A Shocking Amount of Bleeding…

Trauma and Hemorrhagic Shock

Helen Harvey, MD
March 29, 2024

By the end of this talk…

- **Identify & treat hemorrhagic shock**
- **Increased understanding of:**
  - Damage control resuscitation
  - Lethal triad and trauma induced coagulopathy
  - Use & advantages of TEG
  - 1:1:1 blood product administration
  - Crisis resource management

Our Why? Mission:

To restore, sustain and enhance the health and developmental potential of children through excellence in care, education, research and advocacy

Rady Children's

LOCAL NEWS

Emotional reunion between 10-year-old San Diego boy and Mercy Air flight crew who helped save his life

Trauma Stats

Trauma is the leading cause of mortality & morbidity

30 day mortality in children with traumatic hemorrhagic shock is 36-50% (v. 20-25% in adults)

An estimated 1000 – 2000 preventable deaths in children per year after injury occur in the US because of inadequate or delayed care

Etiology of Traumatic Arrest

- Penetrating versus blunt injury
  - ✓ Better outcomes in penetrating trauma
- Location of injury
- Hemorrhage is the leading cause of traumatic death

Injury patterns in traumatic cardiac arrest
Polytrauma
Exsanguination
Isolated traumatic brain injury
Thoracic trauma
Abdominal trauma
Other causes

Updates in Traumatic Cardiac Arrest

Predictors of Survival

- Mechanism
- Location of injury
- ROSC in field, length of cardiac arrest
- Reversal of tension pneumothorax, cardiac tamponade
- Urgent resuscitation with hemostasis

What is damage control resuscitation?

BEAT ARM

Go Navy Beat Army!

Damage Control Resuscitation

Damage Control Basics

01

Stop the bleeding

02

Treat shock

03

Treat coagulopathy

Contents lists available at ScienceDirect

Blood Reviews

journal homepage: www.elsevier.com/locate/blre

REVIEW

Blood Reviews 23 (2009) 231–240

Resuscitation and transfusion principles for traumatic hemorrhagic shock

Philip C. Spinella [a,*], John B. Holcomb [b,†]

Damage control resuscitation principles.

Rapid recognition of high risk for trauma-induced coagulopathy (massive transfusion prediction)
Permissive hypotension
Rapid definitive/surgical control of bleeding
Prevention/treatment of hypothermia, acidosis, and hypocalcemia
Avoidance of hemodilution by minimizing use of crystalloids
Early transfusion of red blood cells:plasma:platelets in a 1:1:1 unit ratio
Use of thawed plasma and fresh whole blood when available
Appropriate use of coagulation factor products (rFVIIa) and fibrinogen-containing products (fibrinogen concentrates, cryoprecipitate)
*Use of fresh RBCs (storage age of <14 days)
*When available thromboelastography to direct blood product and the hemostatic adjunct (anti-fibrinolytics and coagulation factor) administration

