
STaT KiD
Shock Treatment and Trauma Kids in Distress
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Pediatric Emergency Medicine
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INTERNATIONAL TRAUMA conference CONNECT

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Disclosure
• No financial relationships - under or over

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Objectives
• Review Traumatic Hemorrhage
– Shock
– Trauma Induced Coagulapathy
– Damage Control Resuscitation
• Pediatric Considerations
– Hypotension
– Fluid Resuscitiation
– Antifibrinolytics

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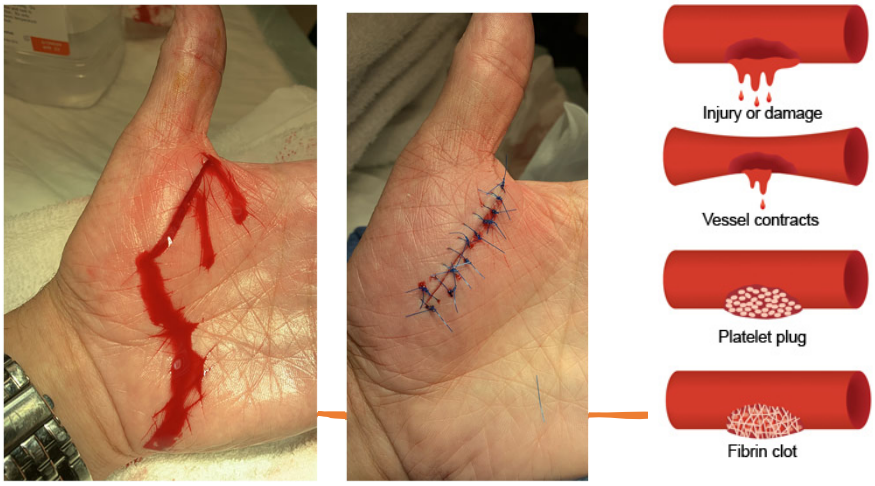
“Normal” wound



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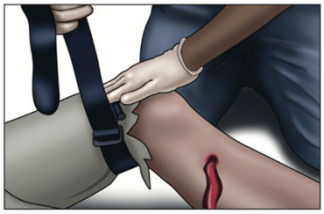
“Trauma” wound



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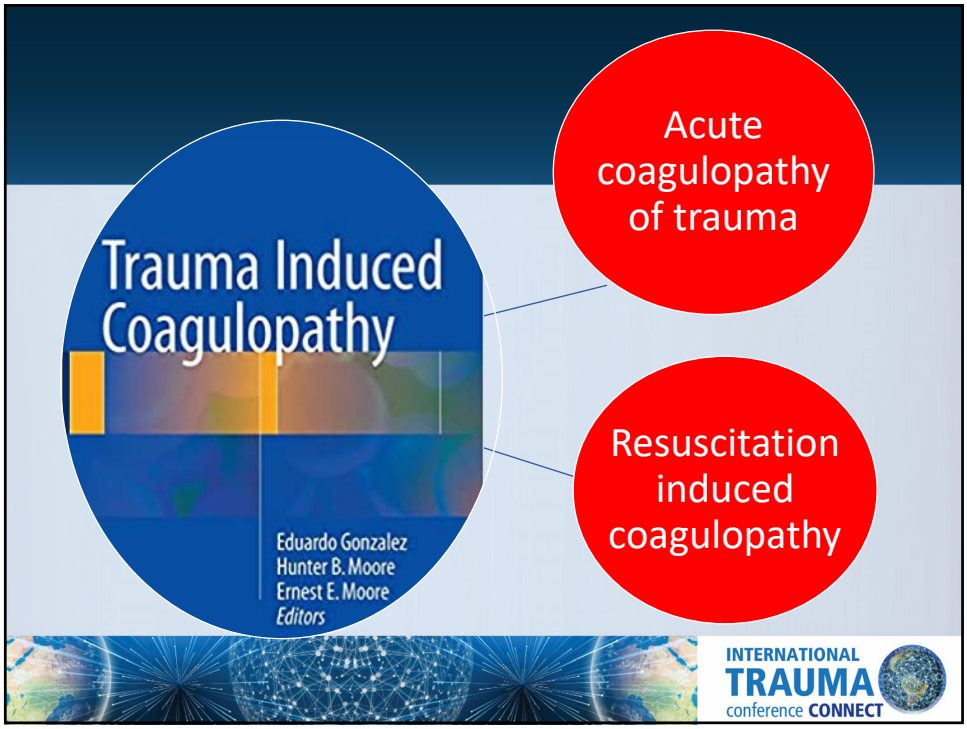
Trauma Induced Coagulopathy
Eduardo Gonzalez
Hunter B. Moore
Ernest E. Moore
Editors
Acute coagulopathy of trauma
Resuscitation induced coagulopathy
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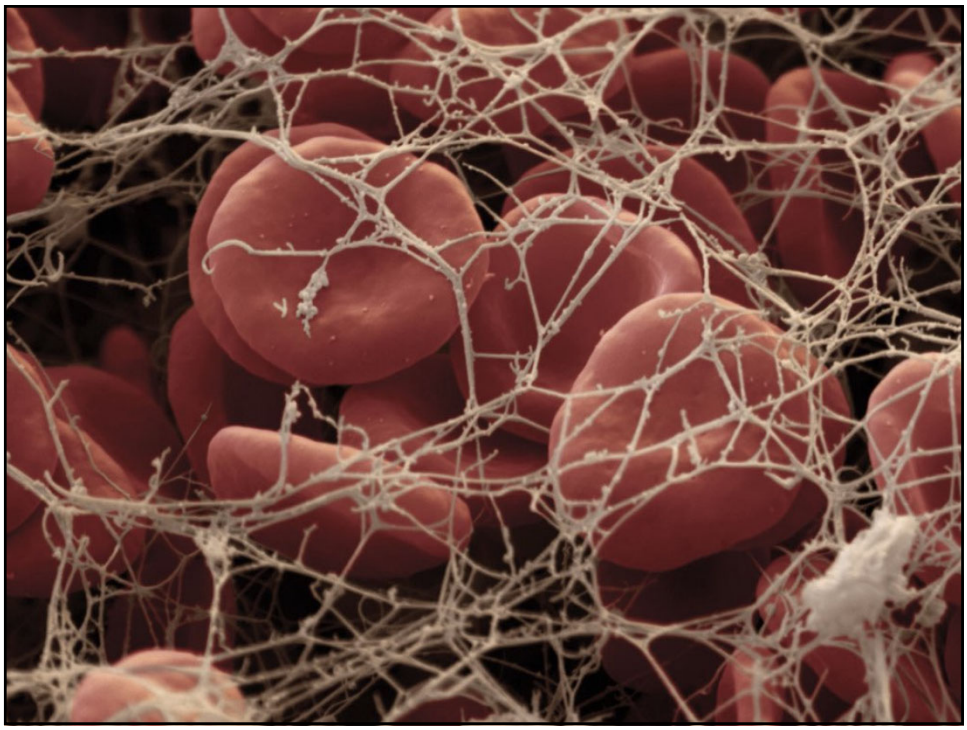

