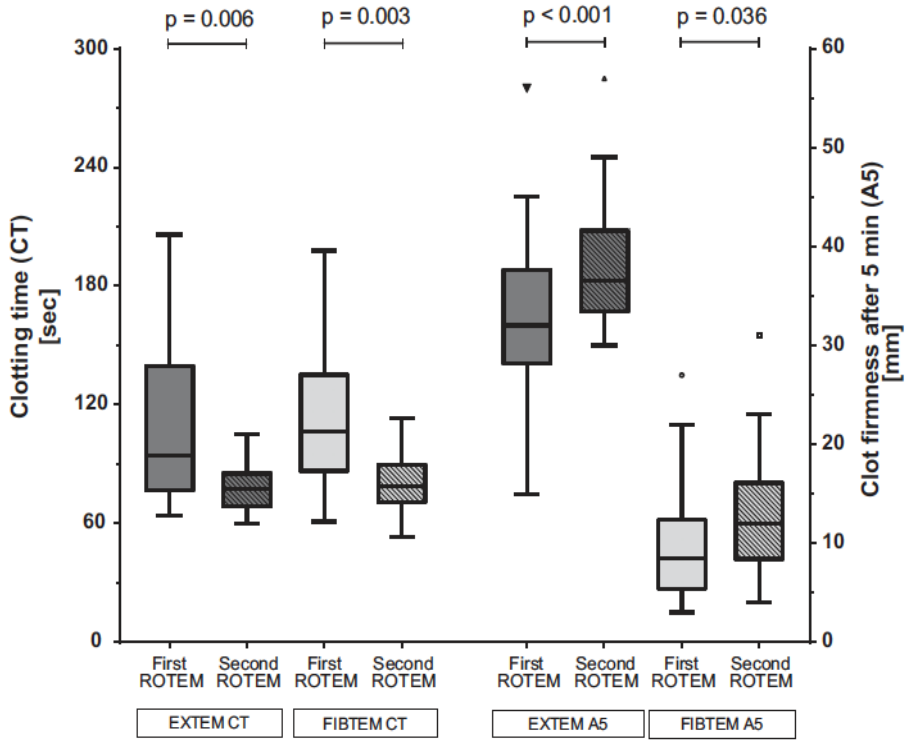
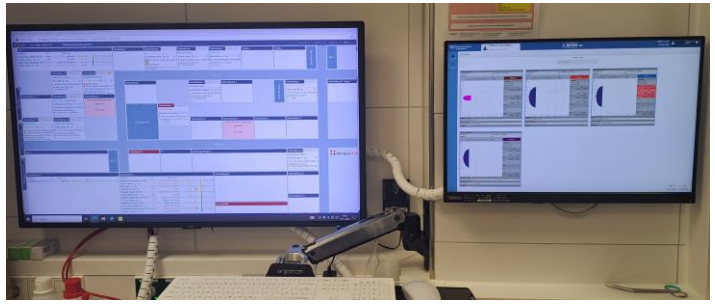


Figure 4 A comparison of the ROTEM results (EXTEM and FIBTEM assays) before and after intervention (first and second ROTEM respectively) (n = 16; in two patients no second ROTEM was performed). Tukey box plots with whiskers of length 1.5 × IQR and outliers are shown.

Goal-directed therapy: Case



Transmission of the ROTEM trace into the Resuscitation Room (ROTEM-Life and Secure View)

Case 2

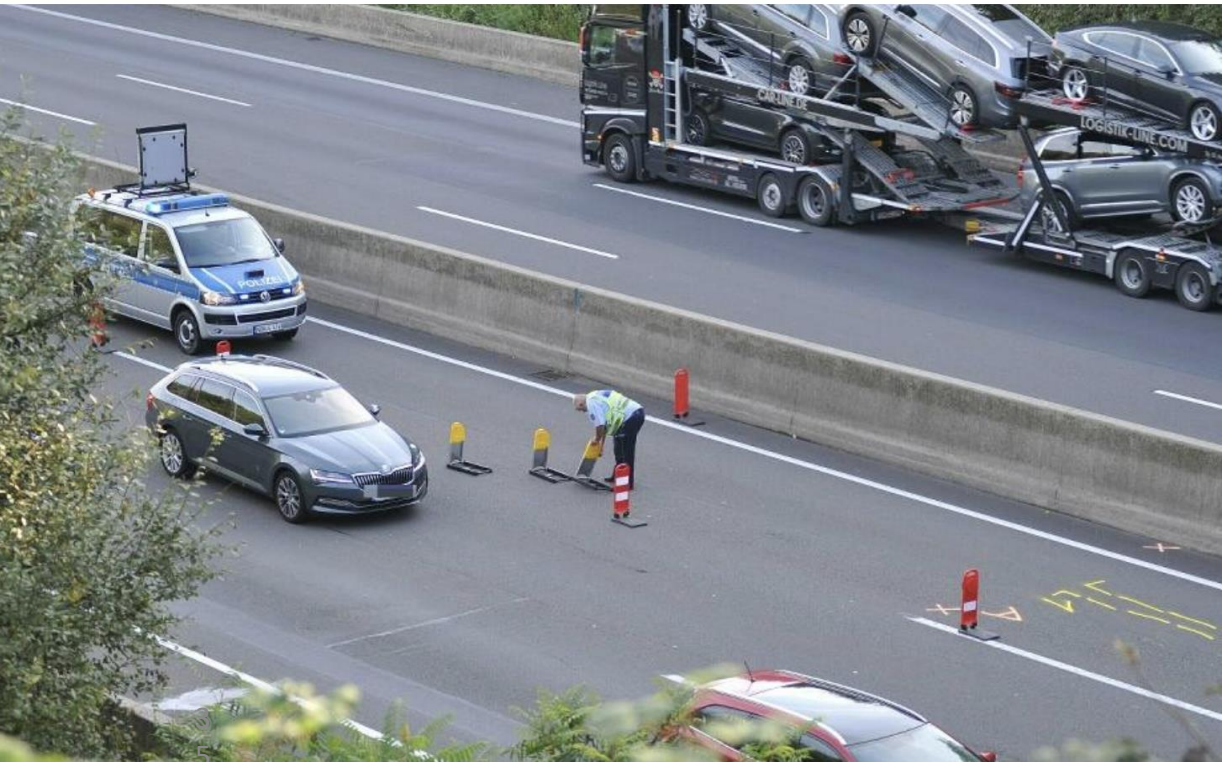
29 yrs male

Jump from a highway bridge after attacking parents with an axe

Ermittlungen in Wermelskirchen

Verdächtiger springt von Brücke nach Axt-Angriff auf Eltern

1. Oktober 2021 um 16:42 Uhr | Lesedauer: 3 Minuten



EINSATZPROTOKOLL

Einsatznummer 109

[redacted]

1. RETTUNGSTECHNISCHE DATEN

Datum 01.10.21 Alarmzeit 07:13

Einsatzort RAB1 Wermelskirchen Ankunft 08:05

Transportziel Leverkusen ZNA Übergabe 09:50

Geschl.: m w geb. am: 06.11.1992

Kostenträger: BKK

Vers.-Nr.

Anzahl Patienten: Auswärts-km:

Einsatzart: Erstversorgung, Verlegung mit NA, NEF - kein Transport erforderlich, Exitus, Psych KG, RTW-Einsatz ohne Transport, Verlegung, Entlassung, Betreuung mit Zwang, Intubation, Bereitstellung ohne Benutzung, Wartezeit ___ min, MEDTRANS, Untersuchung/Behandlung in KH/Praxis: hin rück hin + rück

Fehlfahrt: Blinder Alarm, Einsatz abgebrochen, Pat. hat KH verlassen, Pat. bei Eintreffen entfernt, Transport nicht erforderlich, anderes EM, Transport d. auswärt. EM

Notfallkategorie: kein Notfall, akute Erkrankung, Vergiftung; Unfall / Verletzung: Verkehr, Arbeit, Sport, Haus, Sonstiger

GVS-Klassifizierung bei Abschluss: GVS-0, GVS-1, GVS-2, GVS-3, GVS-4, GVS-5, GVS-6, GVS-7

2. NOTFALLGESCHEHEN / ANAMNESE / BEMERKUNGEN

(V.a.) Infektionserkrankung

SYMPTOMBEGINN:

Assessment on scene: C problem and GCS 9

Sedation, intubation and ventilation by emergency physician

3. ERSTBEFUND

3.1. Neurologie unauffällig

Glasgow-Coma-Scale

Augen öffnen: spontan 4, auf Aufforderung 3, auf Schmerzreiz 2, kein 1

Beste verbale Reaktion: konversationsfähig 5, orientiert 5, desorientiert 4, inadäquate Aussagen 3, unverständlich 2, keine 1

Beste motorische Reaktion: auf Aufforderung 6, auf Schmerzreiz: gezielt 5, normale Beugeabwehr 4, abnorme Abwehr 3, Strecksynergismen 2, keine 1

GCS-SUMME 3

Pupillenweite: re / li; eng, mittel, weit, entrundet, nicht beurteilbar

Lichtreaktion: prompt, träge, keine

Nystagmus

Seitendifferenz vorhanden

Fazialisparese: normal, pathologisch

Sprech-Test: normal, pathologisch

Bewegung: gerichtet, ungerichtet, angepasst / paretisch

3.2. Motorik

	Aktive Bewegung	Schlaffe Lähmung	Spastische Lähmung	Tonische o. klonische Bewegungsstörung
Gesicht				
Arm links				
Arm rechts				
Bein links				
Bein rechts				

Bemerkungen:

3.3. EKG: kein

Sinusrhythmus, absolute Arrhythmie, AV-Block I°, AV-Block II° Wenckebach, AV Block II° Mobitz, AV-Block III°, Extrasystolen (supraventrikulär, ventrikulär), QRS schmal, QRS breit/Schenkelblock, Kammerflattern/-flimmern, elektromechanische Dissoziation, Asystolie, Schrittmacherrhythmus (monomorph, polymorph)

