Best Practices in Blood Resuscitation for Acute Trauma and in Disasters

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REGION 1
Regional Disaster Health Response System

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Learning Objectives

1. Review best practices and current principles of blood product resuscitation in acute traumatic injuries.

2. Discuss recent advances in the pre-hospital administration of blood products for major traumatic injuries.

3. Identify challenges in the effective mobilization and administration of blood products for major mass casualty incidents

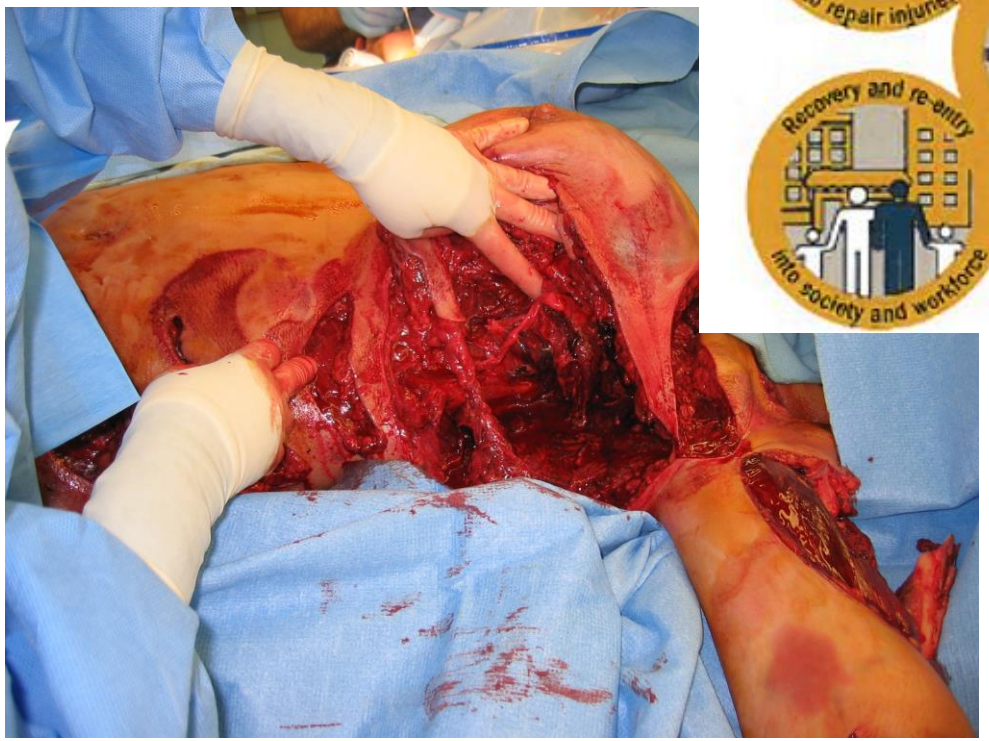
4. Present potential regional solutions to these blood product challenges.

Objective 1: Current best practices and principles of blood resuscitation in acute traumatic injuries and disasters

- Discuss evidence to support whole blood vs component therapy for trauma resuscitation
- Discuss logistical challenges in implementation
- Resource considerations
  - Prehospital vs In-hospital
  - HIC vs LMIC countries