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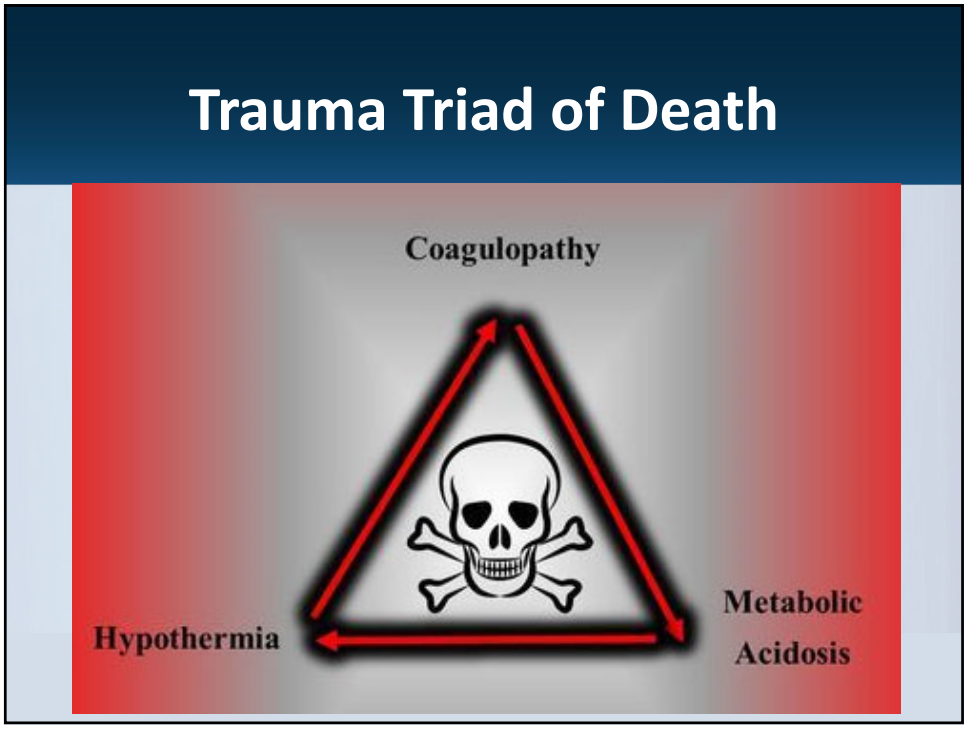
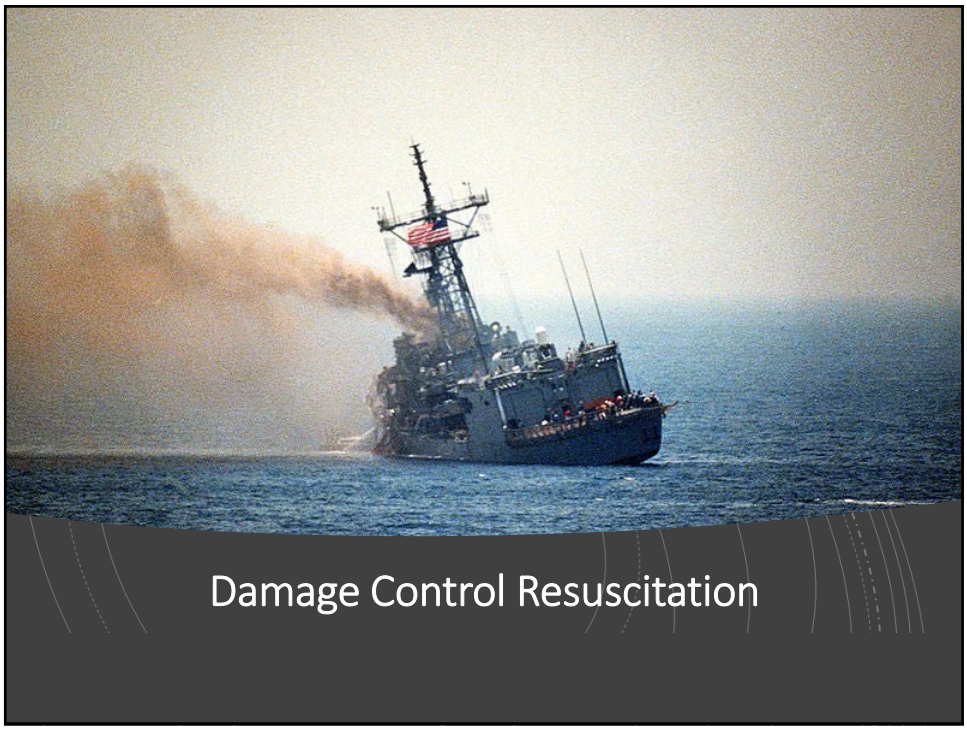
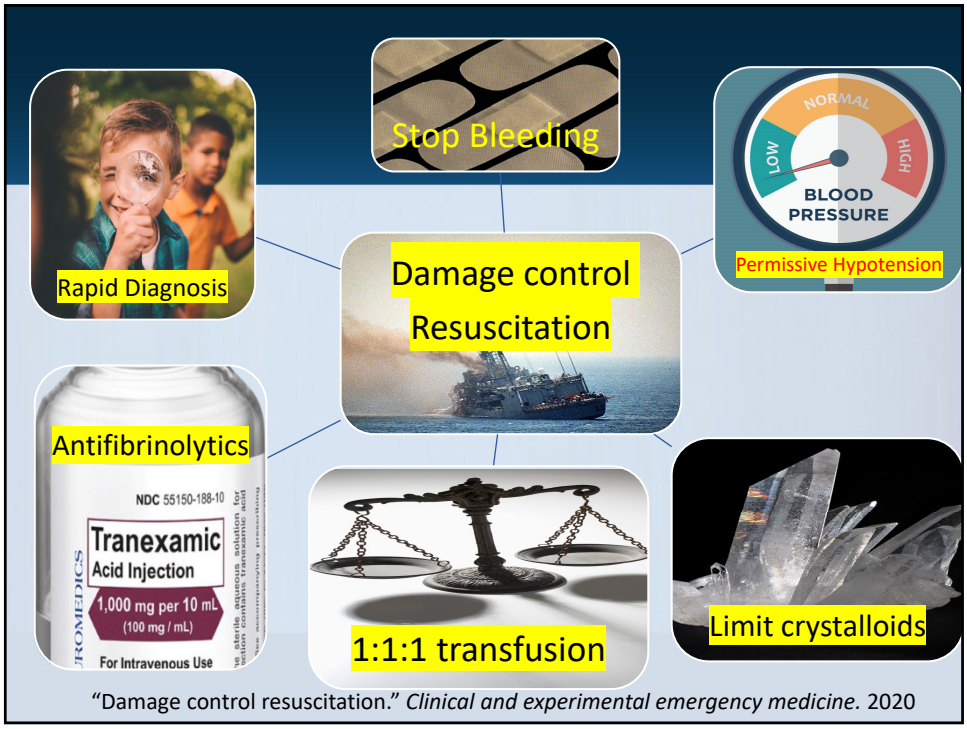

Trauma Triad of Death
Coagulopathy
Hypothermia
Metabolic
Acidosis

9


Damage Control Resuscitation

10



"Damage control resuscitation." *Clinical and experimental emergency medicine.* 2020

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Major trauma: assessment and management of major trauma

NICE Guideline NG39

Methods, evidence and recommendations

February 2016

- Restrictive volume resuscitation
- Early use of blood components

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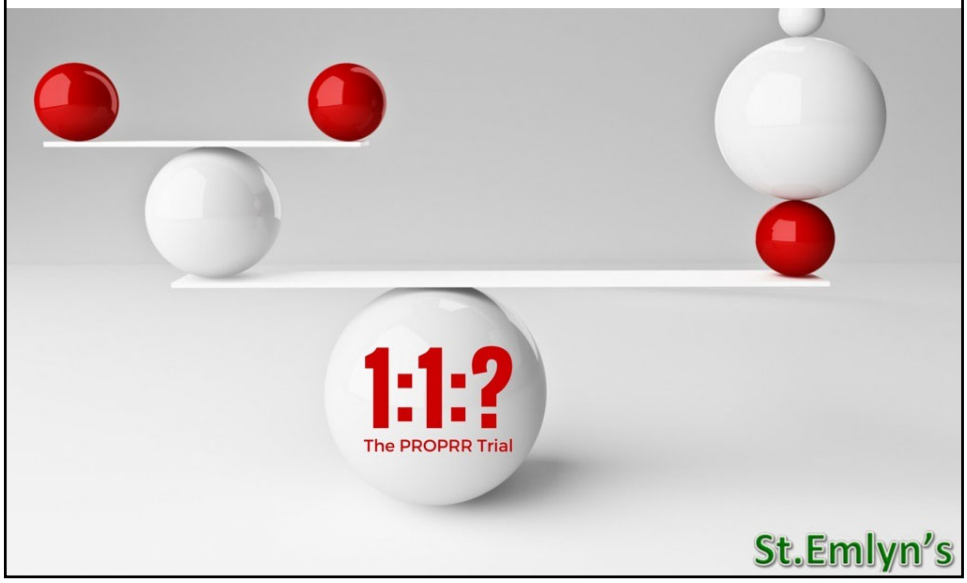
Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients With Severe Trauma
The PROPPR Randomized Clinical Trial



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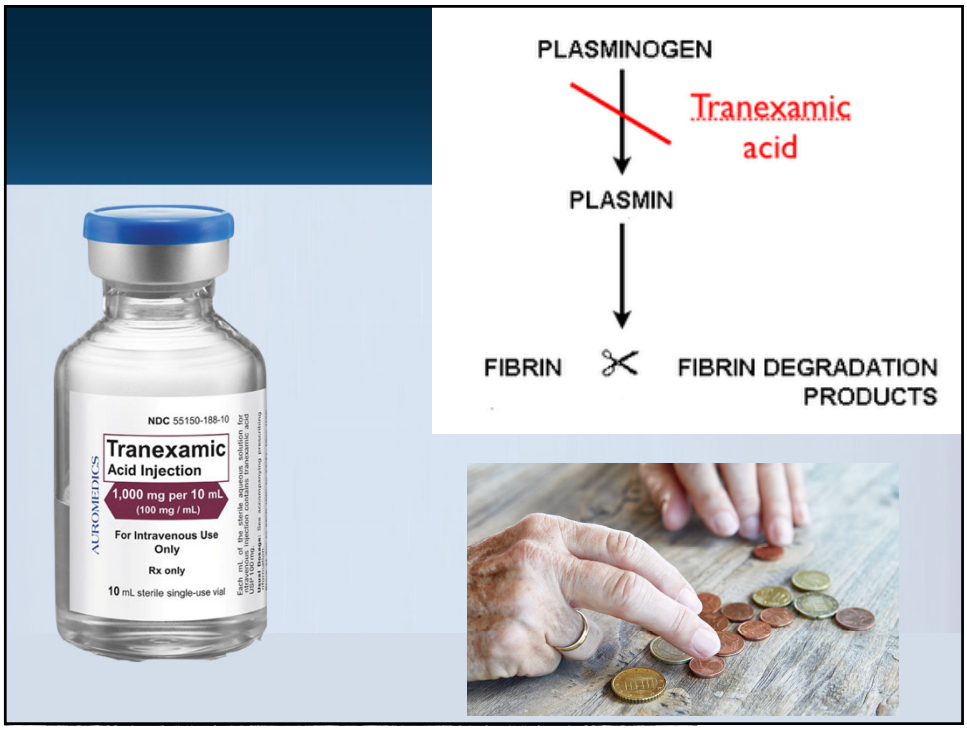