3.4. Atmung

unauffällig, Dyspnoe, Zyanose, Spastik, Nasalgeräusche, Stridor, Schnappatmung, Apnoe, Beatmung, Hyperventilation, BVM

4. ERSTDIAGNOSE

Polytrauma

SHT

Hand-over to HEMS „Christoph 3 Cologne“

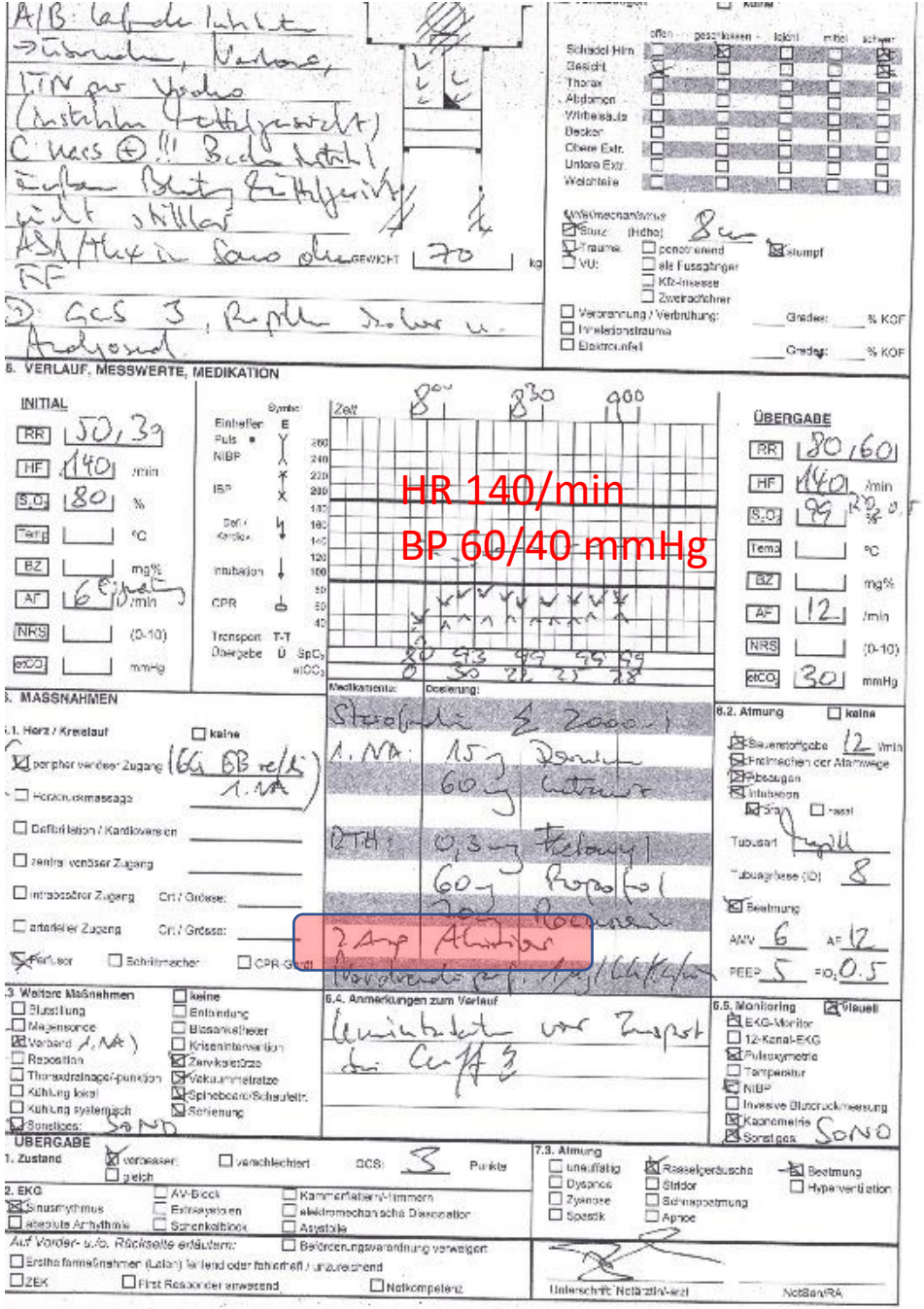
Exemplar für weiterbehandelnde Stelle

Case 2

29 yrs male

Jump from a highway bridge after attacking parents with an axe

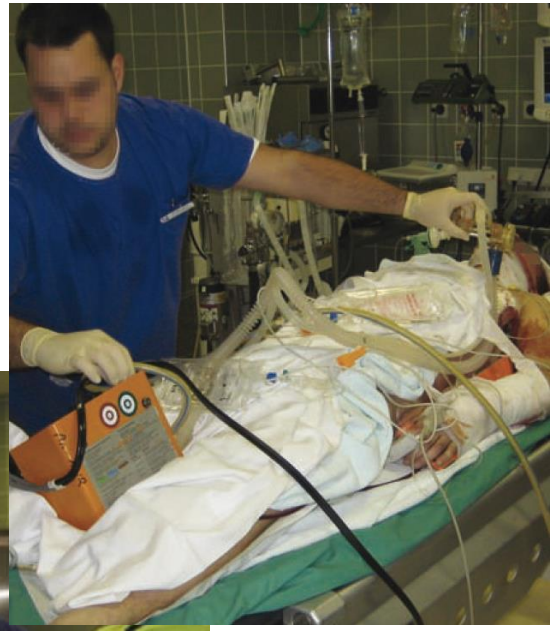
After hand-over



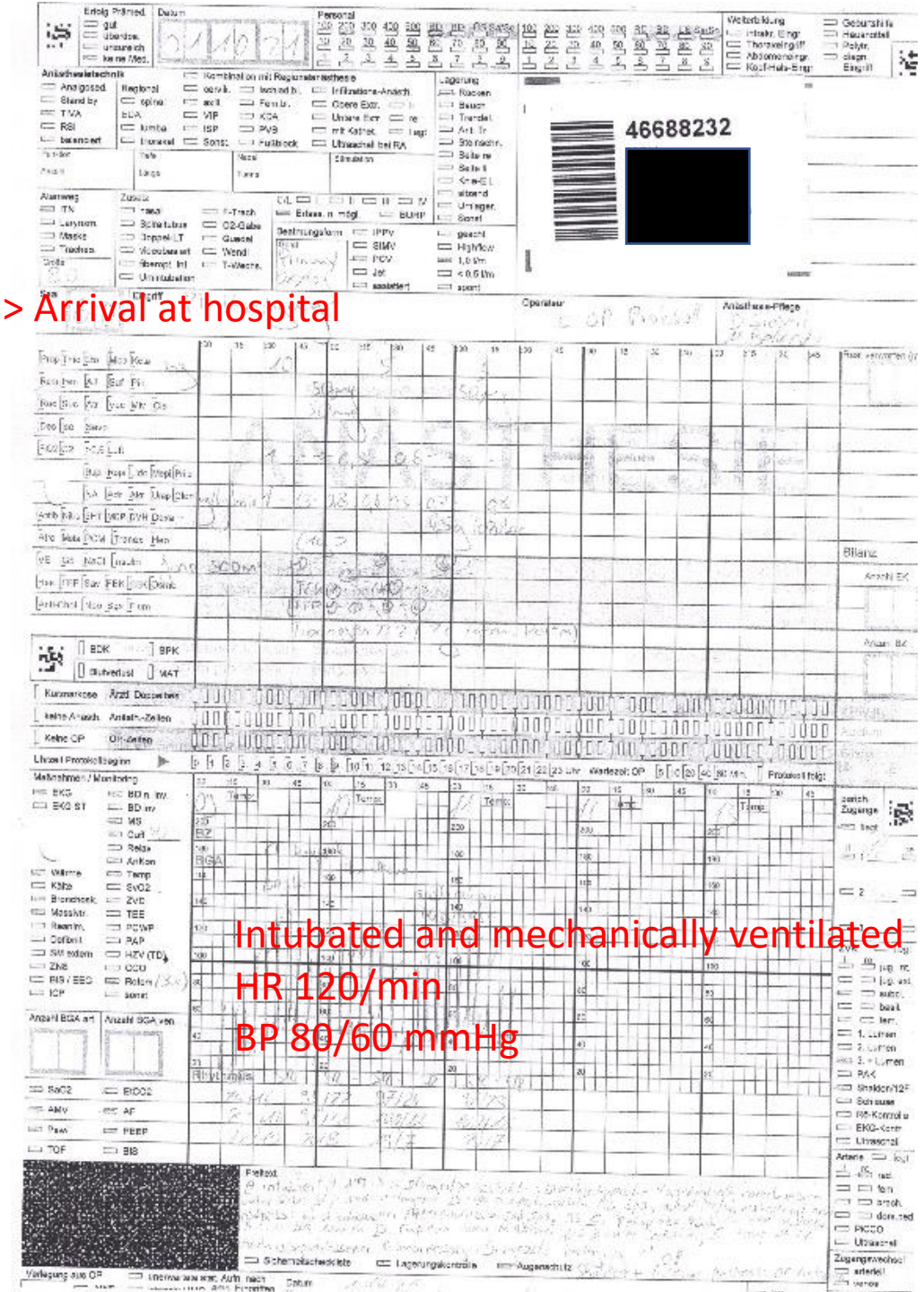
Case 2

29 yrs male

Jump from a highway bridge after attacking parents with an axe



Transport > Arrival at hospital



Case 2

Diagnostic work-up

ABG

RADIOMETER ABL90 SERIE

ABL90 393-090R1062NC044 10:10 01.10.2021
PATIENTENBERICHT Spritze - S 65µL Probe Nr. 4499