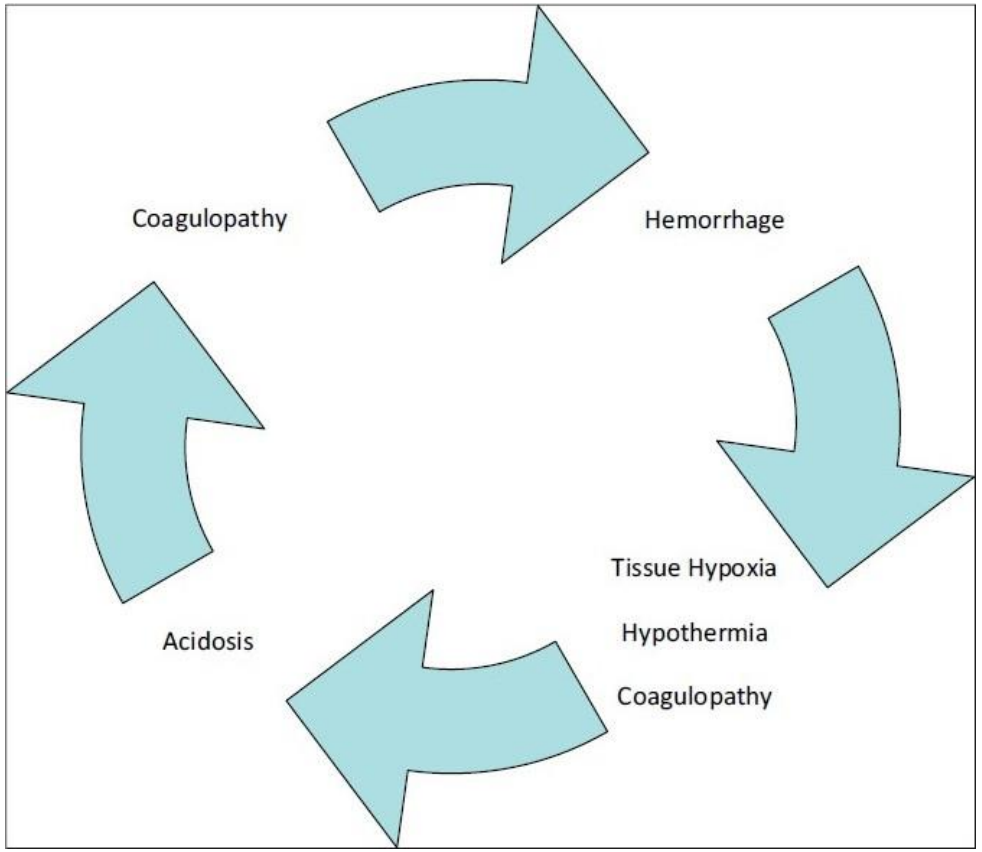
What's the Problem?

- Hemorrhage is the leading cause of early death after injury
- Leading cause of preventable death on the battlefield
- Median time hemorrhagic death 3 hours
- Minimizing time to hemorrhage control is vital



Operating Room, 2005

The Bloody Vicious Triad



Trauma Induced Coagulopathy

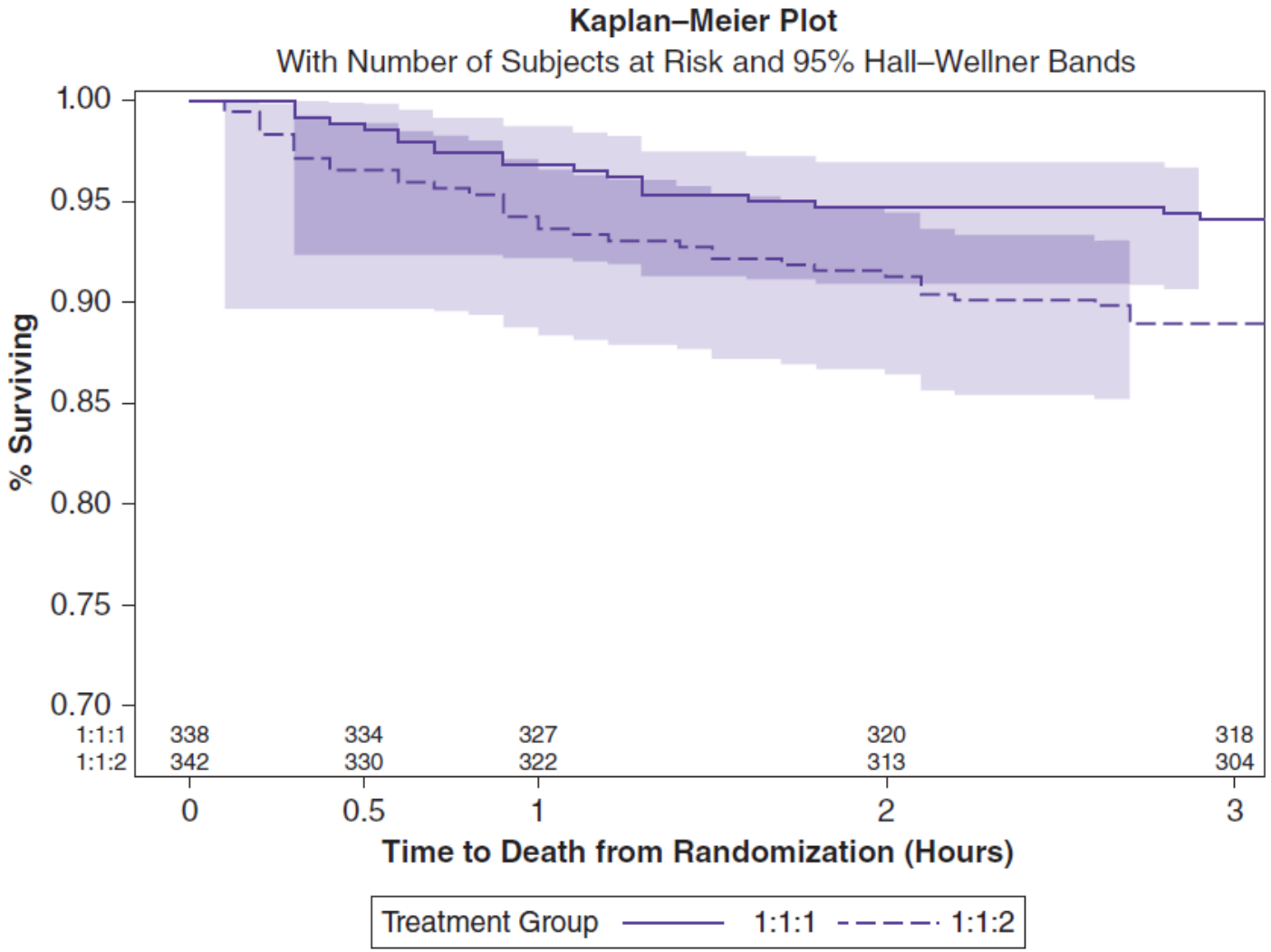
- Present upon admission for 25-40% major trauma patients