Stop The Bleed

STOP THE BLEED℠

SAVE A LIFE

ACS AMERICAN COLLEGE OF SURGEONS

THE COMMITTEE ON TRAUMA

STOPTHEBLEED.ORG


1 APPLY PRESSURE WITH HANDS
2 APPLY DRESSING AND PRESS
3 APPLY TOURNIQUET
WRAP
WIND
SECURE
TIME

Identification of Hemorrhagic Shock

Shock Severity

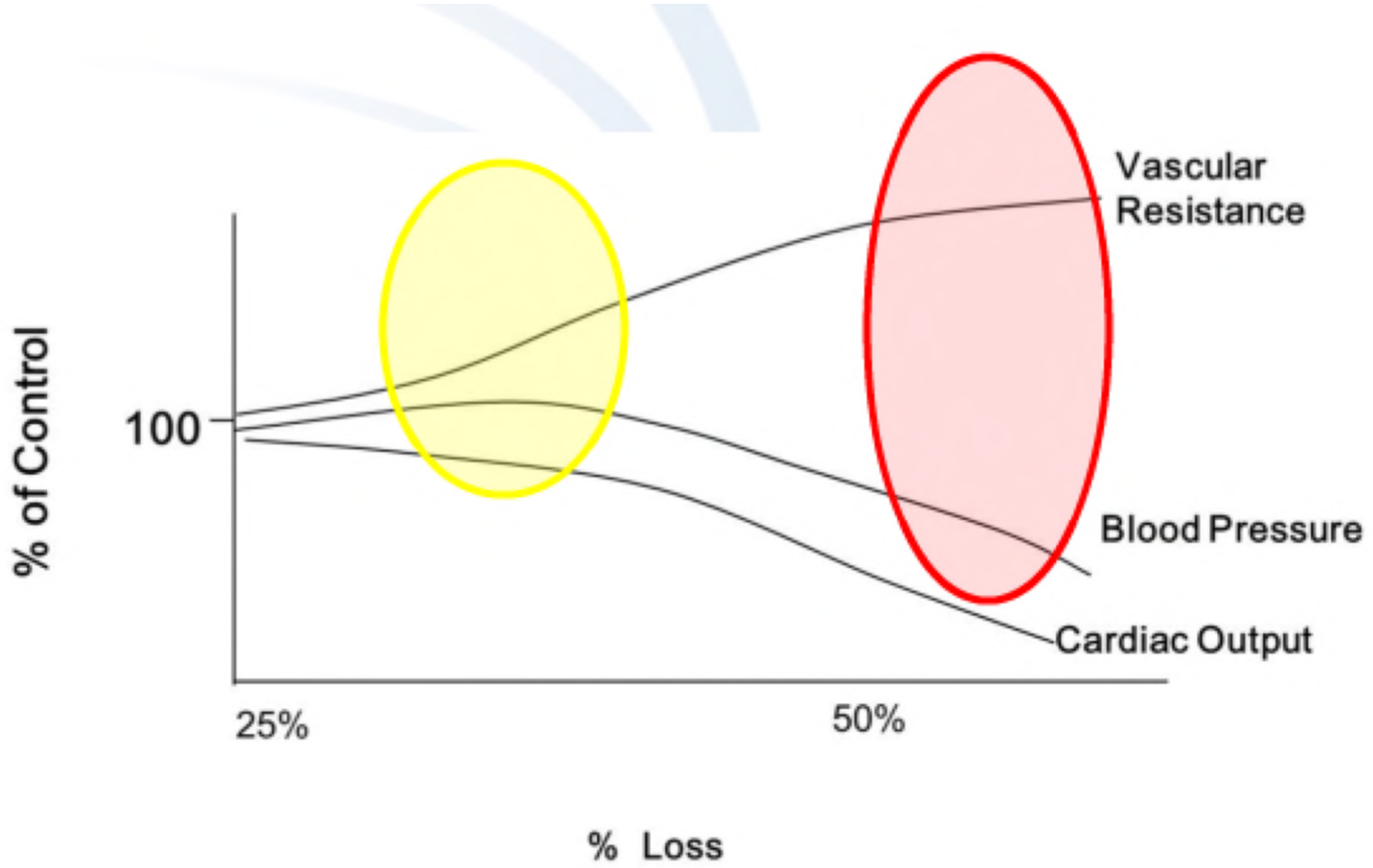
- ✓ Based on systolic blood pressure
- ✓ Compensated vs. uncompensated (hypotensive) shock
- ✓ Hypotension

Term neonates (0-28d)	SBP < 60 mmHg
Infants (1-12 months)	SBP < 70 mmHg
Children (1-10y)	SBP < 70 + (2 x age) mmHg
Children (> 10y)	SBP < 90 mmHg

Unique to Children

- Cardiac output = stroke volume (SV) x HR
  - ✓ Younger children have limited ability to increase SV
  - ✓ Usually maintain adequate CO by becoming tachycardic
- Improved ability to maintain SVR & BP
- In kids... TACHYCARDIA is a sign of shock and HYPOTENSION is a late ominous sign

Hemorrhagic Shock (CO ≠ BP)



Stages of Shock… End organ perfusion?

Organ system	↓Perfusion
CNS	
Respiration	
Gut	
Kidney	↓UOP, ↑Specific gravity
Skin	Delayed cap refill
CVS	↑HR

Organ system	↓Perfusion	↓↓Perfusion
CNS		Restless, apathetic, anxious
Respiration		↑Ventilation
Gut		↓Motility
Kidney	↓UOP, ↑Specific gravity	Oliguria (<0.5 ml/kg/h)
Skin	Delayed cap refill	Cool extremities
CVS	↑HR	↑↑HR, ↓peripheral pulses

Organ system	↓Perfusion	↓↓Perfusion	↓↓↓Perfusion
CNS		Restless, apathetic, anxious	Agitated/confused, stuporous, coma
Respiration		↑Ventilation	↑↑Ventilation
Gut		↓Motility	Ileus
Kidney	↓UOP, ↑Specific gravity	Oliguria (<0.5 ml/kg/h)	Oliguria / anuria
Skin	Delayed cap refill	Cool extremities	Mottled, cyanotic, cold extremities
CVS	↑HR	↑↑HR, ↓peripheral pulses	↓BP, central pulses only

What is your blood volume in ml/kg?