Identifikation

Patienten ID	46688232
Benutzer-ID	60053962
Nachname (Pat.)	SR757_2021_M_MCU
Vorname (Pat.)	SR757_2021_M_MCU
Geburtsdatum	01.01.1950
Geschlecht	Männlich
Probentyp	Arteriell
T	37,0 °C
$FO_2(t)$	21,0 %
Notfallzentrum	Meinem

Blutgas Ergebnis

↓ pH	7,150		[7,350 - 7,450]	
↑ pCO_2	63,9	mmHg	[35,0 - 48,0]	
↑ pO_2	438	mmHg	[83,0 - 108]	

Oxymetrie Ergebnis

↓ ctHb	7,9	g/dL	[11,7 - 17,4]	
↑ sO_2	100,2	%	[94,0 - 98,0]	
↑ FO_2Hb	98,8	%	[95,0 - 98,0]	
↓ $FCOHb$	0,4	%	[0,5 - 3,0]	
↓ $FHHb$	-0,2	%	[0,0 - 3,0]	
$FMetHb$	1,0	%	[0,0 - 1,5]	

Elektrolyt Ergebnis

↓ cK^+	2,6	mmol/L	[3,4 - 4,6]	
cNa^+	140	mmol/L	[136 - 145]	
↓ cCa^{2+}	0,77	mmol/L	[1,15 - 1,27]	
cCl^-	102	mmol/L	[98 - 107]	

Metabolit Ergebnis

↑ cGlu	281	mg/dL	[70 - 100]	
↑ cLac	4,2	mmol/L	[0,0 - 1,6]	
cBil	0,6	mg/dL	[-]	

Temperatur Korrektion

pH(T)	7,150	
$pCO_2(T)$	63,9	mmHg
$pO_2(T)$	438	mmHg

Sauerstoff Status

$pO_2(a)/FO_2(t)_c$	2086	mmHg

Säure Basen Status

cBase(Ecf)c	-6,6	mmol/L
$cHCO_3^-(P,st)_c$	19,1	mmol/L

Meldungen

↑ Wert(e) oberhalb Referenzbereich
↓ Wert(e) unterhalb Referenzbereich
‡ Wert(e) oberhalb oberer kritischer Grenze
c Kalkulierte(r) Wert(e)

Los Lösungspack: MA-10 Sensorkassette Run-Nr.
Gedruckt: 10:10:55 01.10.2021 516-274

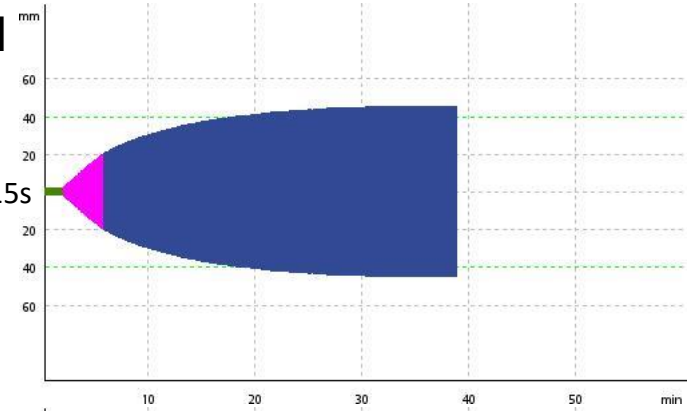
pH 7,14

Hb 7,9 g/dl

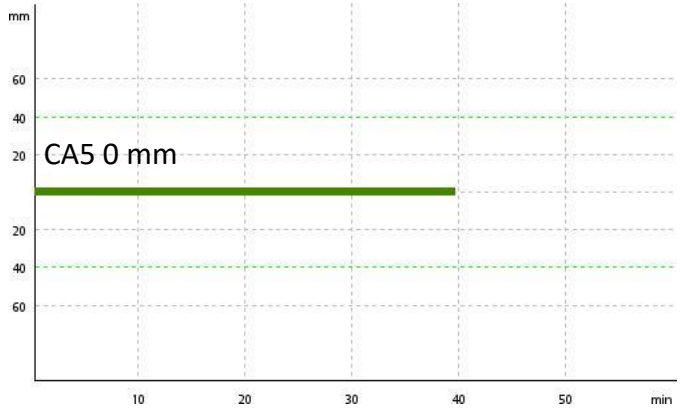
Lac 4,2 mmol/l

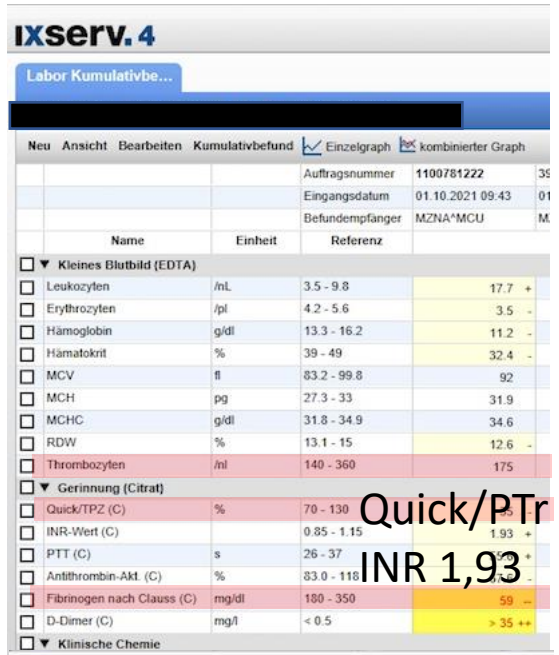
BE -6,6 mmol/l

EXTEM



FIBTEM





IXserv. 4

Labor Kumulativbe...

[redacted]

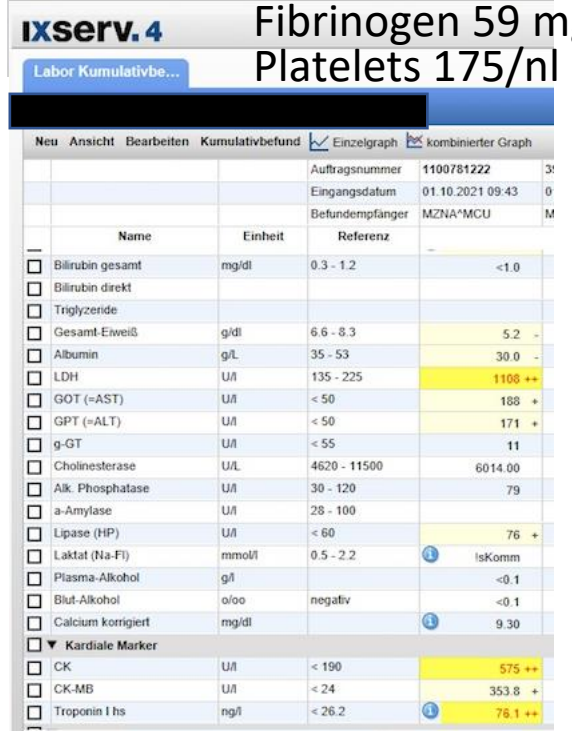
Neu Ansicht Bearbeiten Kumulativbefund Einzelgraph kombinierter Graph

		Auftragsnummer	1100781222
		Eingangsdatum	01.10.2021 09:43
		Befundempfänger	MZNA^MCU

Name	Einheit	Referenz	
▼ Kleines Blutbild (EDTA)			
Leukozyten	/nL	3.5 - 9.8	17.7 +
Erythrozyten	/pl	4.2 - 5.6	3.5 -
Hämoglobin	g/dl	13.3 - 16.2	11.2 -
Hämatokrit	%	39 - 49	32.4 -
MCV	fl	83.2 - 99.8	92
MCH	pg	27.3 - 33	31.9
MCHC	g/dl	31.8 - 34.9	34.6
RDW	%	13.1 - 15	12.6 -
Thrombozyten	/nl	140 - 360	175
▼ Gerinnung (Citrat)			
Quick/TPZ (C)	%	70 - 130	35 --
INR-Wert (C)		0.85 - 1.15	1.93 +
PTT (C)	s	26 - 37	[illegible] +
Antithrombin-Akt. (C)	%	83.0 - 118	[illegible] -
Fibrinogen nach Clauss (C)	mg/dl	180 - 350	59 --
D-Dimer (C)	mg/l	< 0.5	> 35 ++
▼ Klinische Chemie			

Quick/PTr 35%

INR 1,93



IXserv. 4

Labor Kumulativbe...