- Increased risk for:
  - Higher transfusion requirements
  - Multiple organ failure
  - Longer ICU stay
  - 4X increase in mortality

Definitions

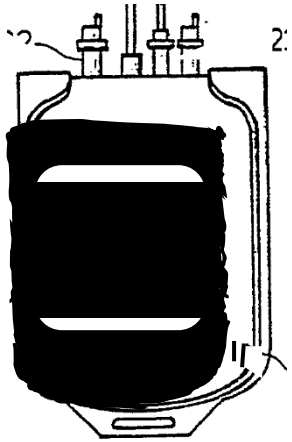
- Component therapy: A combination of blood products administered rapidly to the patient to resuscitate and manage trauma induced coagulopathy
- Red Blood Cells, Plasma, Platelets, Cryoprecipitate
- Balanced Resuscitation: Component therapy approach which seeks to mimic WB, (i.e., 1: 1:1 ratio of PRBC, Plasma and Platelets)
- Whole blood: cold-stored, leukoreduced, low titer Group O RhD positive

Blood Resuscitation Saves Lives



Whole Blood or the 3 Conventional Blood Components Made From It

Whole Blood

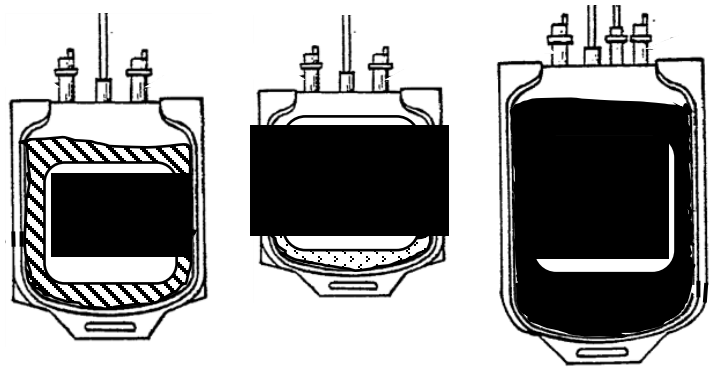


200 mL RBC
300 mL plasma
125 x 10^9 plts @
212K plts/µL
70 mL anticoagulant

80% plasma 212K plts, Hct 35%

(INR 1.1, PTT 33, Plts 142K)