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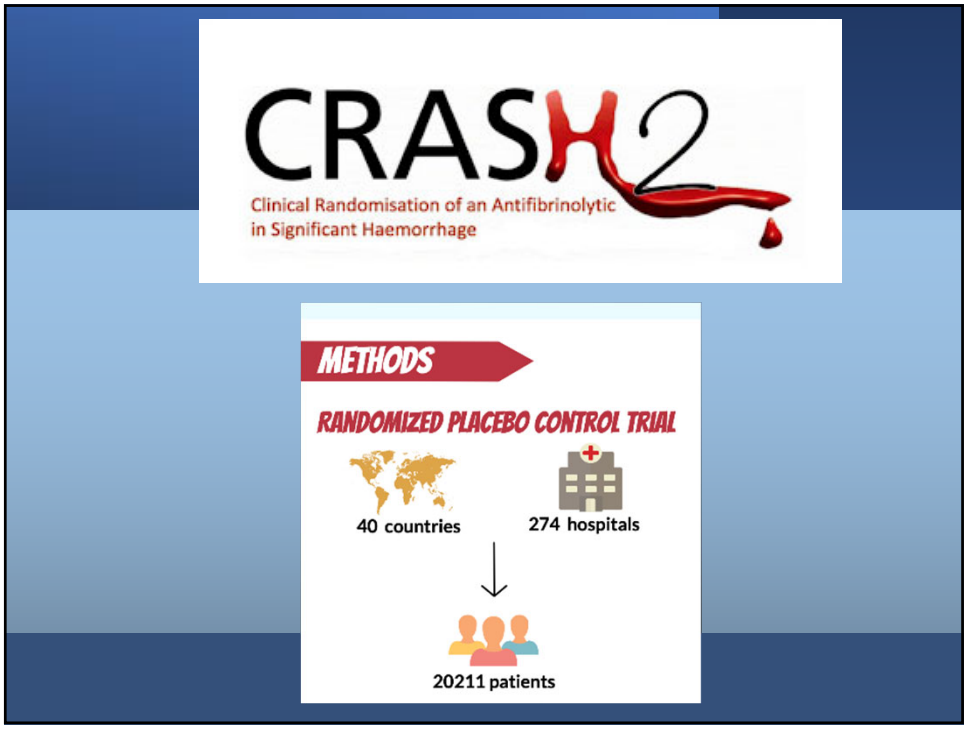
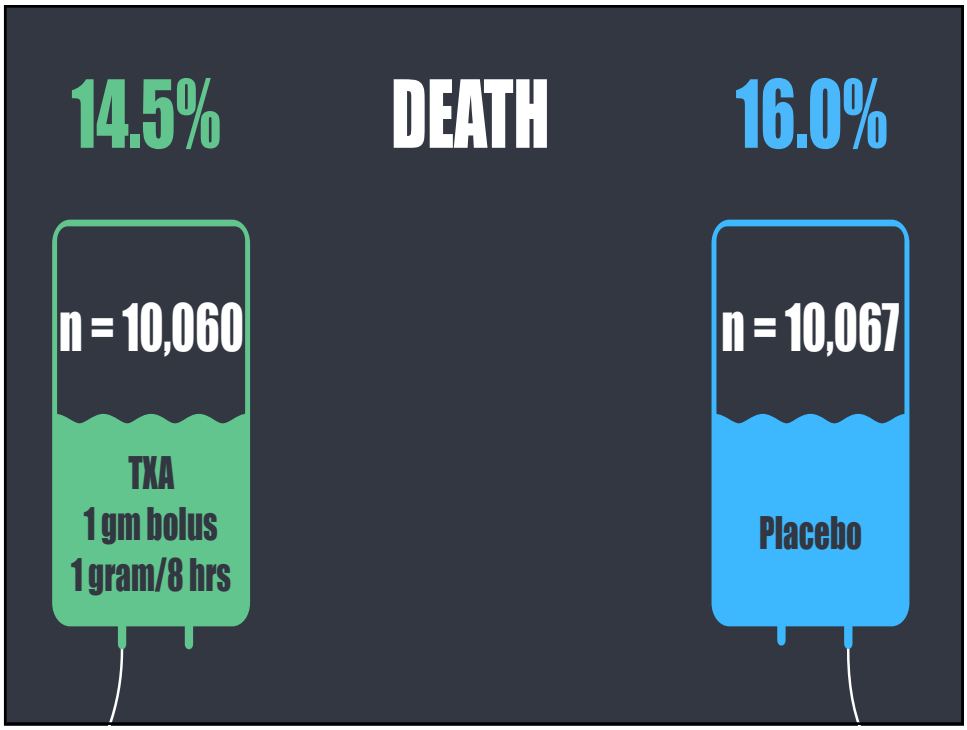
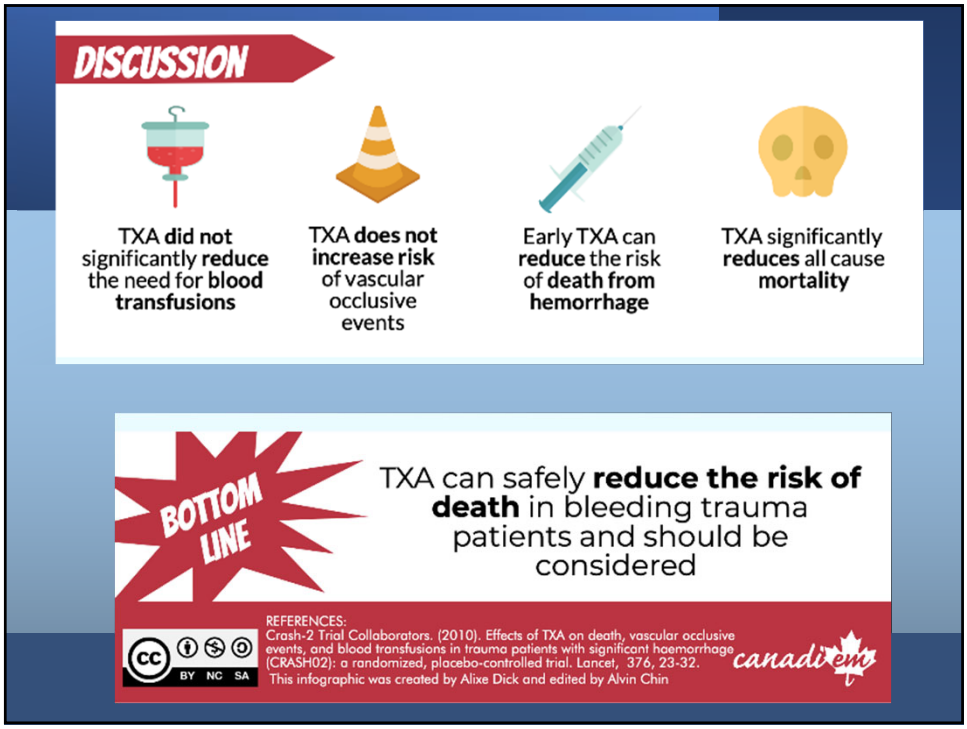

CRASH 2
Clinical Randomisation of an Antifibrinolytic in Significant Haemorrhage
METHODS
RANDOMIZED PLACEBO CONTROL TRIAL
40 countries
274 hospitals
20211 patients

15


14.5%
DEATH
16.0%
n = 10,060
TXA
1 gm bolus
1 gram/8 hrs
n = 10,067
Placebo

16


DISCUSSION
TXA did not significantly reduce the need for blood transfusions
TXA does not increase risk of vascular occlusive events
Early TXA can reduce the risk of death from hemorrhage
TXA significantly reduces all cause mortality
BOTTOM LINE
TXA can safely reduce the risk of death in bleeding trauma patients and should be considered
REFERENCES:
Crash-2 Trial Collaborators. (2010). Effects of TXA on death, vascular occlusive events, and blood transfusions in trauma patients with significant haemorrhage (CRASH02): a randomized, placebo-controlled trial. Lancet, 376, 23-32.
This infographic was created by Alixe Dick and edited by Alvin Chin
BY NC SA
canadiem

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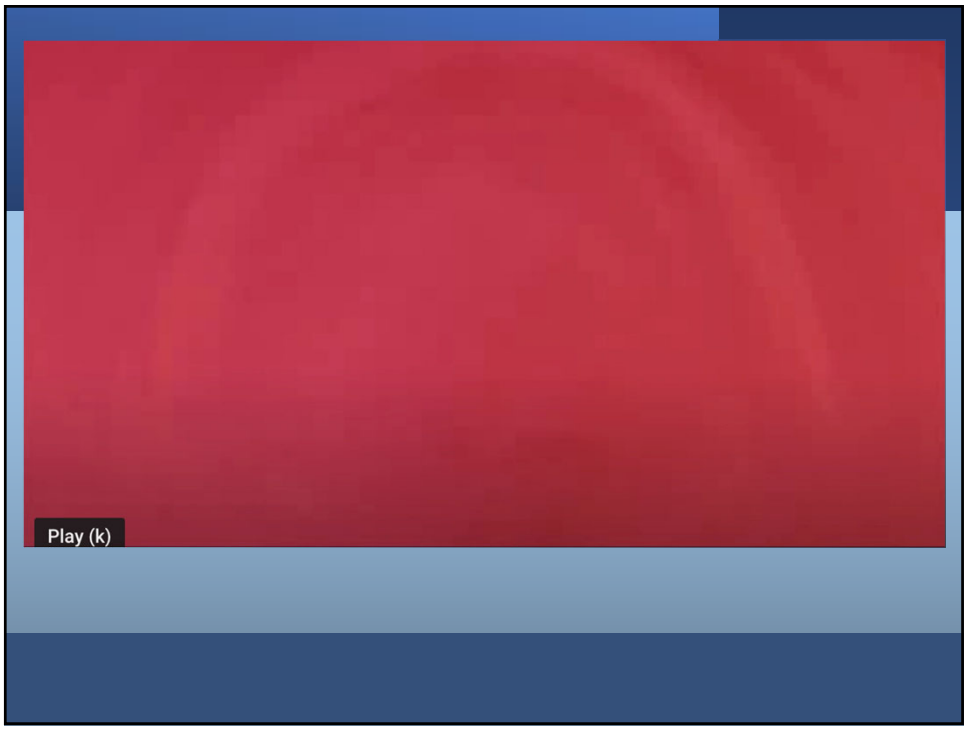
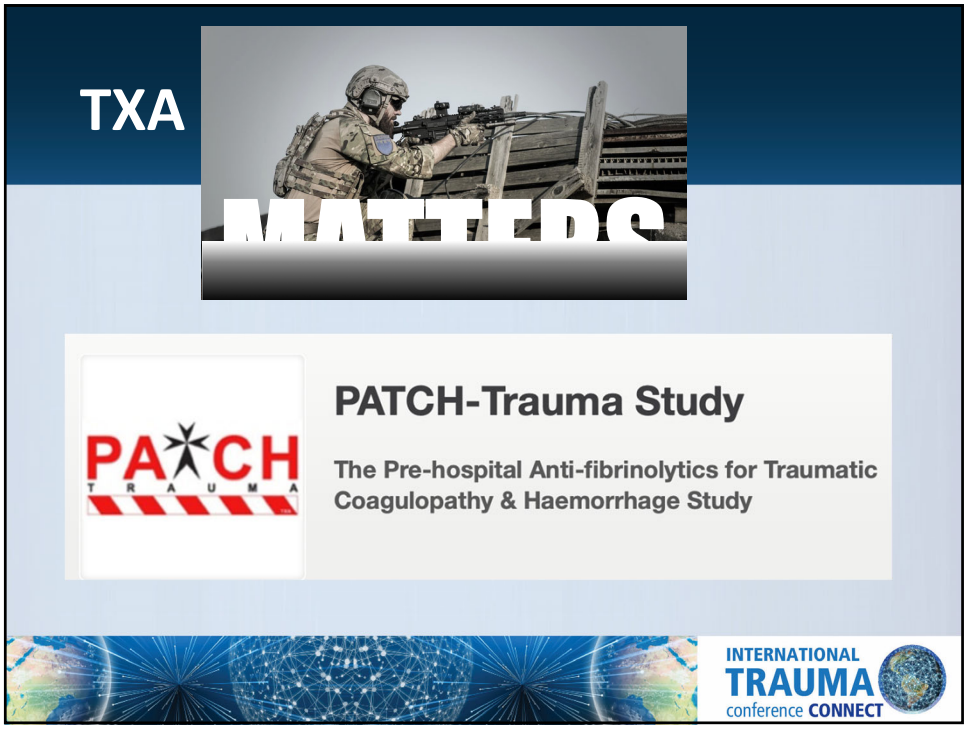