[redacted]

Neu Ansicht Bearbeiten Kumulativbefund Einzelgraph kombinierter Graph

		Auftragsnummer	1100781222
		Eingangsdatum	01.10.2021 09:43
		Befundempfänger	MZNA^MCU

Name	Einheit	Referenz	
Bilirubin gesamt	mg/dl	0.3 - 1.2	<1.0
Bilirubin direkt			
Triglyzeride			
Gesamt-Eiweiß	g/dl	6.6 - 8.3	5.2 -
Albumin	g/L	35 - 53	30.0 -
LDH	U/l	135 - 225	1108 ++
GOT (=AST)	U/l	< 50	188 +
GPT (=ALT)	U/l	< 50	171 +
g-GT	U/l	< 55	11
Cholinesterase	U/L	4620 - 11500	6014.00
Alk. Phosphatase	U/l	30 - 120	79
a-Amylase	U/l	28 - 100	
Lipase (HP)	U/l	< 60	76 +
Laktat (Na-Fl)	mmol/l	0.5 - 2.2	IsKomm
Plasma-Alkohol	g/l		<0.1
Blut-Alkohol	o/oo	negativ	<0.1
Calcium korrigiert	mg/dl		9.30
▼ Kardiale Marker			
CK	U/l	< 190	575 ++
CK-MB	U/l	< 24	353.8 +
Troponin I hs	ng/l	< 26.2	76.1 ++

Fibrinogen 59 mg/dl

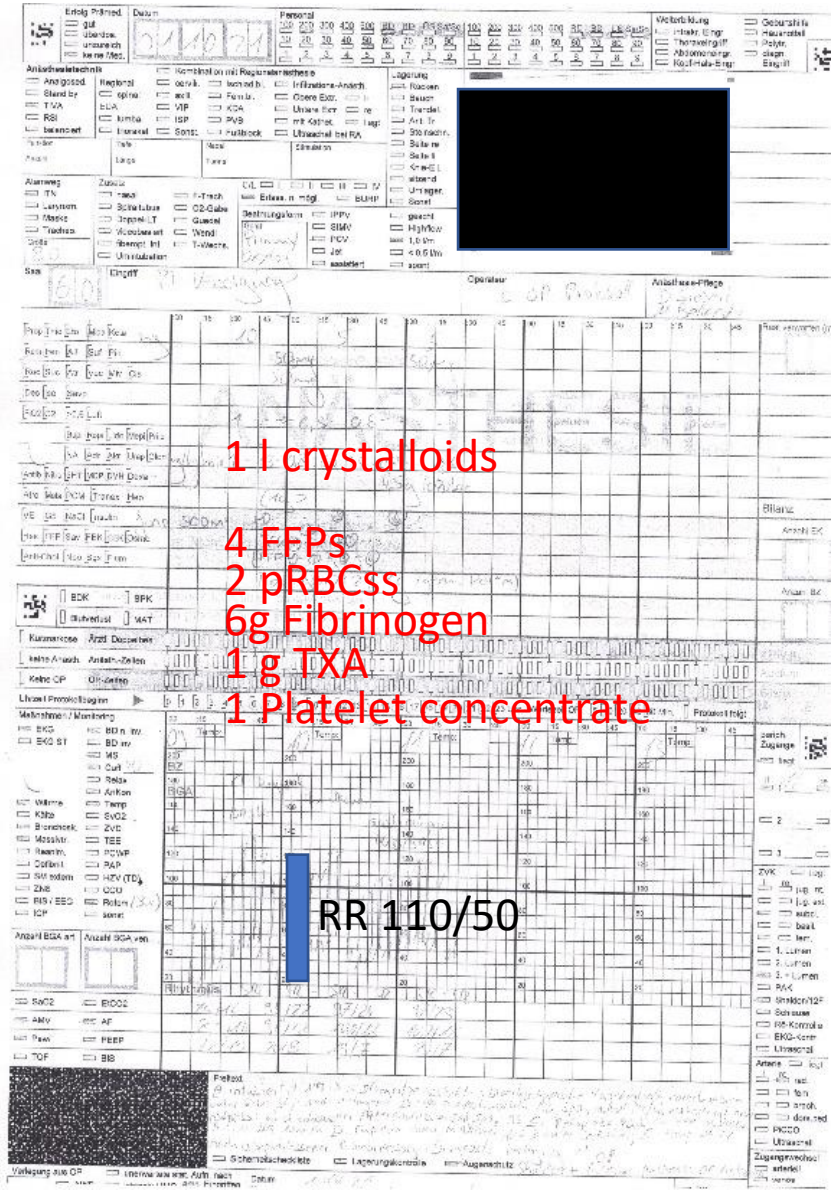
Platelets 175/nl

Case 2

? next ?

Case 2

Management



RADIOMETER ABL90 SERIE

ABL90 I393-090R1062N0044 10:48 01.10.2021
PATIENTENBERICHT Spritze - S 65uL Probe Nr. 4600

Identifikation

Patienten ID	46686232
Benutzer-ID	60055106
Nachname (Pat.)	SR757_2021_M_MCU
Vorname (Pat.)	SR757_2021_M_MCU
Geburtsdatum	01.01.1950
Geschlecht	Männlich
Probentyp	Arteriell
T	37,0 °C
$FO_2(I)$	21,0 %
Notfallzentrum	Mannheim

Blutgas Ergebnis

↓ pH	7,256		[7,350 - 7,450]
↑ pCO_2	54,7	mmHg	[35,0 - 48,0]
↑ pO_2	115	mmHg	[83,0 - 108]

Oxymetrie Ergebnis

↓ ctHb	8,3	g/dL	[11,7 - 17,4]
↑ sO_2	98,6	%	[94,0 - 98,0]
FO_2Hb	97,4	%	[93,0 - 98,0]
FCOHb	0,6	%	[0,5 - 3,0]
FHHb	1,2	%	[0,0 - 6,0]
FMetHb	0,8	%	[0,0 - 1,5]

Elektrolyt Ergebnis

cK^+	4,2	mmol/L	[3,4 - 4,5]
cNa^+	140	mmol/L	[136 - 146]
↓ cCa^{2+}	0,99	mmol/L	[1,15 - 1,27]
cCl^-	104	mmol/L	[98 - 107]

Metabolit Ergebnis

↑ cGlu	248	mg/dL	[70 - 100]
↑ cLac	4,0	mmol/L	[0,0 - 1,6]
ctBil	0,5	mg/dL	[-]

Temperatur Korrektion

pH(T)	7,256	
$pCO_2(T)$	54,7	mmHg
$pO_2(T)$	115	mmHg

Sauerstoff Status

$pO_2(a)/FO_2(I)_c$	550	mmHg

Säure Basen Status

cBase(Ecf)c	-2,8	mmol/L
$cHCO_3^-(P,st)_c$	21,9	mmol/L

Meldungen

↑ Wert(e) oberhalb Referenzbereich
↓ Wert(e) unterhalb Referenzbereich
c Kalkulierte(r) Wert(e)

Los Lösungspack: MA-10
Gedruckt: 10:48:30 01.10.2021
Sensorkassette Run-Nr. 516-274

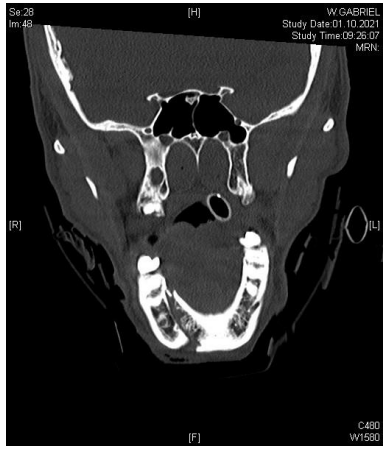
pH 7,25

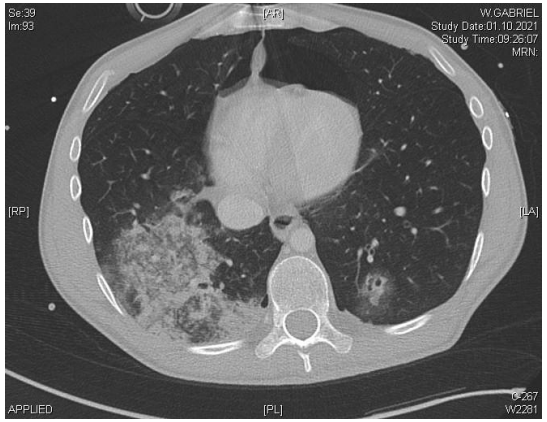
Hb 8,3 g/dl

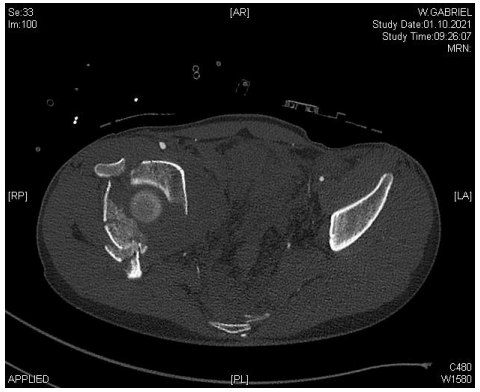
BE -2,8 mmol/l

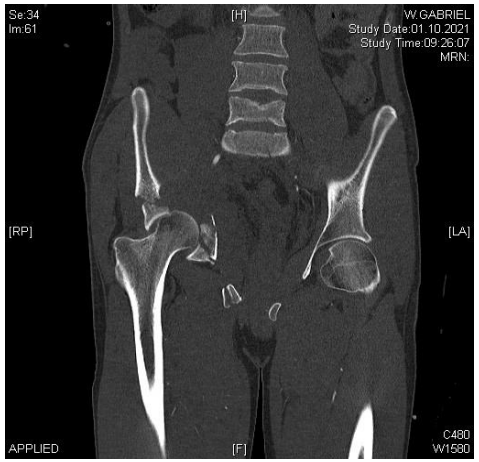
Case 2

Injury pattern





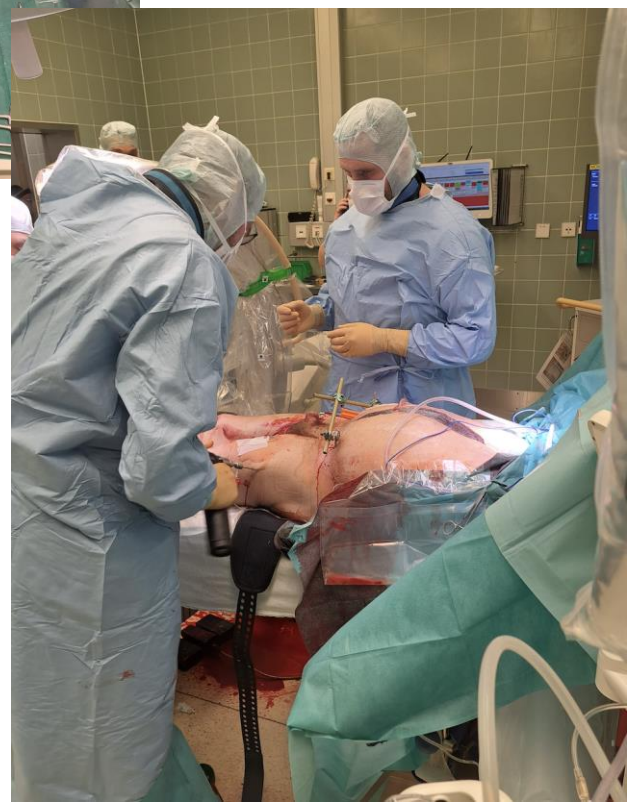




Case 1

? next ?