1:1:1



65% plasma, 90K plts, Hct 29%

(INR 1.31, PTT 42, circ plts 63K)

Unit from a donor with a 40% Hct and Plt count of 250,000/µL

Armand and Hess, Transfus Med Rev 2003; Kornblith et al. J Trauma 2014

Emerging Evidence to Support Whole Blood

2023 Meta-analysis of 16 studies in Adults, both civilian and military*

- Only two were RCTs
- Significant heterogeneity
- No difference in 24 hrs or 30 days mortality on meta-analysis
- Reduction in RBC transfusion volume was significant at 6 hrs and 24 hrs
- Confounded by patients that received both WB and Component therapy

Single center, retrospective Pediatric study (n=80)**

- WB as part of the resuscitation associated with improved 72 hrs and 28 days survival

TQIP analysis, n=2785, WB as an adjunct to component therapy

- WB group associated with significant reduction in mortality at both 24 hrs and 30 days***

Objective 2: Discuss recent advances/cutting edge in the prehospital administration of blood products for major traumatic injuries

- EMS 101
- Challenges to prehospital blood transfusion programs
- Scope of Practice
- Components of EMS blood transfusion programs
- Blood Supply
- Surge blood options
- Other uses for prehospital transfusion programs
- Prehospital Blood Transfusion Initiative Coalition

EMS 101

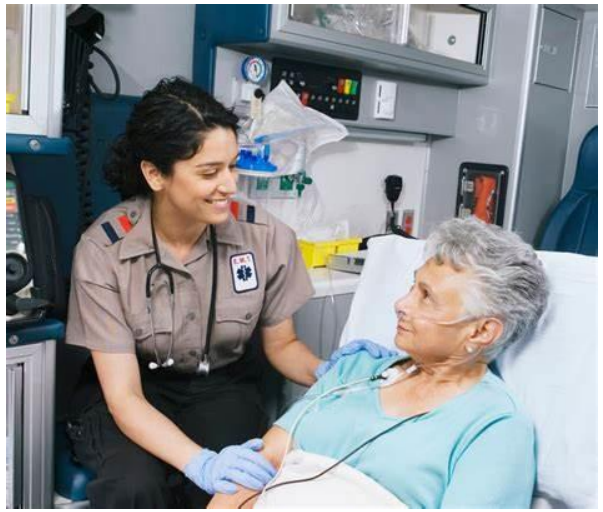
- EMS in NOT considered an essential service in most states
- EMS is regulated at the state level
  - No mandated federal oversight or control
- Levels of EMS clinicians
  - Emergency Medical Responder (EMR)
  - Emergency Medical Technician (EMT)
  - Advanced Emergency Medical Technician (AEMT)
  - Paramedic (PM)
- Levels of agencies – FR / BLS / ALS