Play (k)

18


TXA
MATTERS
PATCH
TRAUMA
PATCH-Trauma Study
The Pre-hospital Anti-fibrinolytics for Traumatic Coagulopathy & Haemorrhage Study
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Pediatric Trauma

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Pediatric Shock
* photo warning…

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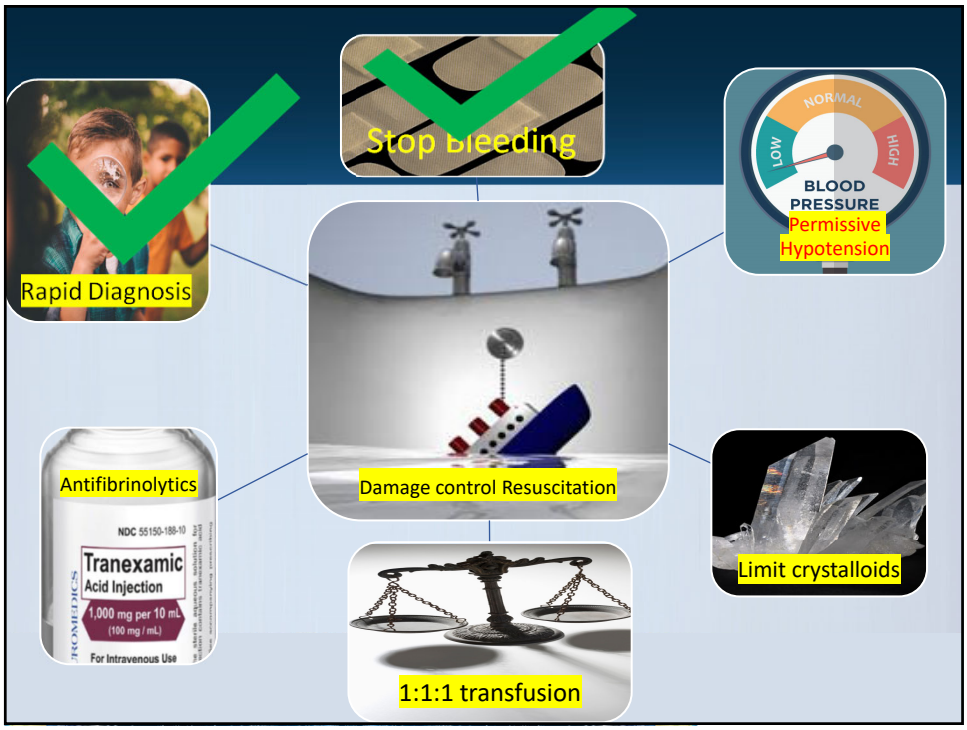
Stop Bleeding
Rapid Diagnosis
NORMAL
LOW
HIGH
BLOOD PRESSURE
Permissive Hypotension
Damage control Resuscitation
Antifibrinolytics
NDC 55150-188-10
Tranexamic
Acid Injection
1,000 mg per 10 mL
(100 mg / mL)
For Intravenous Use
Limit crystalloids
1:1:1 transfusion

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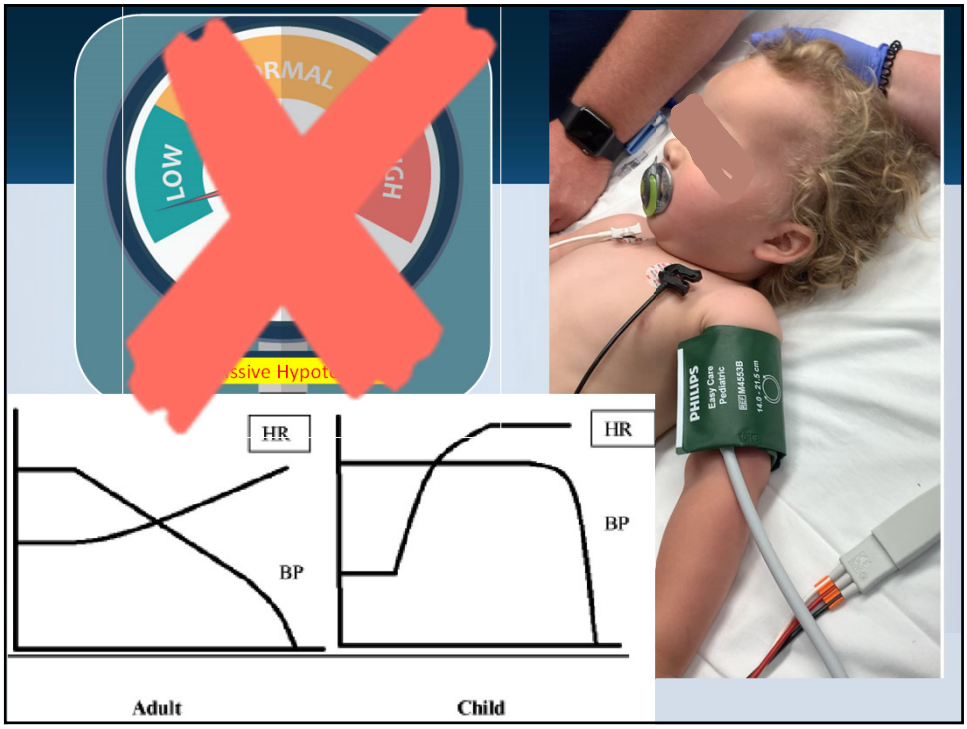
LOW
HR
BP
HR
BP
Adult
Child
PHILIPS
Easy Care
Pediatric

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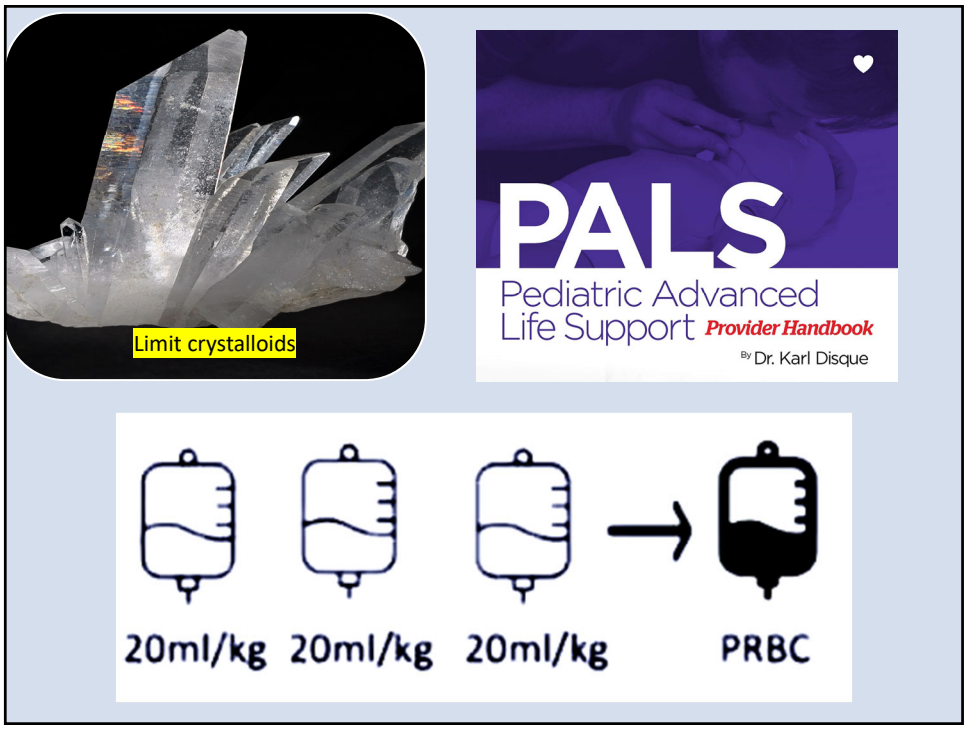
Limit crystalloids
PALS
Pediatric Advanced
Life Support
Provider Handbook
By Dr. Karl Disque
20ml/kg
20ml/kg
20ml/kg
PRBC