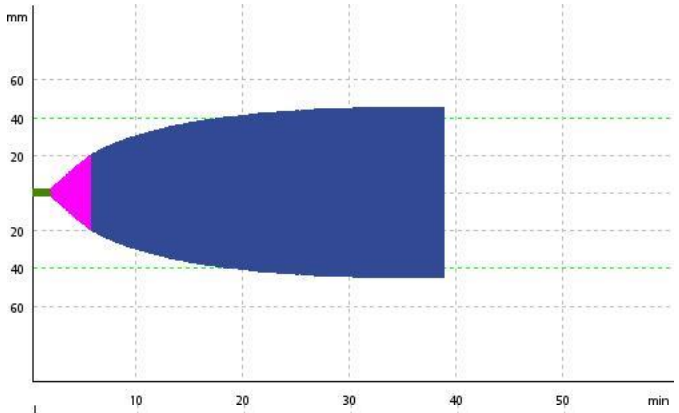
Case 2



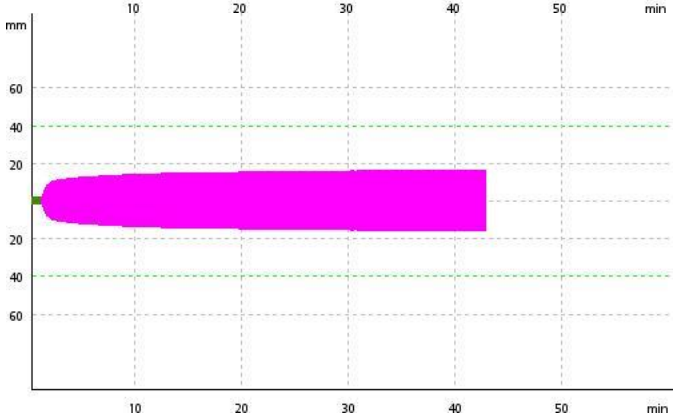
Case 2

Management

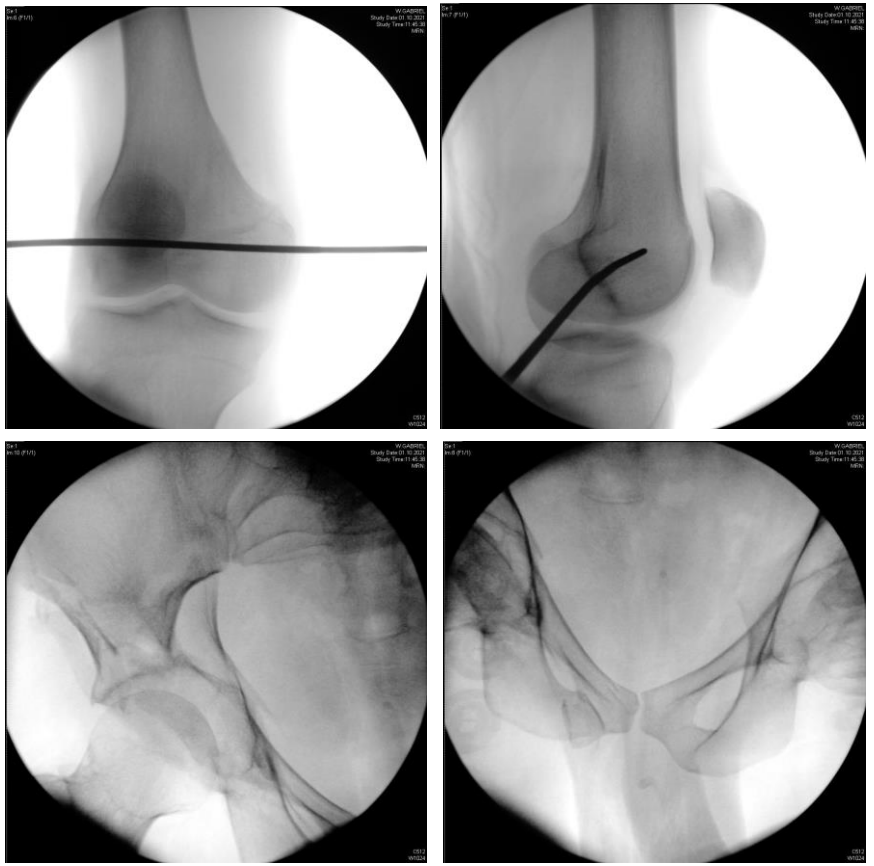
EXTEM



FIBTEM



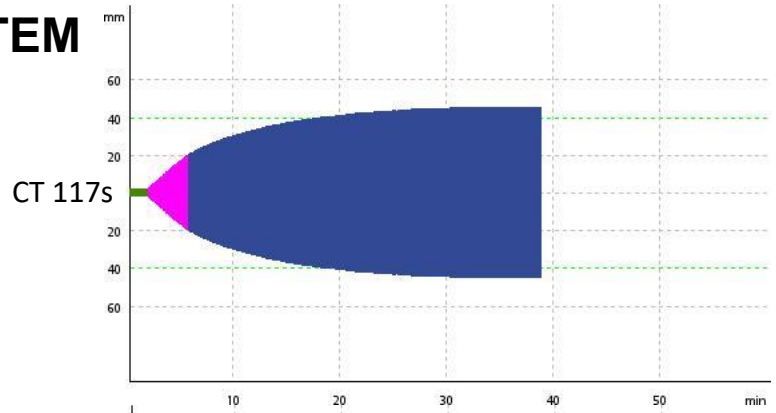
Theatre



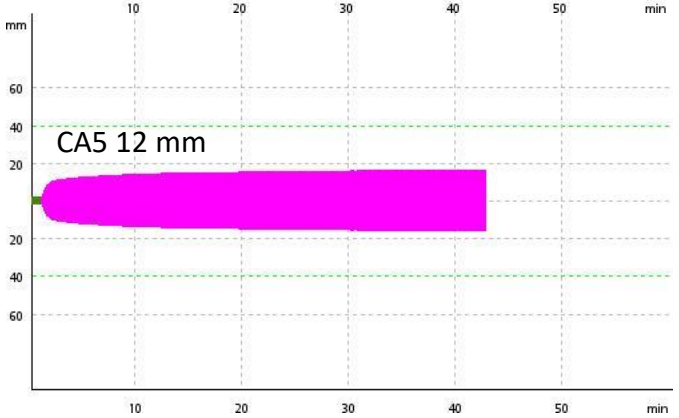
Case 2

Management

EXTEM

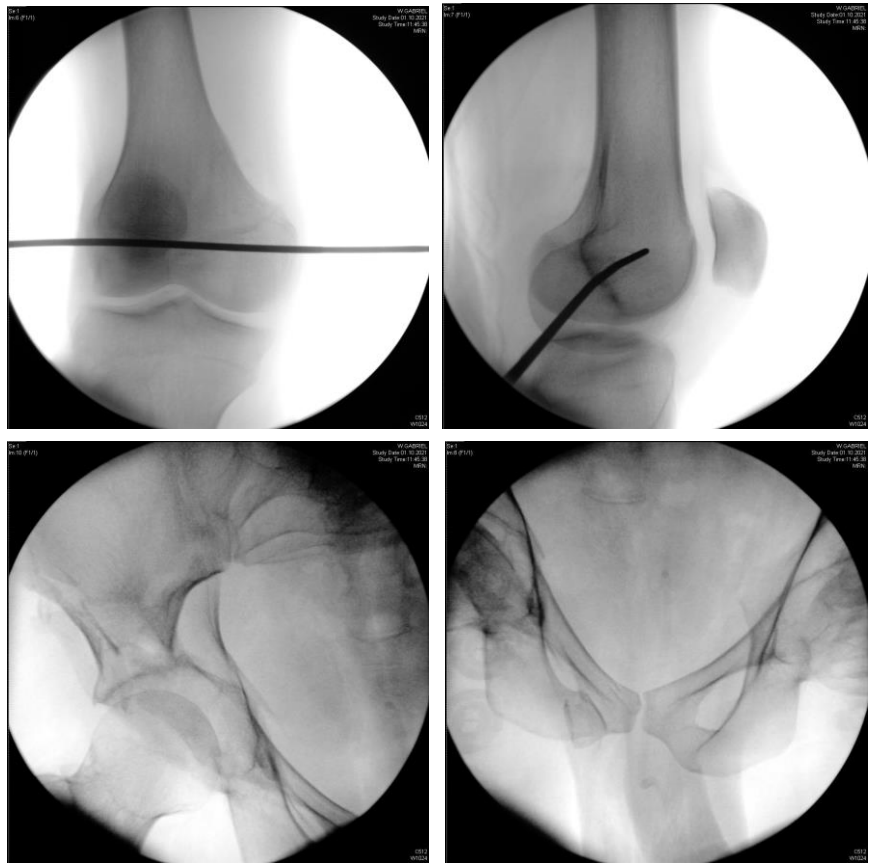


FIBTEM



Oxymetrie Ergebnis			
↓ ctHb	4,8	g/dL	[11,7 - 17,4]
↓ Hct_C	14,6	%	[35,0 - 51,0]

Theatre

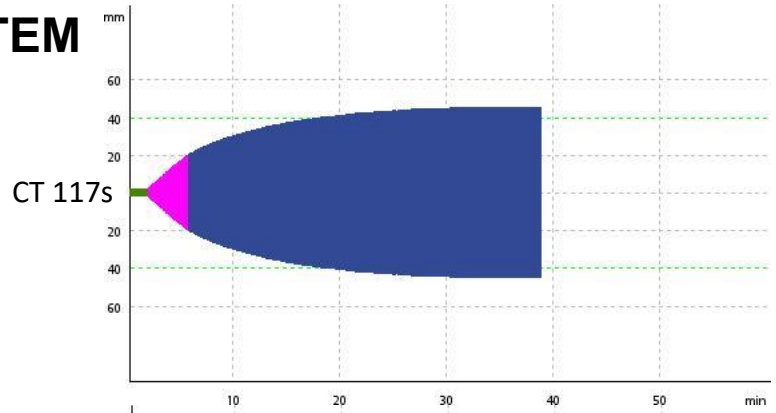


Coagulation management?