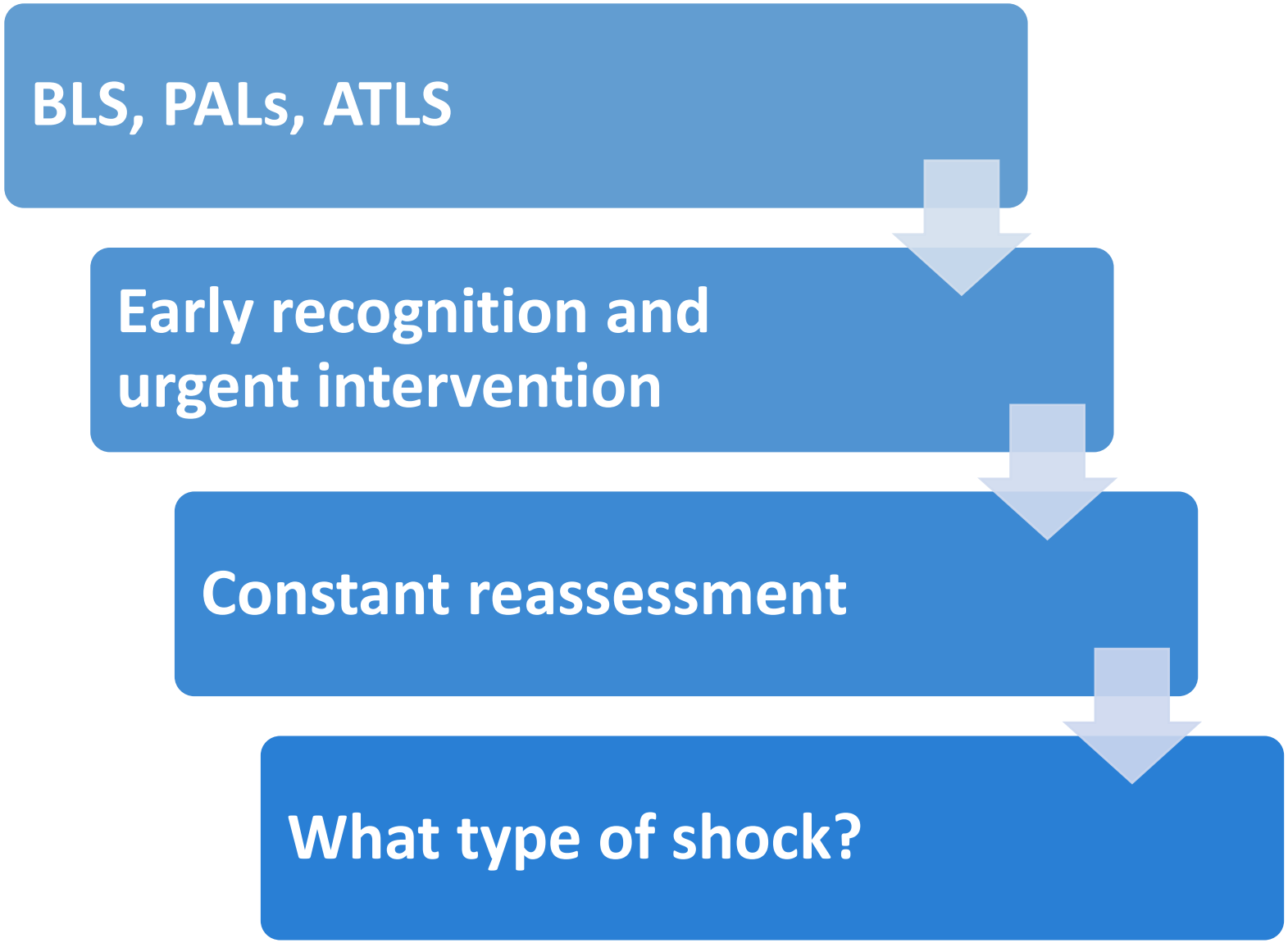
Age Specific Blood Volume

Newborn to 1 month	90mL/kg
1-12 months	85 mL/kg
1-14 years	80 mL/kg
>14 years	75 mL/kg