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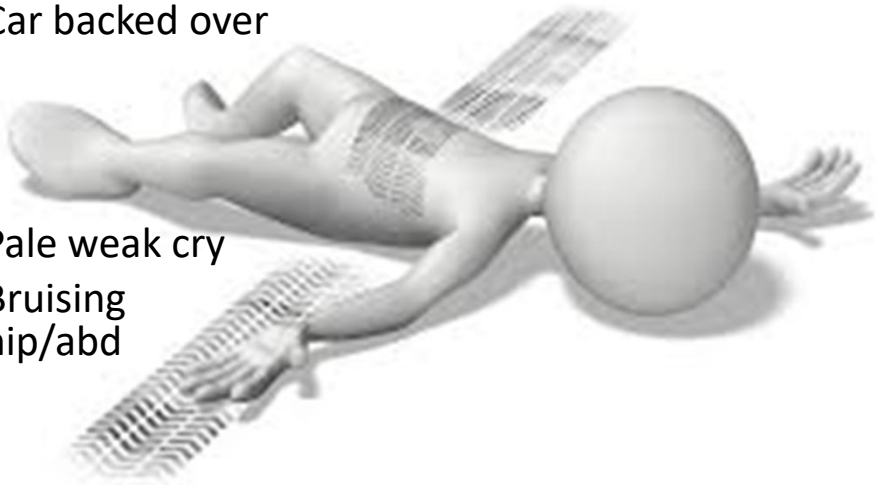
- 2 yo
- Car backed over



- Pale weak cry
- Bruising hip/abd
- SBP 70's
- HR 150

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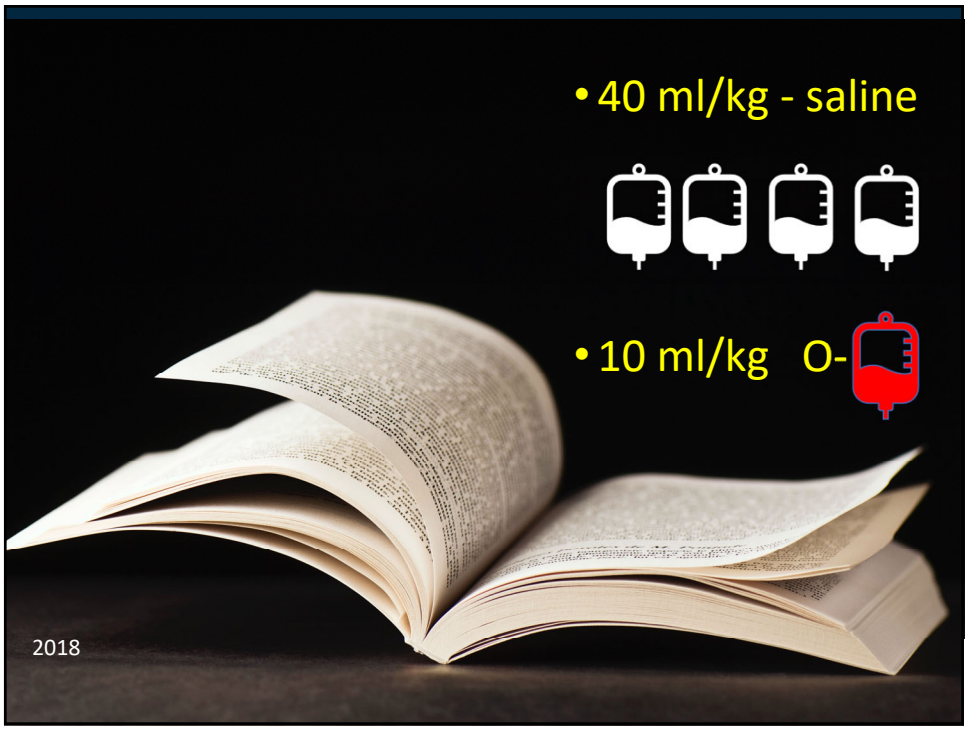

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- 2012

> J Trauma Acute Care Surg. 2012 Nov;73(5):1273-7. doi: 10.1097/TA.0b013e318265d267.

A pediatric massive transfusion protocol

- 2015

> J Trauma Acute Care Surg. 2015 Jan;78(1):22-8; discussion 28-9. doi: 10.1097/TA.0000000000000488.

Clearly defining pediatric massive transfusion: cutting through the fog and friction with combat data

- 2016

> Transfusion. 2016 Nov;56(11):2712-2719. doi: 10.1111/trf.13781. Epub 2016 Aug 29.

The effect of massive transfusion protocol implementation on pediatric trauma care

- 2018

Review > Curr Opin Pediatr. 2018 Jun;30(3):338-343. doi: 10.1097/MOP.0000000000000617.

Damage control resuscitation in pediatric trauma

- 2018

Review > Pediatr Emerg Care. 2018 Aug;34(8):594-598. doi: 10.1097/PEC.0000000000001570.

Pediatric Massive Transfusion: A Systematic Review

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Review > Semin Pediatr Surg. 2019 Feb;28(1):61-66. doi: 10.1053/j.sempedsurg.2019.01.011. Epub 2019 Jan 23.

Pediatric trauma-related coagulopathy: Balanced resuscitation, goal-directed therapy and viscoelastic assays

Natalie A Drucker [1], S Keisin Wang [1], Christopher Newton [2]

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ATLS 10th edition offers new insights into managing trauma patients

by SHARON HENRY, MD, FACS
PUBLISHED JUNE 1, 2018 • PRINT-FRIENDLY

CH 10: PEDIATRIC TRAUMA

- Limit crystalloid resuscitation
  - 20 ml/kg bolus
- MTP (massive transfusion protocol)
  - 10-20 ml/kg PRBC & 10-20 ml/kg FFP + Plts
- Thus far, NO survival advantages have been demonstrated….

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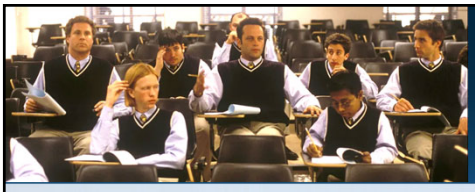
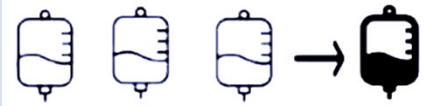


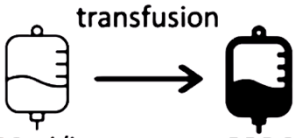
OLD SCHOOL

- Prior protocols suggested 3 boluses of crystalloid prior to blood transfusion



NEW SCHOOL

In pediatric trauma, failure of a sustained hemodynamic response to a single bolus of 20mL/kg crystalloid should be followed by blood transfusion



Polites, J Trauma Acute Care Surg 2020

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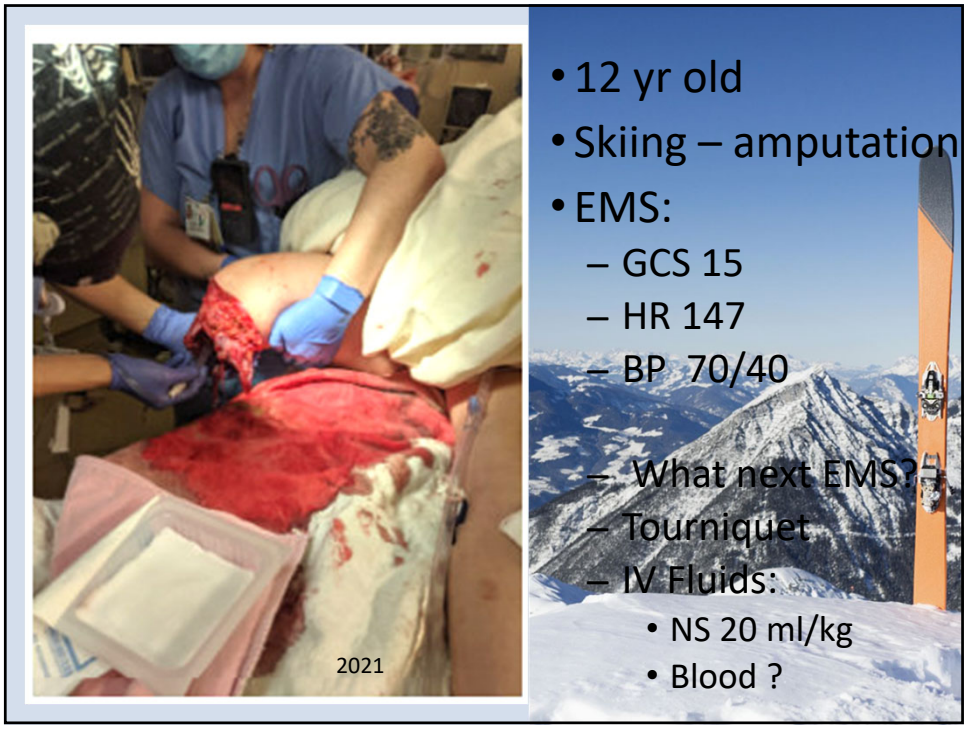
2021
• 12 yr old
• Skiing – amputation
• EMS:
– GCS 15
– HR 147
– BP 70/40
– What next EMS?
– Tourniquet
– IV Fluids:
• NS 20 ml/kg
• Blood ?