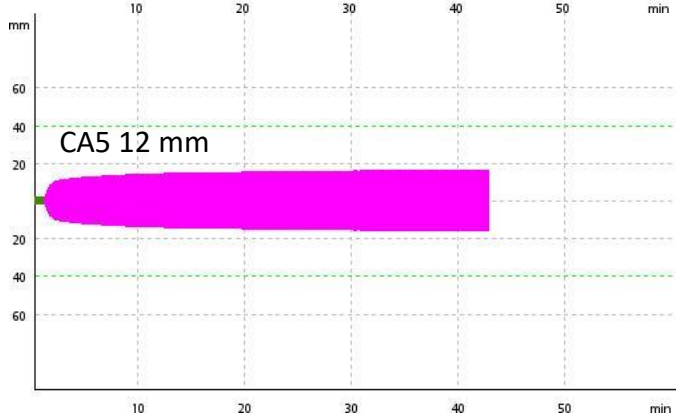
Case 2

Management

EXTEM



FIBTEM



Oxymetrie Ergebnis			
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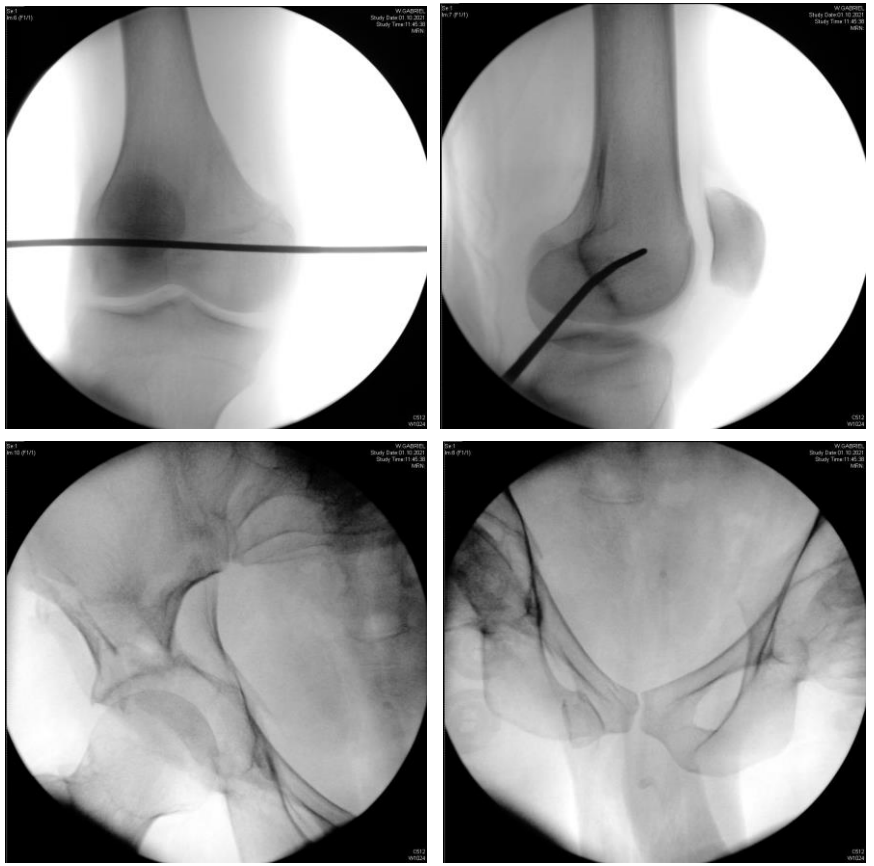
↓ Hct_C	14,6	%	[35,0 - 51,0]