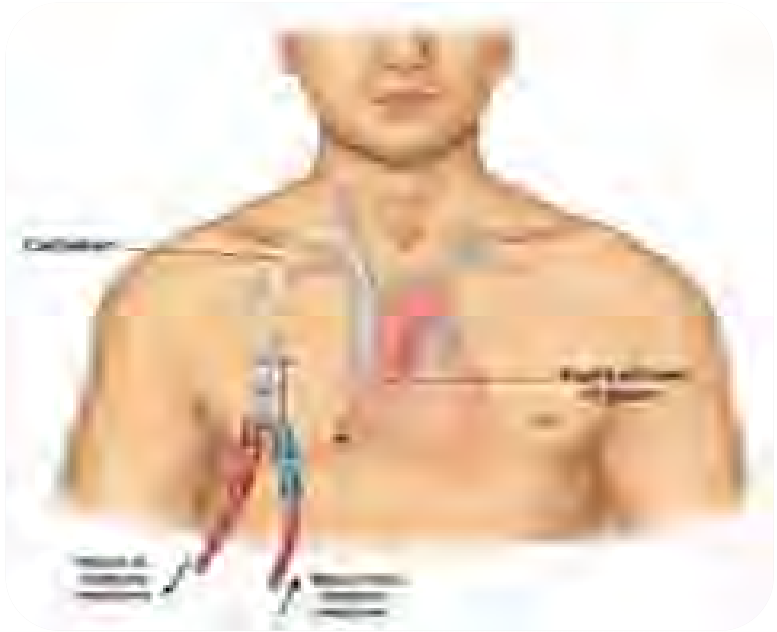
Treatment of Hemorrhagic Shock


RESUSCITATE
LIKE A
CHAMPION

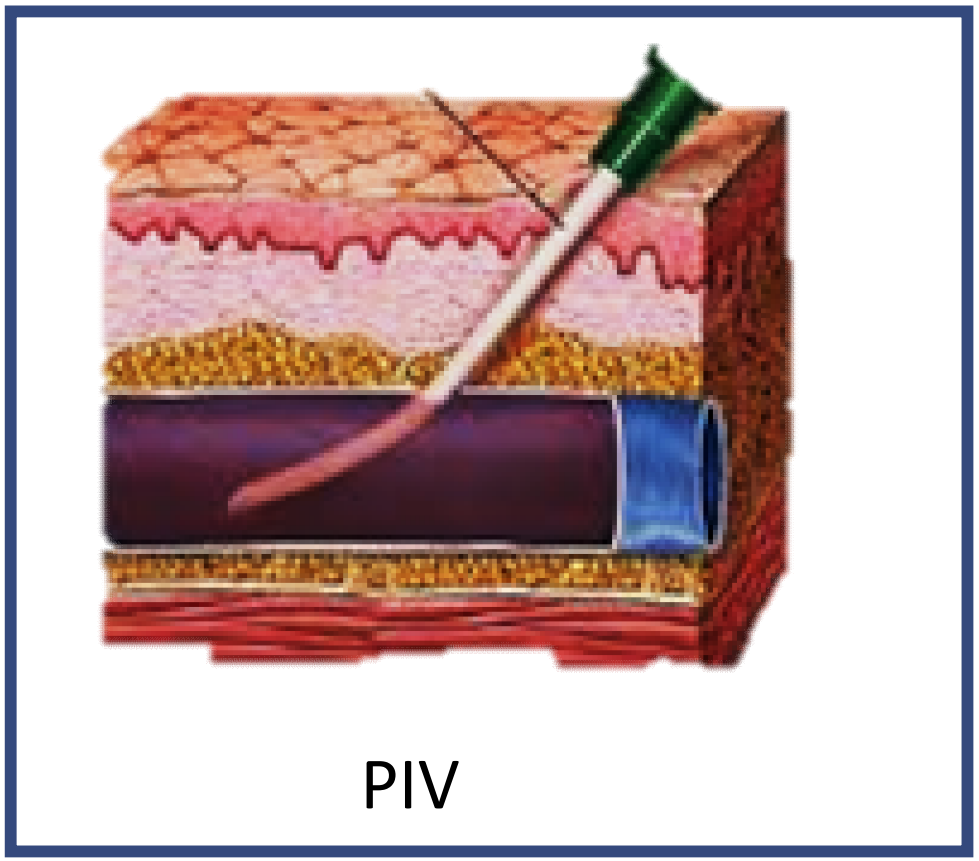
ABCs of Shock



Access: PIV vs IO vs Central Line?