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R
JNW
Portable
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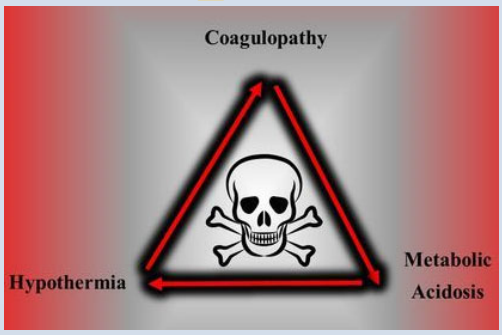
TIME	TEMP	BLOOD PRESSURE	HR	RHYTHM	RR	O2 SAT / O2	GCS
1718	34.9	145/132	134	SR	21	100 NRB	15
1722		144/119	135	SR	18	100 NRB	
1730		82/36	112	SR	16	100 NRB	
1733		93/48	100	SR	23	100	
1737		68/58	94	SR	18	100	



- T: 34.9
- Lactic Acid: 8.1
- CO_2 17
- INR/PT ↑
- ↓ BP

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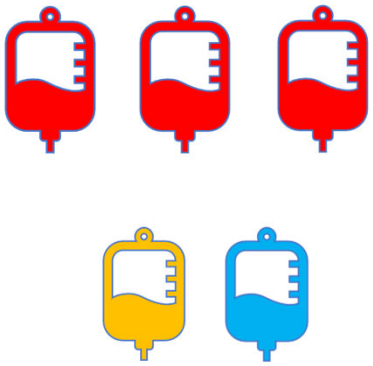
TIME	TEMP	BLOOD PRESSURE	HR	RHYTHM	RR	O2 SAT / O2	GCS	L PUPIL SIZE/ REACT.	R PUPIL SIZE/ REACT.	PAIN	MEDS & NURSING
1718	34.9	145/132	134	SR	21	100 NRB	15	3/x	3/x	6/10	
1722		144/119	135	SR	18	100 NRB		/	/		Blood started
1730		82/36	112	SR	16	100 NRB		/	/		
1733		93/48	100	SR	23	100		/	/		
1737		68/58	94	SR	18	100					
1739		88/49	90	SR	16	100					
1752		115/104	95	SR	26	100					
1755		109/90	98	SR	22	100					
1801	36.1	114/78	98	SR	20	100					
1804		112/90	97	SR	18	98					
1806		121/[illegible]	[illegible]	SR	20	100					



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PEDIATRICS

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Pediatric Life Support

2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations

- Review new research
- ? changes to management
  - Crystalloids vs blood
  - How much and when

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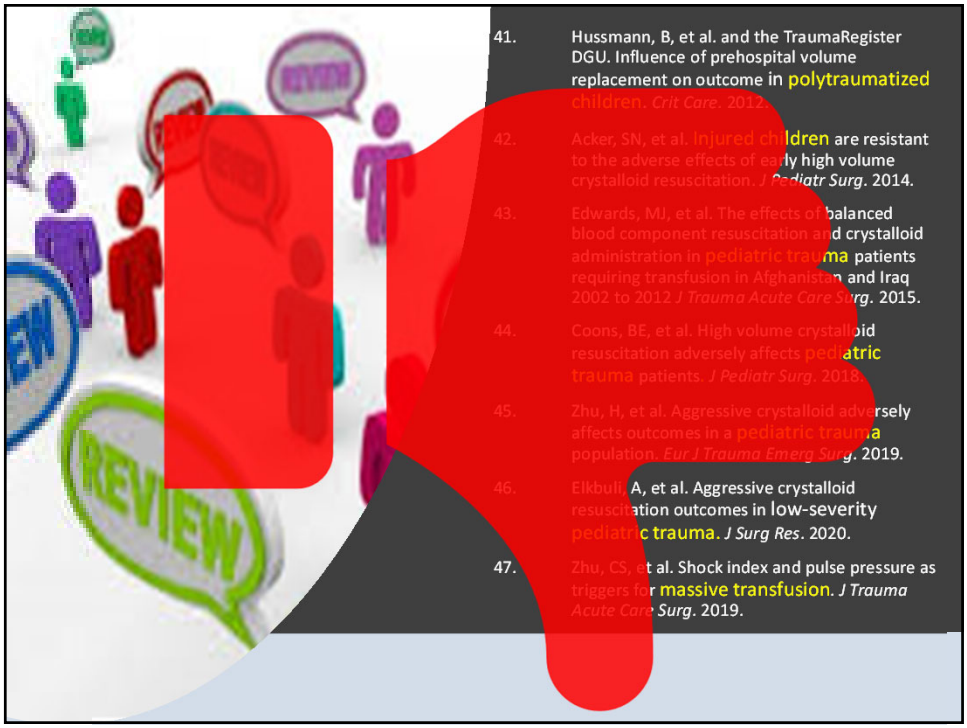

41. Hussmann, B, et al. and the TraumaRegister DGU. Influence of prehospital volume replacement on outcome in polytraumatized children. *Crit Care*. 2012.
42. Acker, SN, et al. Injured children are resistant to the adverse effects of early high volume crystalloid resuscitation. *J Pediatr Surg*. 2014.
43. Edwards, MJ, et al. The effects of balanced blood component resuscitation and crystalloid administration in pediatric trauma patients requiring transfusion in Afghanistan and Iraq 2002 to 2012 *J Trauma Acute Care Surg*. 2015.
44. Coons, BE, et al. High volume crystalloid resuscitation adversely affects pediatric trauma patients. *J Pediatr Surg*. 2018.
45. Zhu, H, et al. Aggressive crystalloid adversely affects outcomes in a pediatric trauma population. *Eur J Trauma Emerg Surg*. 2019.
46. Elkbuli A, et al. Aggressive crystalloid resuscitation outcomes in low-severity pediatric trauma. *J Surg Res*. 2020.
47. Zhu, CS, et al. Shock index and pulse pressure as triggers for massive transfusion. *J Trauma Acute Care Surg*. 2019.

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PEDIATRIC DCR

- Ideal ratio blood products not defined for children
- Blood product-based resuscitation not same survival results as adults
- Despite lack of published data – many pedi trauma centers use 1:1:1 (PRBC, FFP, Plts)

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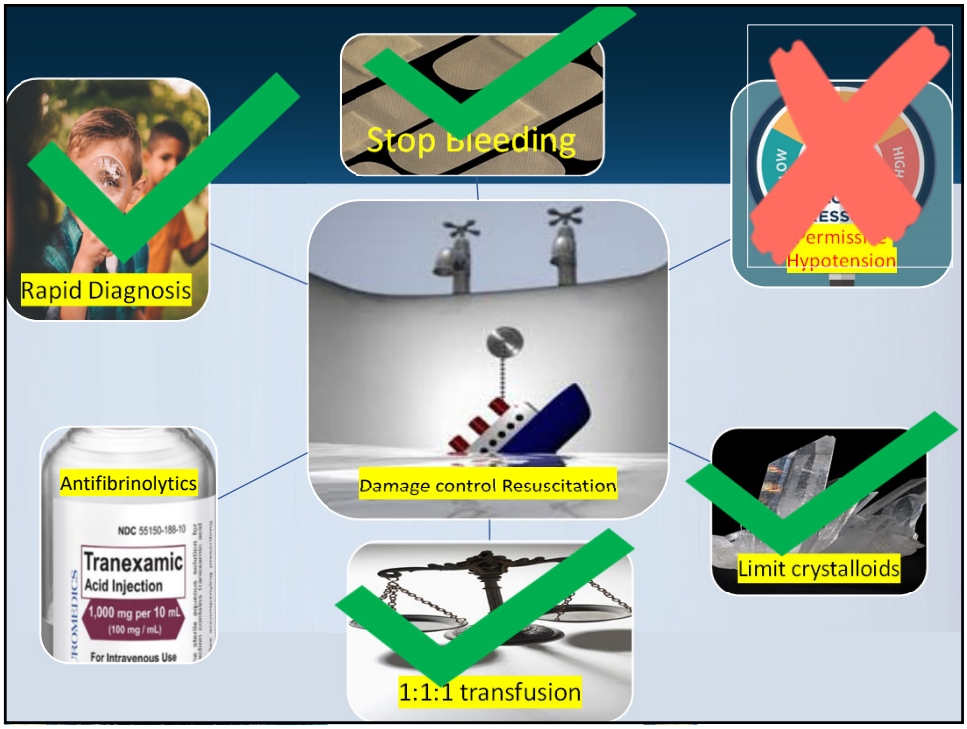

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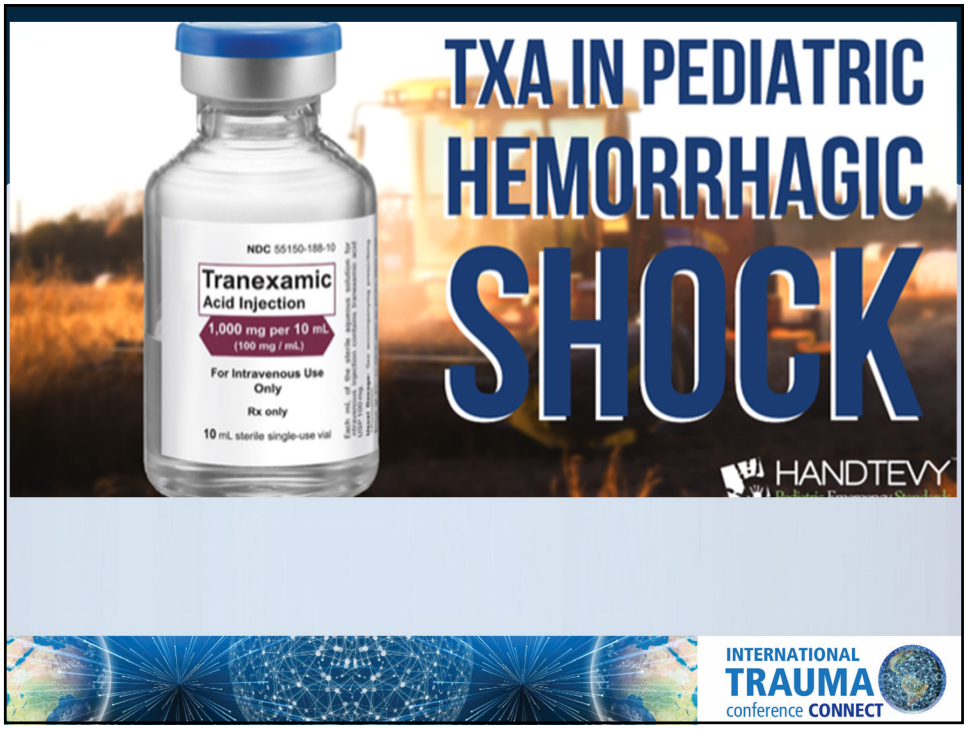
TXA IN PEDIATRIC
HEMORRHAGIC
SHOCK
NDC 55150-188-10
Tranexamic
Acid Injection
1,000 mg per 10 mL
(100 mg / mL)
For Intravenous Use
Only
Rx only
10 mL sterile single-use vial
HANDTEVY
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Slide Title
PED-TRAX

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Review > Crit Care. 2014 Jul 2;18(4):313. doi: 10.1186/cc13965.