EMS 101

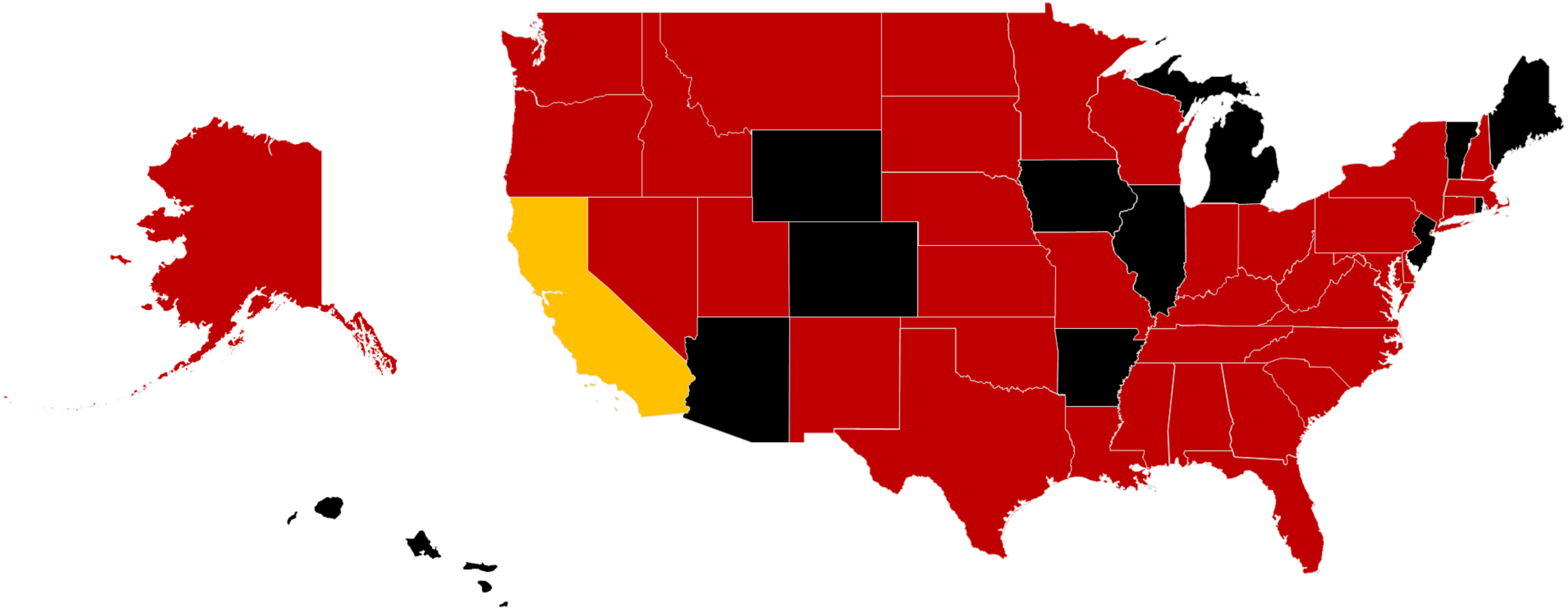
- Models of EMS Delivery
  - Public safety
    - Fire based
    - Third service
    - Law enforcement
  - Hospital based
  - Private, not for profit
  - Private, for profit
  - Volunteer
  - Other

Major Challenges to Prehospital Programs

- Scope of Practice
  - National Scope of Practice Model - guidelines
  - States determine actual SoP
  - 36 states allow for initiation on transfusion
- Reimbursement
  - No consistent reimbursement for field transfusions
    - Funded through grants / donations / operational budget
  - CMS proposed regulatory modification for ground ambulances
    - LTO+WB / no additional reimbursement
- Availability of blood / components
  - Initial focus on LTO+WB / acknowledge utility of other components
  - Increase donation pool



US States Allowing EMS Blood Transfusion Initiation



Components of Prehospital Programs

Multidisciplinary approach

- EMS / Trauma / Medical / Blood community

Infrastructure

- Education
- Blood supply
- Blood Administration
- Protocols / clinical guidelines
- Blood Storage and access
- Documentation

Blood Supply

- Recognize the importance of whole blood and/or components
- Local or regional blood centers or blood banks
- Purchase vs rotation

Blood Surge Supply Capacity

- Local capacity
  - Boston Marathon
  - Heroes in Arms
- Regional capacity
  - STRAC – Uvalde shooting
  - Heroes in Arms
- National capacity
  - Blood Emergency Readiness Corps (BERC)
    - National consortium of over 35 blood centers

Blood Emergency Readiness Corps (BERC)

Clinical Indications for Prehospital Transfusion

- Hemorrhagic shock:
  - Agnostic of etiology
    - Traumatic injuries
    - OB/GYN – peripartum
    - Medical – GI bleed / dialysis
  - Agnostic to patient age
  - Agnostic to blood product

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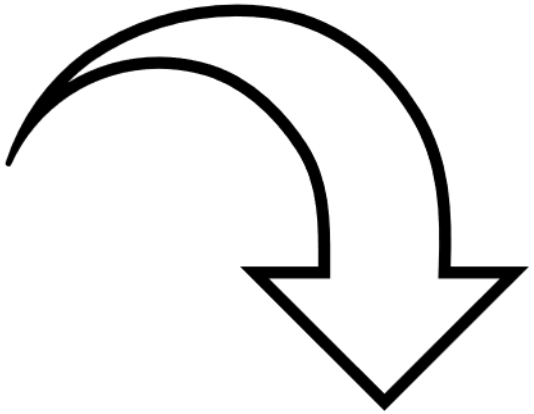
Objective 3: Transfusion management in disaster and mass casualty

Transfusion strategies: recent history

- Blood banking and component therapy
- Damage control and goal-directed strategies
- “Simulated whole blood” 1:1:1 Transfusion Strategy
- Protocolization of Massive Transfusion Strategies



Transfusion Management in Disaster and Mass Casualty

Simulated Whole Blood on a per patient basis

Vs.

