

Early Resuscitation in Hemorrhagic Shock



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Disclosures

•No relevant financial disclosures or conflicts of interest




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Case

59 y/o male motor vehicle crash

- Intubated in field for altered mentation
- Tourniquet placed LLE
- Initial SBP 50 mmHg; HR 70 bpm



- Potential causes of hypotension?
- Now what?



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Case

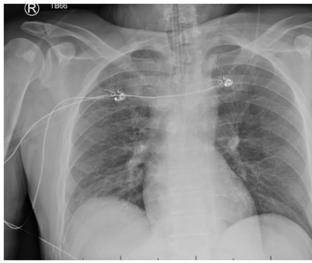
- 2 units whole blood/MTP activated
- 1 gram TXA
- TEG sent
- Hemostatic dressing applied



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Case



(-) FAST

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Case



Prior to CT scan noted to have active bleeding from LLE. What now?

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Case



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Case

- OR for LLE exploration
- Transected popliteal artery and vein
- Hemodynamics improve
- Repaired, fasciotomy performed

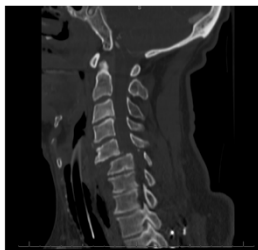


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Case

- Patient shot himself in leg prior to crash
- High spinal cord injury
- Hypotension related to hemorrhage and neurogenic shock



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Primary Survey: (C)ABCDE

- Circulation (major external hemorrhage)
- Airway
- Breathing
- Circulation
- Disability
- Exposure

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The Hypotensive Patient

Hypotension = bleeding until proven otherwise

Bleeding = #1 cause of PREVENTABLE death in trauma

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The Hypotensive Patient

- Where are the 7 places into which a human can exsanguinate?
 - Thoracic cavity (x 2)
 - Abdomen
 - Pelvis/retroperitoneum
 - Femur (x 2)
 - Onto the floor (external hemorrhage)

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Initial Resuscitation

- Early balanced resuscitation
 - 1:1:1 PRBC/Plasma/Platelets *and/or whole blood*
 - Cryoprecipitate
 - TEG-guided resuscitation may improve survival
- Pharmaceutical adjuncts
 - Tranexamic acid (TXA)
 - Prothrombin complex concentrate

1. Reynolds M et al. The proportion, observational incidence, and clinical outcomes of a low-mortality bleeding and coagulopathy risk score. *Transfusion*. 2013;53(12):2277-2284.

2. Reynolds M et al. The proportion, observational incidence, and clinical outcomes of a low-mortality bleeding and coagulopathy risk score. *Transfusion*. 2013;53(12):2277-2284.

3. Reynolds M et al. The proportion, observational incidence, and clinical outcomes of a low-mortality bleeding and coagulopathy risk score. *Transfusion*. 2013;53(12):2277-2284.

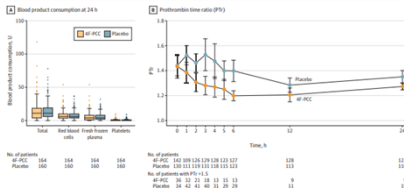
4. Reynolds M et al. The proportion, observational incidence, and clinical outcomes of a low-mortality bleeding and coagulopathy risk score. *Transfusion*. 2013;53(12):2277-2284.

5. Reynolds M et al. The proportion, observational incidence, and clinical outcomes of a low-mortality bleeding and coagulopathy risk score. *Transfusion*. 2013;53(12):2277-2284.



Addition of PCC to MTP

Figure 2. Transfusion-Related Secondary Outcomes by Treatment Group

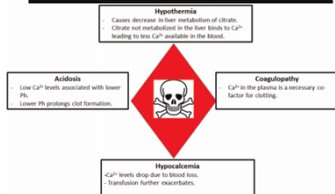


1. Reynolds M et al. Efficacy and safety of early administration of factor prothrombin complex concentrate in patients with trauma of risk of massive transfusion: the PROPPR randomized clinical trial. *JAMA*. 2021;325(18):1701-1710.