Theatre

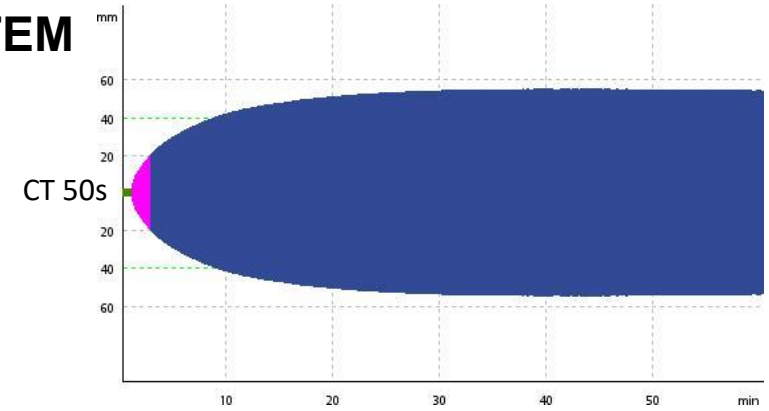


2500 U PCC
4 pRBCss
2g Fibrinogen

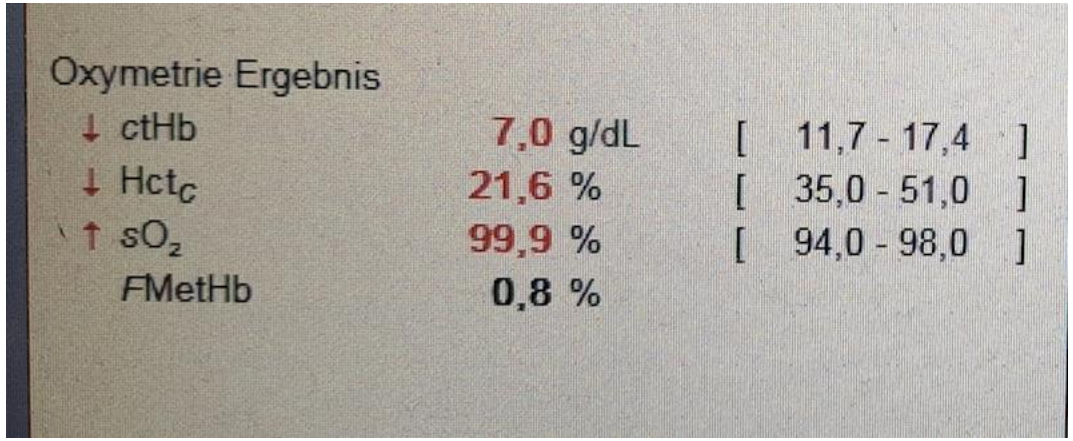
Case 2

Management

EXTEM

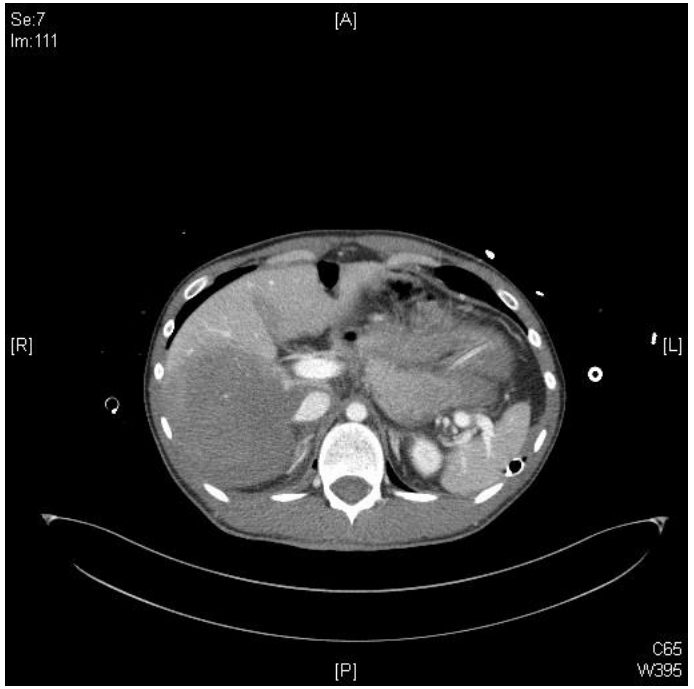


FIBTEM



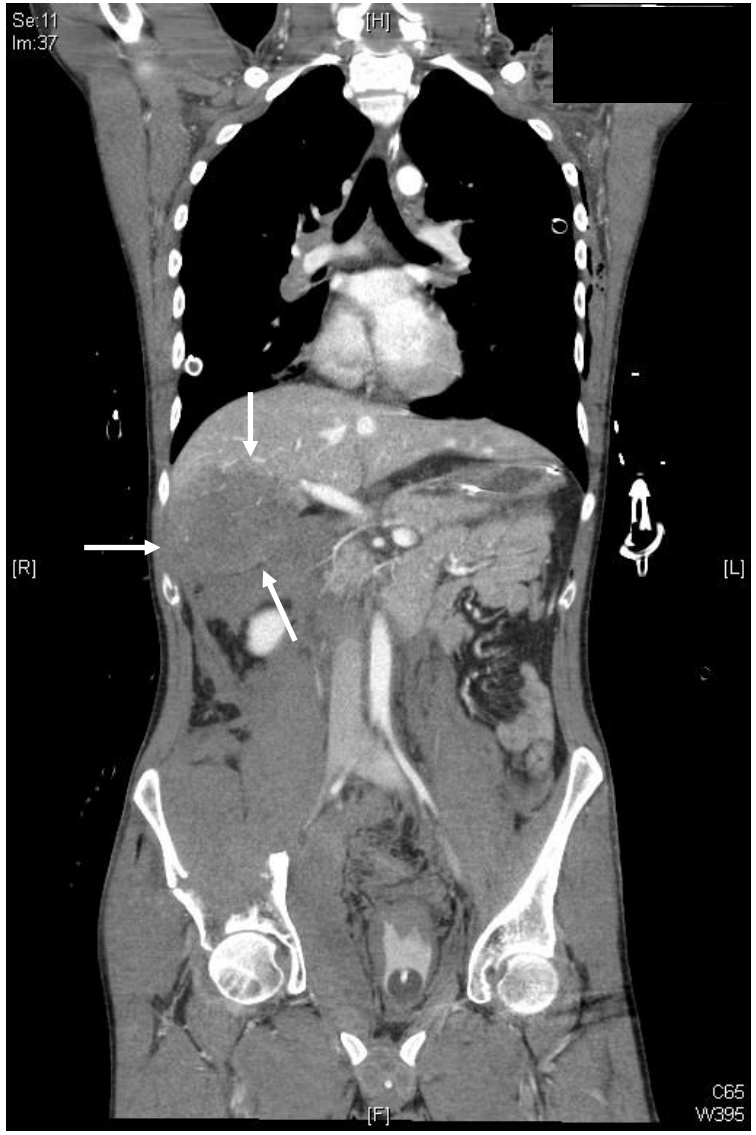
Case 2

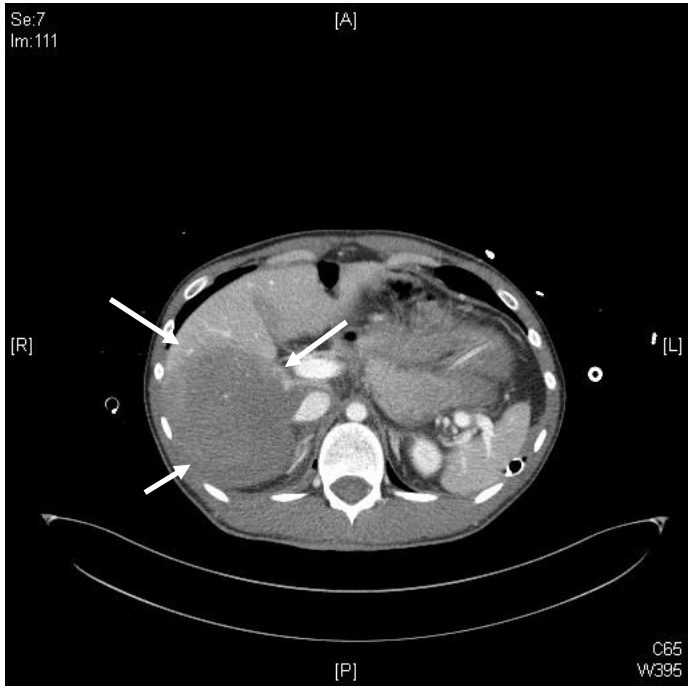
After „Damage Control“> 2nd CT due to developing pupil asymmetry



Case 2

After „Damage Control“> 2nd CT due to developing pupil asymmetry



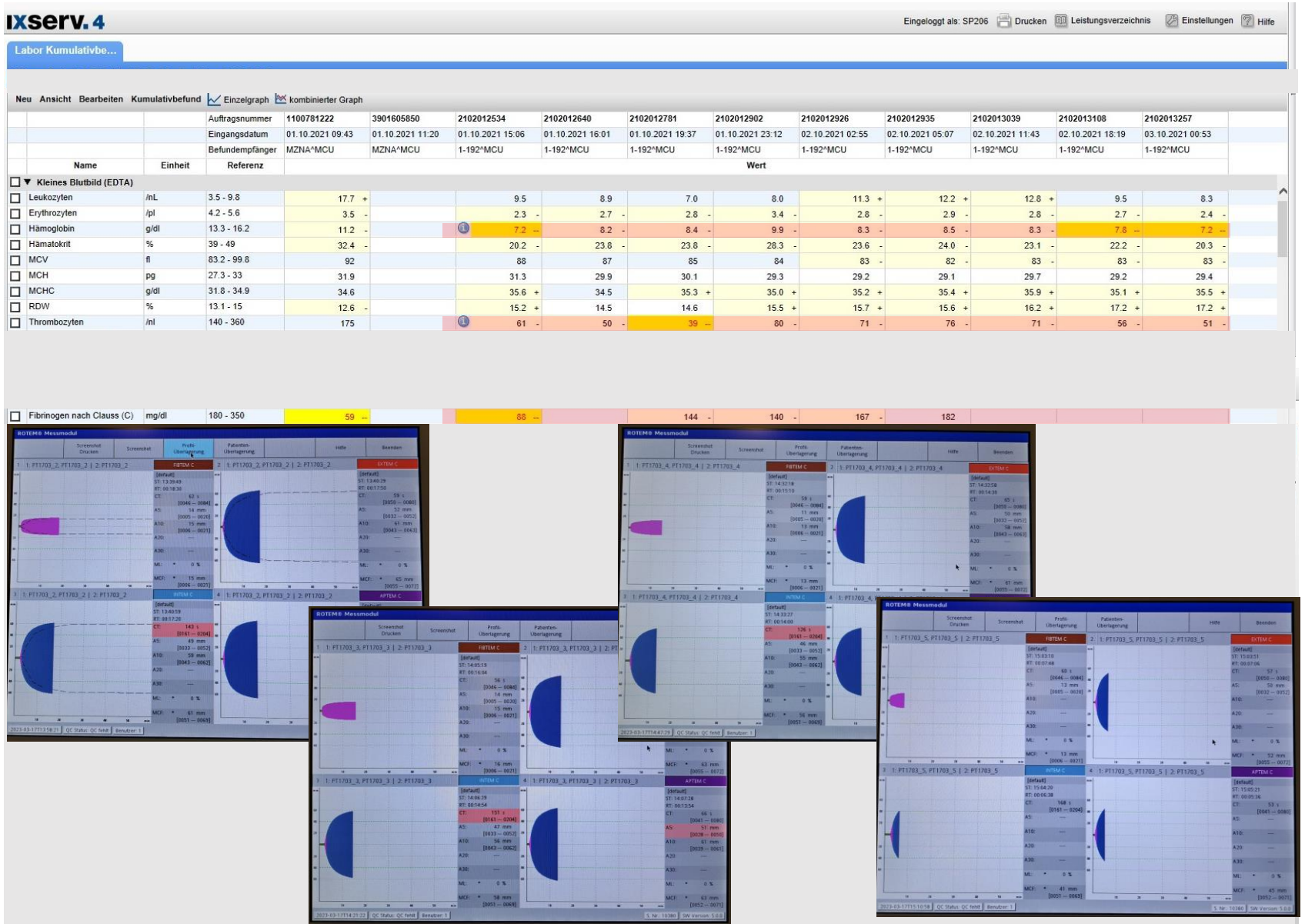


Case 2:

? next ?

Case 2

Non-operative management (NOM) > Stabilisation of coagulation function!



ixserv.4

Eingeloggt als: SP206 | Drucken | Leistungsverzeichnis | Einstellungen | Hilfe

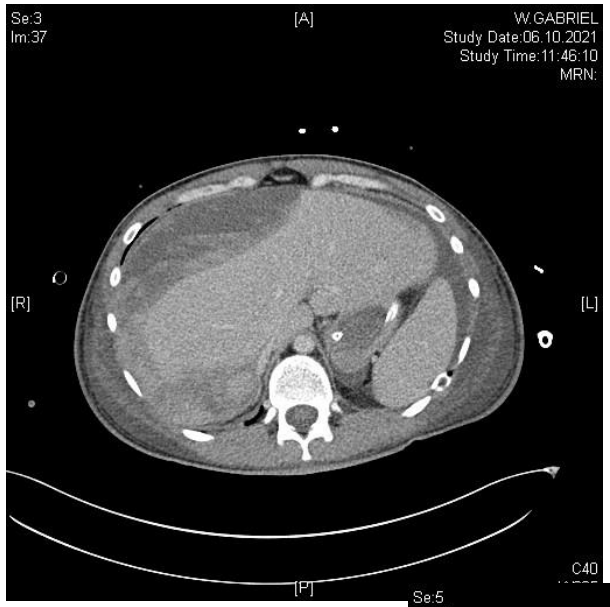
Labor Kumulativbe...