Central Line



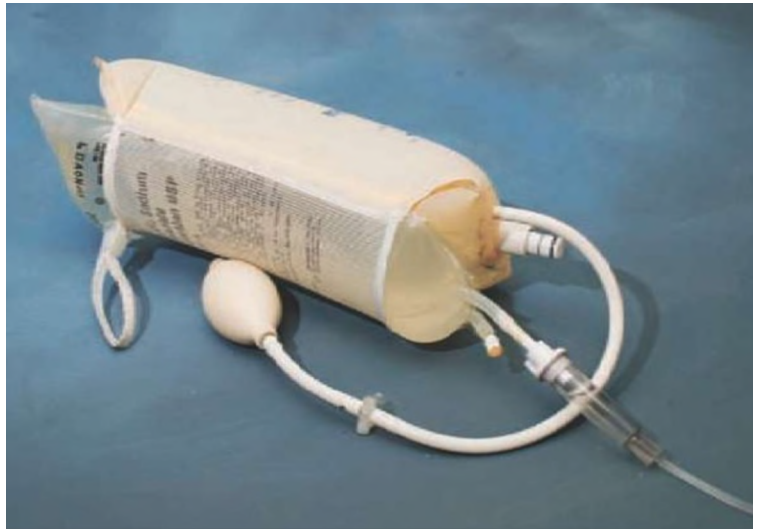
PIV

Poiseuille's Law $R = 8nl/r^4$

Access

- IO
- Large bore PIV
- Cordis

IV CATHETER SIZES AND FLOW RATES



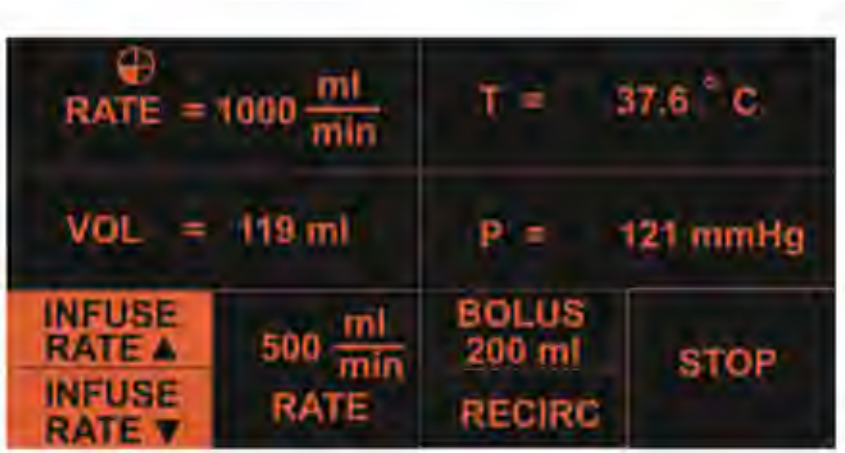
How do you administer fluids?

How do you administer fluids?

- Do it Fast!
- Traditional IV pump
  - Max rate 999 ml/hr
  - Can ONLY deliver 20ml/kg within 5 min to a child that weight less than
    - 4.16 kg

Belmont Rapid Infuser

- 10 – 1000 ml/min
  - Set a rate
  - Set bolus infusion
- Automatic air removal
- Heated
- Reservoir for fluid mixtures