"Lethal Diamond"

LETHAL DIAMOND- THE ROLE OF CA²⁺



1. Moore FA et al. A review of transfusion and transfusion-related complications. Is it time to change the blood bank in the hospital? *J Trauma Acute Care Surg*. 2010;68(2):439-45.



Evolution of Fluid Resuscitation

- Whole blood
- Individual components (around Vietnam)
- Massive crystalloid resuscitation (1990s)
- 1:1:1 resuscitation
- Whole blood

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PROMTT

- Prospective cohort study
- Adults surviving > 30 minutes who received blood
- Increased plasma:PRBC and platelet:PRBC = better 6 hour mortality
- <1:2 were 3-4x more likely to die (early) compared with 1:1 or higher

1. Holcomb JJ et al. The prospective, observational, multicenter, major trauma transfusion (PROMTT) study. JAMA Surg. 2013;148(2):127-36.

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PROPPR

- RCT of patients predicted to require MTP
- 1:1:1 vs 1:1:2 (plasma/platelets/PRBC)
- Decreased death by exsanguination at 24 hours in 1:1:1
- No difference in overall survival

1. Holcomb JJ et al. Transfusion of plasma, platelets, and low-dose RBCs to 4:1:1 or 1:1:2 ratio and mortality in patients with severe trauma: the PROPPR randomized clinical trial. JAMA. 2015;313(10):471-81.

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Potential Whole Blood Benefits

- Improved logistics
- Faster resolution of shock/coagulopathy
- Decreased infection
- Less citrate
- Less donor exposure
- Decreased overall transfusion requirements
- Improved survival?

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Whole Blood vs. Component Therapy

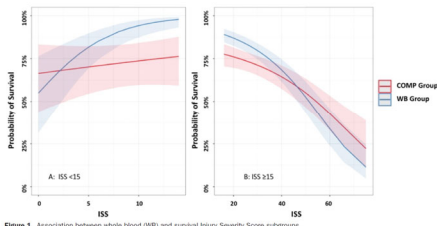


Figure 1. Association between whole blood (WB) and survival injury Severity Score subgroups.

1. Bell JL, et al. Impact of incorporating whole blood into hemorrhagic shock resuscitation: analysis of 1,377 consecutive trauma patients receiving emergency-release uncrossmatched blood products. J Am Coll Surg. 2022;234(4):638-645.

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Whole Blood vs. Component Therapy

Multivariable Analyses Evaluating the Impact of Low-Titer Group O Whole Blood on 30-Day Survival

	Unweighted Analysis		Weighted Analysis	
	Odds Ratio (95% CI)	p Value	Odds Ratio (95% CI)	p Value
30-Day Survival				
WB group	4.10 (2.22-7.45)	<.001	1.59 (1.28-1.98)	<.001
Age, per year	0.97 (0.96-0.98)	0.001	0.99 (0.98-0.99)	<.001
Male sex	0.46 (0.24-0.87)	0.018	0.77 (0.60-0.98)	0.04
ISS, per point	0.93 (0.92-0.95)	<.001	0.95 (0.94-0.96)	<.001
Scene SBP, per mmHg	1.00 (0.99-1.01)	0.286	1.009 (1.006-1.012)	<.001
Arrival lactate, per mmol/L	0.82 (0.76-0.88)	<.001	0.89 (0.87-0.92)	<.001

1. Bell JL, et al. Impact of incorporating whole blood into hemorrhagic shock resuscitation: analysis of 1,377 consecutive trauma patients receiving emergency-release uncrossmatched blood products. J Am Coll Surg. 2022;234(4):638-645.

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Pre-Hospital Whole Blood

The Impact of Prehospital Whole Blood on Hemorrhaging Trauma Patients: A Multi-Center Retrospective Study

Patients Who Underwent Transfusion in Trauma Bay (n=1562)

Pre-Hospital Whole Blood (pWB) recipients (n=173)

Pre-Hospital Non-Whole Blood/Non-pWB recipients (n=1391)

pWB Patients Had:

- Median Change in SO_2 : 0.04 vs. -0.05 (p<0.01)
- Less Crystalloid Resuscitation
- >10U in 24h: 22.6% vs. 32.4% (p<0.01)

Prediction of Rebleeding/Reck Index on Multivariate Analysis:

Median Change in SO_2 : 0.04 vs. -0.05 (p<0.01)

Conclusion: pWB is Independently Associated with Reduction in Shock Index.