Tranfusion triage in a population

An All-Hazards Approach

Mass Casualty Events may be “rare or recurrent” depending on local context

In addition to MCE, blood bank shortages with similar implications have accompanied

Weather events	Supply chain vulnerabilities • Power disruptions • Cyberattack	Pandemics

How much blood will we need?

A review of 1645 mass casualty events in Israel over five years suggests an average of 1.3 RBC units per patient

Moderate and severe traumatic injuries in this cohort received an average of 4.5 and 6.7 units per patient, respectively

Other countries report similar numbers: approximately 2-4 units per injured patient

Significant Risk of Over-ordering

- Anticipated demand may far exceed the actual need

- September 11th Terrorist Attacks
  - Approx 4000 injured patients
  - 475,000 blood units collected nationwide
  - 258 units transfused

High risk of psychological stress for lab staff

The risks of cognitive overload, moral distress, and burnout are well-described in first responders and medical teams exposed to MCE and disaster

Less well reported are the strains on labarotory and blood bank teams

Even when actual transfusion volumes are low, there may be significant stress on lab and blood bank teams

Naumann DN, Boulton AJ, Sandhu A, et al. Fresh whole blood from walking blood banks for patients with trau- matic hemorrhagic shock: a systematic review and meta- analysis. J Trauma Acute Care Surg 2020; 89: 792e800
Chowdhury F, Doughty H, Batrick N. London 2017: lessons learned in transfusion emergency planning. Transfus Med 2021; 31: 81e7

Maintaining Safety, Minimizing Waste

Standardization and coordination (health system, state, country)

Maintenance of transfusion safety using sequential record systems for patients and units

Triage systems for product allocation

Modified transfusion protocols rather than fixed ratios

Simulation and annual system testing

Transfusion Coordinators

Future Directions: AI and Predictive Analytics

Transfusion Risk

Avital G, Gelikas S, Radomislensky I, et al. A prehospital scoring system for predicting the need for emergent blood product transfusion. *Transfusion*. 2021; 61: S195–S205

Lou SS, Liu H, Lu C, Wildes TS, Hall BL, Kannampallil T. Personalized Surgical Transfusion Risk Prediction Using Machine Learning to Guide Preoperative Type and Screen Orders. Anesthesiology. 2022 Jul 1;137(1):55-66)

Blood antigen quantification/prediction

Hyvärinen K, Haimila K, Moslemi C, Biobank BS, Olsson ML, Ostrowski SR, Pedersen OB, Erikstrup C, Partanen J, Ritari J. A machine-learning method for biobank-scale genetic prediction of blood group antigens. PLoS Comput Biol. 2024 Mar 21;20(3):e1011977

Red cell age optimization

Isiksacan Z, D'Alessandro A, Wolf SM, McKenna DH, Tessier SN, Kucukal E, Gokaltun AA, William N, Sandlin RD, Bischof J, Mohandas N, Busch MP, Elbuken C, Gurkan UA, Toner M, Acker JP, Yarmush ML, Usta OB. Assessment of stored red blood cells through lab-on-a-chip technologies for precision transfusion medicine. Proc Natl Acad Sci U S A. 2023 Aug 8;120(32):e2115616120)

Waste minimization

Xiang, R.F., Quinn, J.G., Watson, S., Kumar-Misir, A. and Cheng, C. (2021), Application of unsupervised machine learning to identify areas of blood product wastage in transfusion medicine. Vox Sang, 116: 955-964.

Blood bank supply and demand prediction models

Shih H, Rajendran S. Comparison of Time Series Methods and Machine Learning Algorithms for Forecasting Taiwan Blood Services Foundation's Blood Supply. J Healthc Eng. 2019 Sep 17;2019:6123745

Questions

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