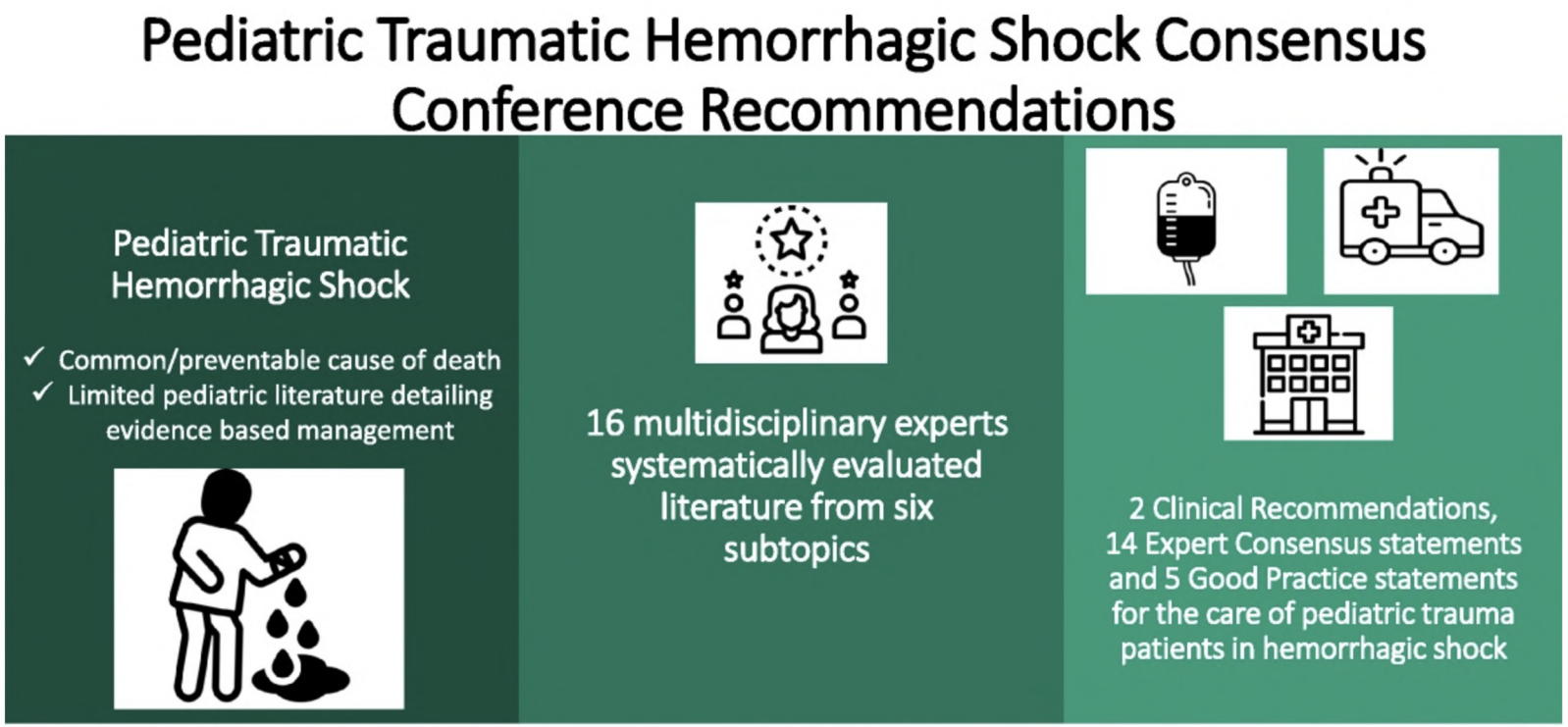
Infuse Screen

CONSENSUS STATEMENT

The Journal of Trauma and Acute Care Surgery

Pediatric traumatic hemorrhagic shock consensus conference recommendations

Robert T. Russell, MD, MPH, Joseph R. Esparaz, MD, MPH, Michael A. Beckwith, MD, Peter J. Abraham, MD, Melania M. Bembea, MD, PhD, MPH, Matthew A. Borgman, MD, Randall S. Burd, MD, PhD, Barbara A. Gaines, MD, Mubeen Jafri, MD, Cassandra D. Josephson, MD, Christine Leeper, MD, Julie C. Leonard, MD, MPH, Jennifer A. Muszynski, MD, MPH, Kathleen K. Nicol, MD, Daniel K. Nishijima, MD, MAS, Paul A. Stricker, MD, Adam M. Vogel, MD, Trisha E. Wong, MD, MS, *and* **Philip C. Spinella, MD**, *Birmingham, Alabama*