Strawman MA et al. Journal of Trauma and Acute Care Surgery. DOI: 10.1097/TA.0000000000000968

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UR

Optimal Crystalloid Volume?

- 405 patients
 - About 1/3 received PRBC
 - About 1/2 received Plasma
- Median crystalloid volume was 500 ml
 - 39.5% of patient received NO crystalloid
- 20% died within 24 hours
- Volumes between 250-1250 ml associated with lowest early mortality and inflammatory response to injury

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MTP with Whole Blood at Rochester

Cooler 1

- 4U PRBC or 2U WB

Cooler 2

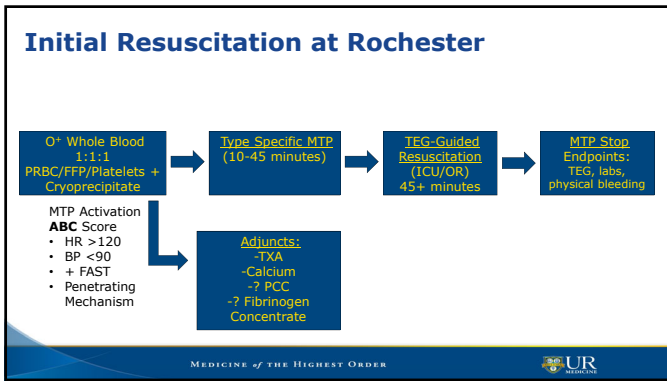
- 2U WB or 4U PRBC

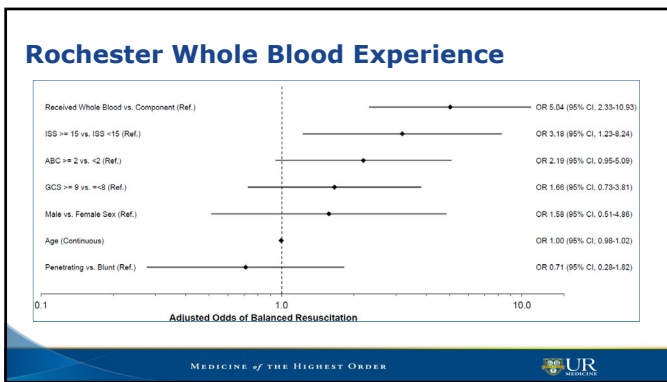
Cooler 3/4

- 4U PRBC/4U FFP/1 PLT or 1U Cryo

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TXA

- RCT patients with/at risk of bleeding within 8 hours of injury
- Primary outcome = death within 4 weeks
- 10,000 patients in each group
- 14.5% vs 16% mortality

1. CRABBE E, VAN DERBOORDEN M. Effects of tranexamsic acid on death, transfusion volume needs, and blood transfusion in trauma patients with significant hemorrhage (CRABBE-2): a randomized, placebo-controlled trial. LANCET. 2012;379:212-21.

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Consider MTP with any 2 of the following:

- Penetrating mechanism
- SBP < 90mmHg
- HR >120 bpm
- Positive FAST exam

Think whole blood EARLY and TXA < 15 minutes in trauma bay

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Reversal Agents

Reversal of Common Medications in Trauma	
Anticoagulant	Reversal Agent(s)
Warfarin	Vitamin K FFP/vitamin K PCC/vitamin K
Dabigatran (direct thrombin inhibitor)	PCC Idarucizumab (Praxbind®)
Rivaroxaban/apixaban (Xa-inhibitors)	PCC Andexanet alfa (Andexxa®)
Antiplatelet agents	DDAVP

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Circulation in Summary

- Humans can exsanguinate into 7 places
- Whole blood and 1:1:1 better than crystalloid
- Crystalloid better than nothing?
- TXA should be considered if concern for major hemorrhage
- Give calcium (2 grams for every 2-4 units PRBC)
- Know the tools you have available
- With blood shortages, increased role for PCC, fibrinogen concentrate?

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