Neu | Ansicht | Bearbeiten | Kumulativbefund | Einzelgraph | kombinierter Graph

Name	Einheit	Referenz	Auftragsnummer	1100781222	3901605850	2102012534	2102012640	2102012781	2102012902	2102012926	2102012935	2102013039	2102013108	2102013257
			Eingangsdatum	01.10.2021 09:43	01.10.2021 11:20	01.10.2021 15:06	01.10.2021 16:01	01.10.2021 19:37	01.10.2021 23:12	02.10.2021 02:55	02.10.2021 05:07	02.10.2021 11:43	02.10.2021 18:19	03.10.2021 00:53
			Befundempfänger	MZNA^MCU	MZNA^MCU	1-192^MCU	1-192^MCU	1-192^MCU	1-192^MCU	1-192^MCU	1-192^MCU	1-192^MCU	1-192^MCU	1-192^MCU
									Wert					
▼ Kleines Blutbild (EDTA)														
Leukozyten	/nL	3.5 - 9.8	17.7 +		9.5	8.9	7.0	8.0	11.3 +	12.2 +	12.8 +	9.5	8.3
Erythrozyten	/pl	4.2 - 5.6	3.5 -		2.3 -	2.7 -	2.8 -	3.4 -	2.8 -	2.9 -	2.8 -	2.7 -	2.4 -
Hämoglobin	g/dl	13.3 - 16.2	11.2 -		7.2 --	8.2 -	8.4 -	9.9 -	8.3 -	8.5 -	8.3 -	7.8 --	7.2 --
Hämatokrit	%	39 - 49	32.4 -		20.2 -	23.8 -	23.8 -	28.3 -	23.6 -	24.0 -	23.1 -	22.2 -	20.3 -
MCV	fl	83.2 - 99.8	92		88	87	85	84	83 -	82 -	83 -	83 -	83 -
MCH	pg	27.3 - 33	31.9		31.3	29.9	30.1	29.3	29.2	29.1	29.7	29.2	29.4
MCHC	g/dl	31.8 - 34.9	34.6		35.6 +	34.5	35.3 +	35.0 +	35.2 +	35.4 +	35.9 +	35.1 +	35.5 +
RDW	%	13.1 - 15	12.6 -		15.2 +	14.5	14.6	15.5 +	15.7 +	15.6 +	16.2 +	17.2 +	17.2 +
Thrombozyten	/nl	140 - 360	175		61 -	50 -	39 --	80 -	71 -	76 -	71 -	56 -	51 -
Fibrinogen nach Clauss (C)	mg/dl	180 - 350	59 --		88 --		144 -	140 -	167 -	182			

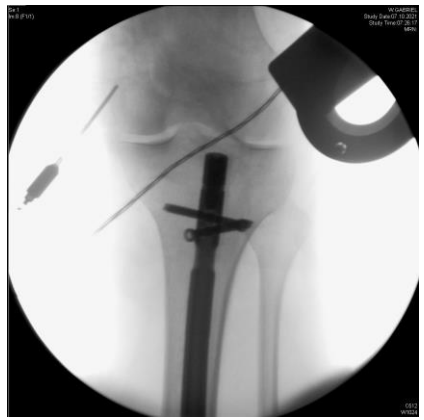
Case 2

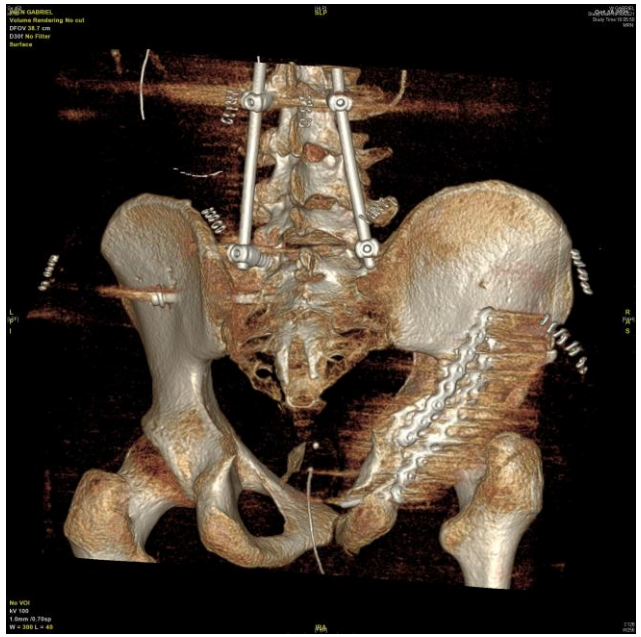
Follow-up CTs: NO incease in haematoma size over time under NON-operative treatment!

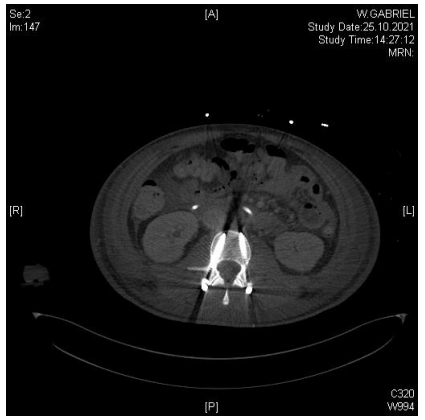


Case 2

Conversion to definitive osteosynthesis







„Hybrid approach“ > Coagulation management in an ideal world!

How I treat patients with massive hemorrhage

Pär I. Johansson,[1,2] Jakob Stensballe,[1,3] Roberto Oliveri,[1] Charles E. Wade,[2] Sisse R. Ostrowski,[1] and John B. Holcomb[2]

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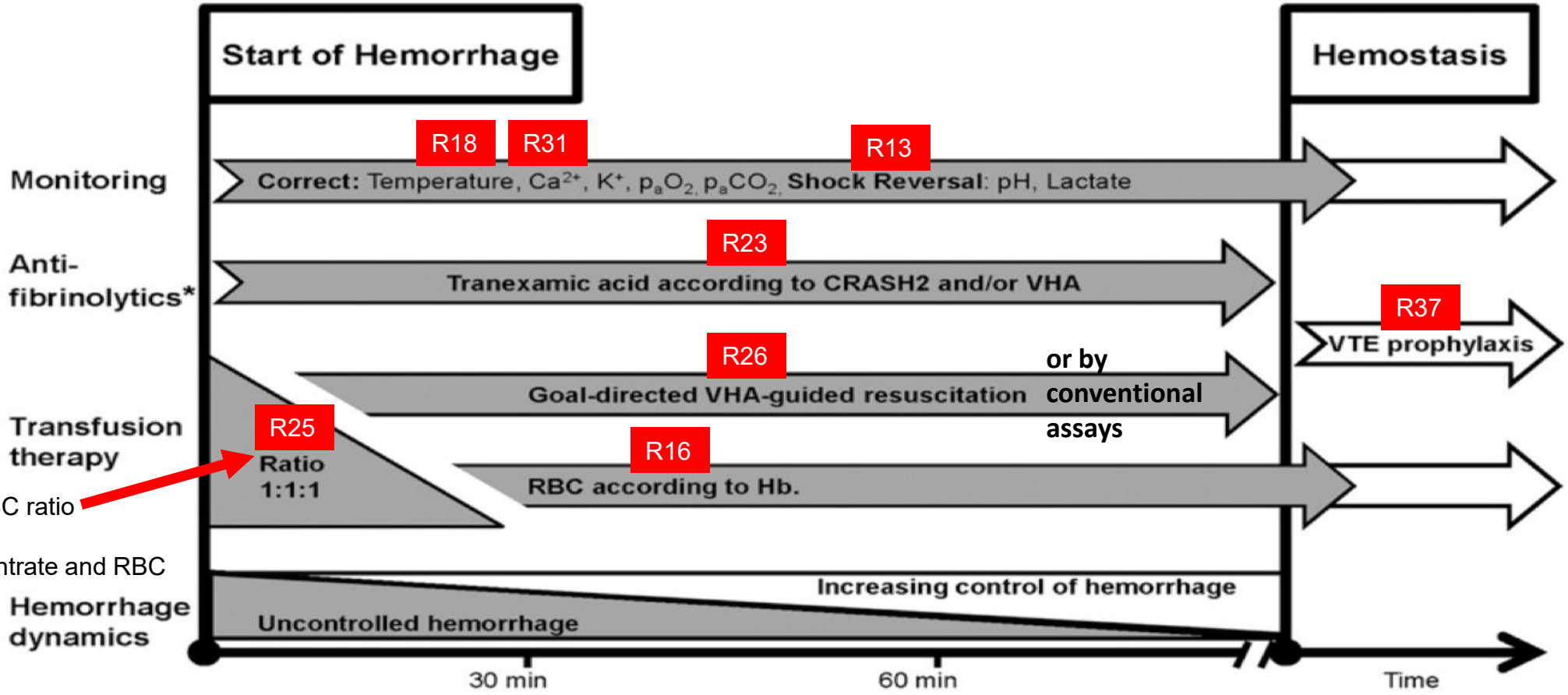
GUIDELINES Open Access

The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition

Rolf Rossaint[1*], Arash Afshari[2], Bertil Bouillon[3], Vladimir Cerny[4,5], Diana Cimpoesu[6], Nicola Curry[7,8], Jacques Duranteau[9], Daniela Filipescu[10], Oliver Grottke[1], Lars Grønlykke[11], Anatole Harrois[9], Beverley J. Hunt[12], Alexander Kaserer[13], Radko Komadina[14], Mikkel Herold Madsen[2], Marc Maegele[15], Lidia Mora[16], Louis Riddez[17], Carolina S. Romero[18], Charles-Marc Samama[19], Jean-Louis Vincent[20], Sebastian Wiberg[11] and Donat R. Spahn[13]

Rossaint *et al. Critical Care* (2023) 27:80
https://doi.org/10.1186/s13054-023-04327-7



FFP:RBC 1:2
+ high platelet:RBC ratio
or
Fibrinogen concentrate and RBC

Take home messages

Uncontrolled bleeding and evolving hemostatic failure (trauma-induced coagulopathy) remain the major killers in trauma

Treat the bleeding is to stopp the bleeding

Viscoelastic testing provides a rapid/comprehesive overview of whole blood coagulation dynamics

Can be use as „Point-of-Care“

Easy and rapid implementation through training (technology and algorithm)

Use supported by updated trauma guidelines (EU trauma, ESAIC and German S3-Trauma)

Test results form the back-bone of „goal-directed“ treatment algorithms

„Goal-directed“ algorithms are associated with less transfusion requirements and mortality

universität Witten/Herdecke

Thank you!