Tranexamic acid in pediatric trauma: why not?

Suzanne Beno, Alun D Ackery, Jeannie Callum, Sandro Rizoli

> J Trauma Acute Care Surg. 2020 Aug;89(2S Suppl 2):S242-S245.
doi: 10.1097/TA.0000000000002701.

Tranexamic acid in pediatric combat trauma requiring massive transfusions and mortality

Mitchell Hamele [1], James K Aden, Matthew A Borgman

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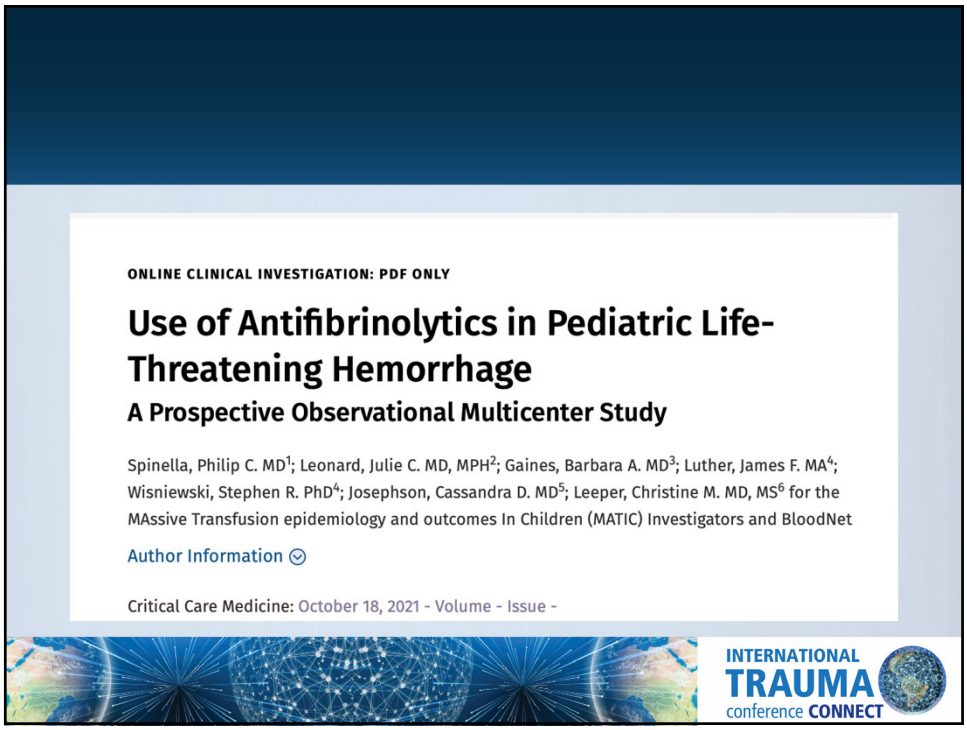

ONLINE CLINICAL INVESTIGATION: PDF ONLY

Use of Antifibrinolytics in Pediatric Life-Threatening Hemorrhage

A Prospective Observational Multicenter Study

Spinella, Philip C. MD[1]; Leonard, Julie C. MD, MPH[2]; Gaines, Barbara A. MD[3]; Luther, James F. MA[4]; Wisniewski, Stephen R. PhD[4]; Josephson, Cassandra D. MD[5]; Leeper, Christine M. MD, MS[6] for the MAssive Transfusion epidemiology and outcomes In Children (MATIC) Investigators and BloodNet

Author Information

Critical Care Medicine: October 18, 2021 - Volume - Issue -

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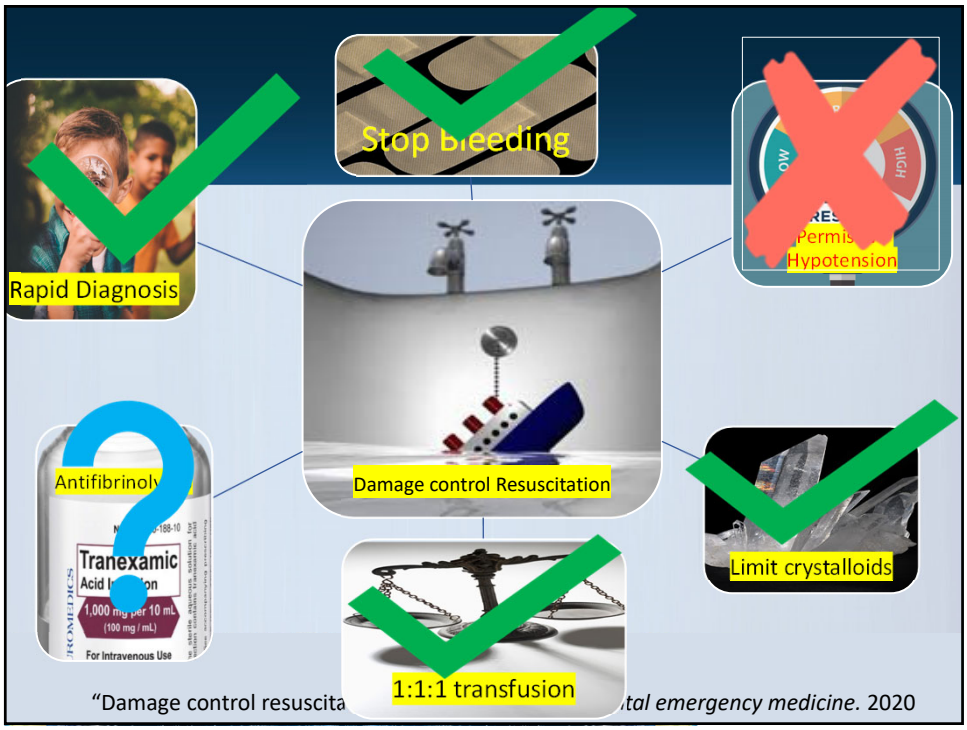

"Damage control resuscita tal emergency medicine. 2020

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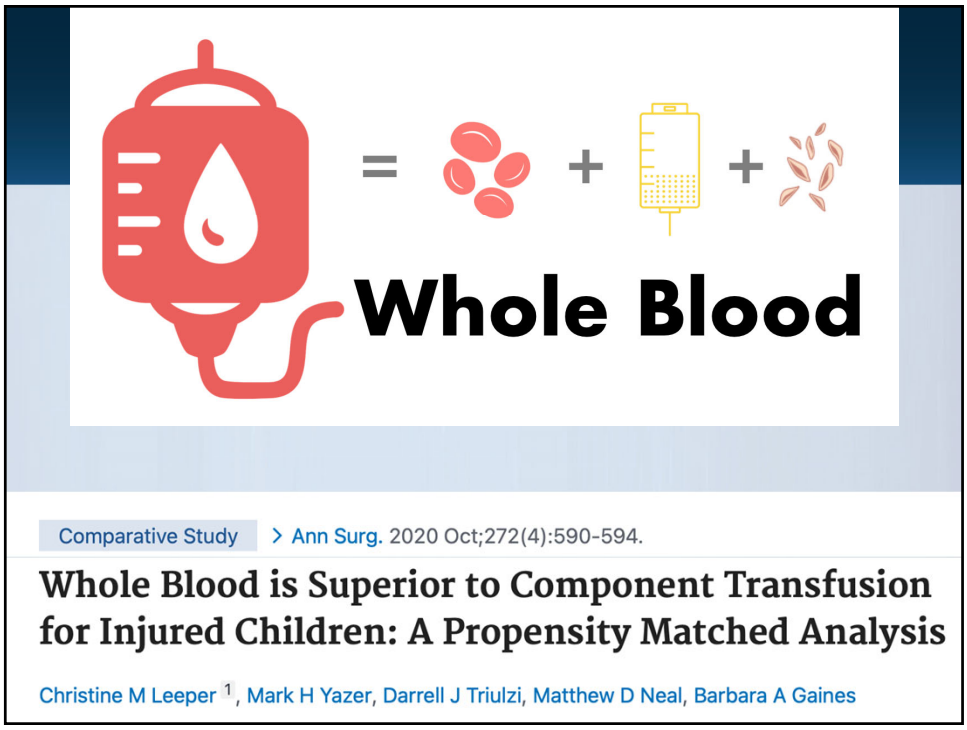

Comparative Study > Ann Surg. 2020 Oct;272(4):590-594.