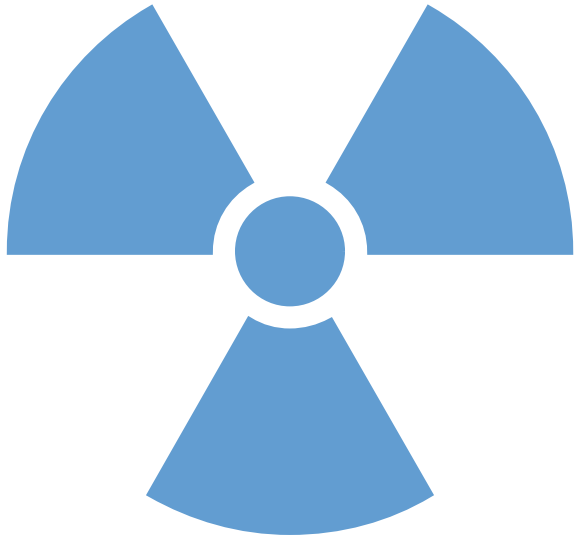


Traumatic Hemorrhagic Shock

- Recent retrospective and prospective observational studies indicate that transfusion strategies can reduce morbidity and mortality in children with traumatic hemorrhagic shock
  - ✓Limiting crystalloid
  - ✓Appropriate transfusion ratios
  - ✓Use of whole blood & hemostatic adjunct therapies

Prioritize blood products over crystalloids

EMERGENCY RELEASE BLOOD



What is the lethal triad?

Lethal Triad

COAGULOPATHY **ACIDOSIS** **HYPOTHERMIA**

Mechanisms of early trauma-induced coagulopathy:
The clot thickens or not?

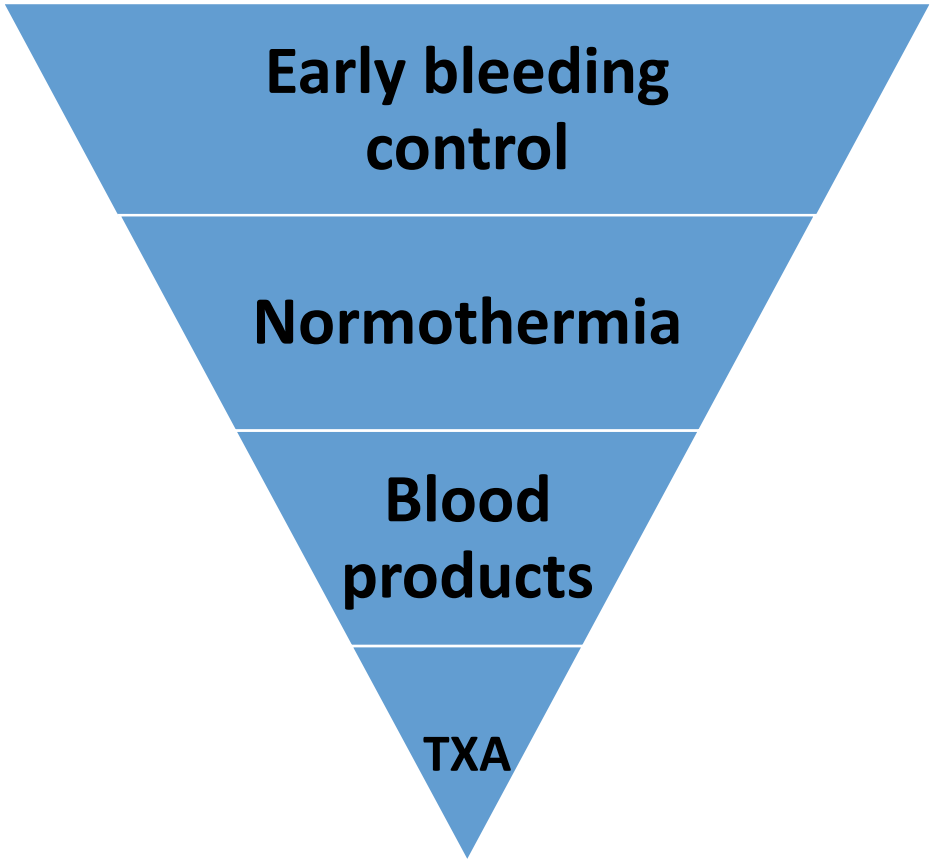
Geoffrey P. Dobson, PhD, Hayley L. Letson, MSc, Rajiv Sharma, MD, Forest R. Sheppard, MD,
and Andrew P. Cap, MD, PhD, *Queensland, Australia*