Whole Blood is Superior to Component Transfusion for Injured Children: A Propensity Matched Analysis

Christine M Leeper [1], Mark H Yazer, Darrell J Triulzi, Matthew D Neal, Barbara A Gaines

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Outcomes for Whole Blood Transfusions in Injured Children

Patient Selection

- ≥ 1 year
- Signs of shock after injury
- Un-crossmatched O whole blood
  - Leukocyte reduced
  - Low Ag titer anti-A and -B
- Transfuse up to 40 mL/kg
- Initial resuscitative fluid

Preliminary Results

- NO adverse transfusion reactions
- Safe and feasible

Propensity-Matched Study

Whole Blood vs. Component Therapy

N = 28 N = 28

Matched for:
Age
Mechanism of Injury
Severe TBI
Admission Hypotension
Need for urgent surgery

Outcomes

Whole Blood Group

- Faster time to resolution of base deficit (2 vs. 6 hours)
- Lower post-transfusion INR (1.4 vs. 1.6)
- Lower transfusions volumes

= No Differences =

- In-hospital mortality
- Functional disability
- Hospital/ICU length of stay
- Ventilator days

Leeper CM et al Ann Surg 270: 590-594, 2020

UVMMC ED trauma blood refrigerator contains 2 units O+ PRBCs and 2 units AB plasma; stocking whole blood being evaluated

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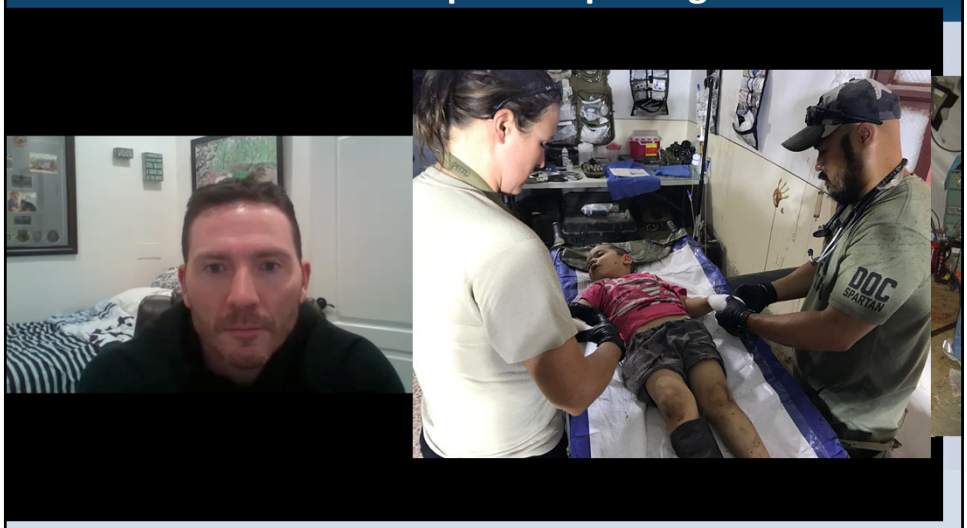
Dr James Bailey, MD FACEP

USAF PICU Nurse → Special Ops Surgical Team



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Dr James Bailey, MD FACEP
USAF PICU Nurse → Specia
Ops Surgical Team

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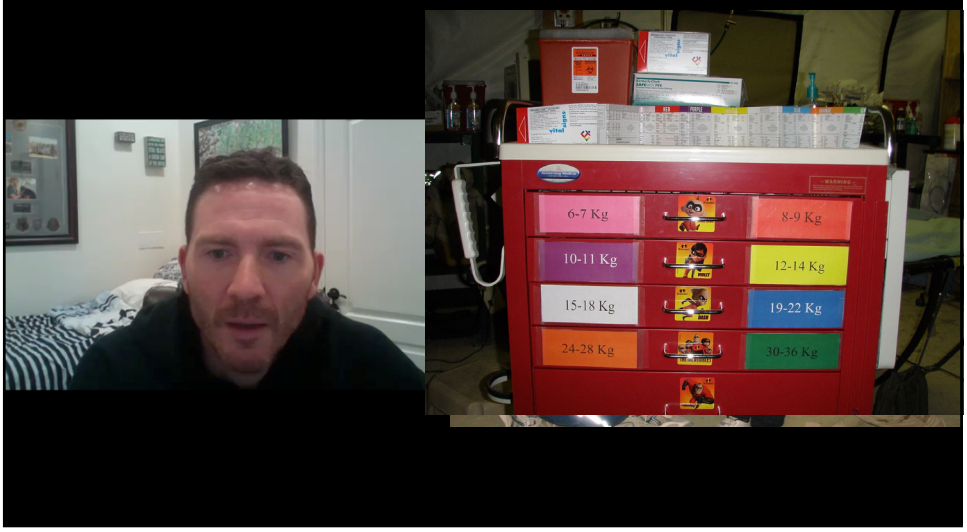
Dr James Bailey, MD FACEP

USAF PICU Nurse → Special Ops Surgical Team



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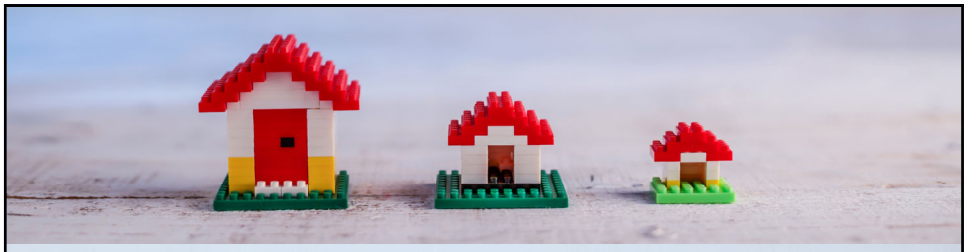

- Pediatric Trauma care is similar to adults
  - Exception: Hypotension = late and deadly finding
- Balanced Resuscitation
  - Limit crystalloids
  - Early blood - 1:1:1 vs Fresh whole blood
- Consider TXA
  - Watch for new Pediatric studies

INTERNATIONAL TRAUMA conference CONNECT

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References

- 48.Kanani, AN, Hartshorn, S. NICE clinical guideline NG39: Major trauma: assessment and initial management. *Arch Dis Child Educ Pract Ed*. 2017;102:20–23. doi: 10.1136/archdischild-2016-310869.
- 49.Henry, S. *ATLS Advanced Trauma Life Support 10th Edition Student Course Manual*. Chicago, IL: American College of Surgeons; 2018.
- Beno, S., *et al.* Tranexamic acid in pediatric trauma: why not?. *Crit Care* **18,** 313 (2014). https://doi.org/10.1186/cc13965
- Leibner E, Andreae M, Galvagno SM, Scalea T. Damage control resuscitation. *Clin Exp Emerg Med*. 2020;7(1):5-13. doi:10.15441/ceem.19.089
- Gilley M, Beno S. Damage control resuscitation in pediatric trauma. Curr Opin Pediatr. 2018 Jun;30(3):338-343. doi: 10.1097/MOP.0000000000000617. PMID: 29474273.
- Holcomb JB, et al. Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients With Severe Trauma: The PROPPR Randomized Clinical Trial. *JAMA*.2015;313(5):471–482. doi:10.1001/jama.2015.12
- Leeper, Christine M et al. Whole Blood is Superior to Component Transfusion for Injured Children, Annals of Surgery: October 2020 - Volume 272 - Issue 4 - p 590-594 doi: 10.1097/SLA.0000000000004378
- Polites SF, et al. Timing and volume of crystalloid and blood products in pediatric trauma: An Eastern Association for the Surgery of Trauma multicenter prospective observational study. *J Trauma Acute Care Surg*. 2020;89(1):36-42. doi:10.1097/TA.0000000000002702
- Hayakawa, Mineji. "Pathophysiology of trauma-induced coagulopathy: disseminated intravascular coagulation with the fibrinolytic phenotype." *Journal of Intensive Care* 5 (2017): n. pag.

INTERNATIONAL TRAUMA conference CONNECT

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References

- https://pedemmorsels.com/damage-control-resuscitation/
- https://www.tamingthesru.com/blog/2018/5/27/whole-blood-more-than-the-sum-of-its-components
- https://www.jems.com/patient-care/whole-blood-in-ems-may-save-lives/
- https://www.stemlynsblog.org/ic-getting-balance-right-proppr-trial/
- Al-Abri M, Trauma-Induced Coagulopathy. Ame J Surg Clin Case Rep. 2021; 2(6): 1-6.
- Panapa M, Davenport M, Winograd SM. Approaches to the hemorrhaging pediatric trauma patient. *Trauma Reports*. 2021;22(6)
- Wong, J.*et al.* Tranexamic acid: current use in obstetrics, major orthopedic, and trauma surgery. *Can J Anesth/J Can Anesth* **68,** 894–917 (2021)
- Mitra, B, et al."Protocol for a Multicentre Prehospital Randomised Controlled Trial Investigating Tranexamic Acid in Severe Trauma: The PATCH-Trauma Trial." BMJ Open 11.3 (2021): E046522. Web.
- Drucker NA, et al. Pediatric trauma-related coagulopathy: Balanced resuscitation, goal-directed therapy and viscoelastic assays. *Semin Pediatr Surg*. 2019;28(1):61-66.
- Spinella PC, et al.,; MAssive Transfusion epidemiology and outcomes In Children (MATIC) Investigators and BloodNet. Use of Antifibrinolytics in Pediatric Life-Threatening Hemorrhage: A Prospective Observational Multicenter Study. Crit Care Med. 2021 Oct 18.

INTERNATIONAL TRAUMA conference CONNECT

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References

- Maw G, Furyk C. Pediatric Massive Transfusion: A Systematic Review. *Pediatr Emerg Care*. 2018;34(8):594-598.
- Chidester SJ, et al., A pediatric massive transfusion protocol. *J Trauma Acute Care Surg*. 2012;73(5):1273-1277.
- Hwu RS, Spinella PC, et al., The effect of massive transfusion protocol implementation on pediatric trauma care. *Transfusion*. 2016;56(11):2712-2719.
- Neff LP, et al., Clearly defining pediatric massive transfusion: cutting through the fog and friction with combat data. *J Trauma Acute Care Surg*. 2015;78(1):22-29.
- Hendrickson JE, et al. Coagulopathy is prevalent and associated with adverse outcomes in transfused pediatric trauma patients. *J Pediatr*. 2012;160(2):204-209.e3.
- Strumwasser A, et al. The impact of acute coagulopathy on mortality in pediatric trauma patients. *J Trauma Acute Care Surg*. 2016;81(2):312-318.

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