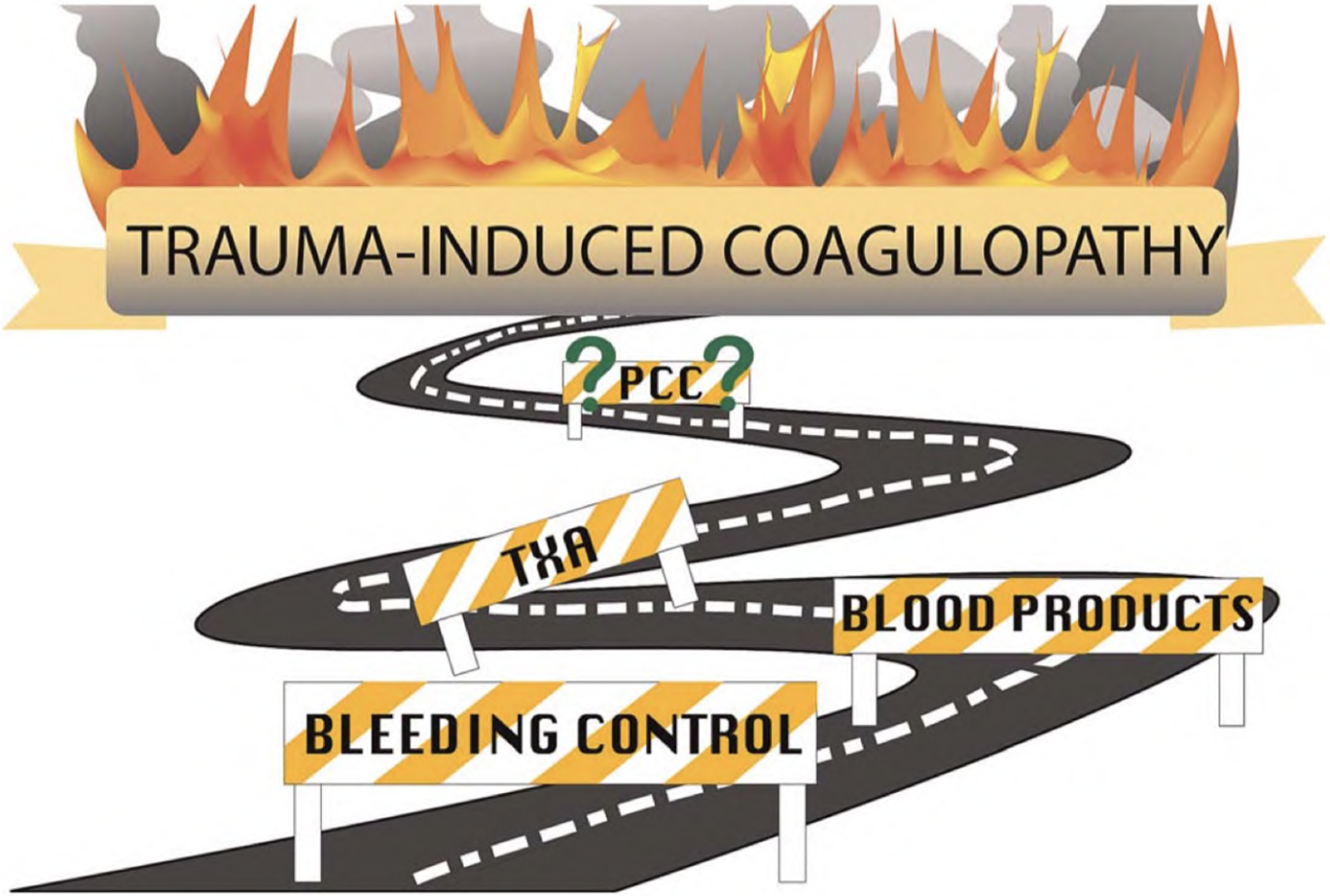
Trauma Induced Coagulopathy

- ✓Direct or anatomic bleeding from the site of injury
- ✓Early coagulopathic bleeding

Dobson et al. 2015. J Trauma Acute Care Surg. 79(2)

Prevention





Trauma-induced coagulopathy: What you need to know

J Trauma Acute Care Surg
Volume 96, Number 2

Trauma Induced Coagulopathy

Dynamic

Early and late phase

Major drivers:

- **Tissue hypoperfusion**
- **Endothelial injury**
- **Inflammation**

Risk Factors for Trauma Induced Coagulopathy

- Severity of trauma
- Shock
- Acidosis
- Hypothermia

Recognition of Trauma Induced Coagulopathy

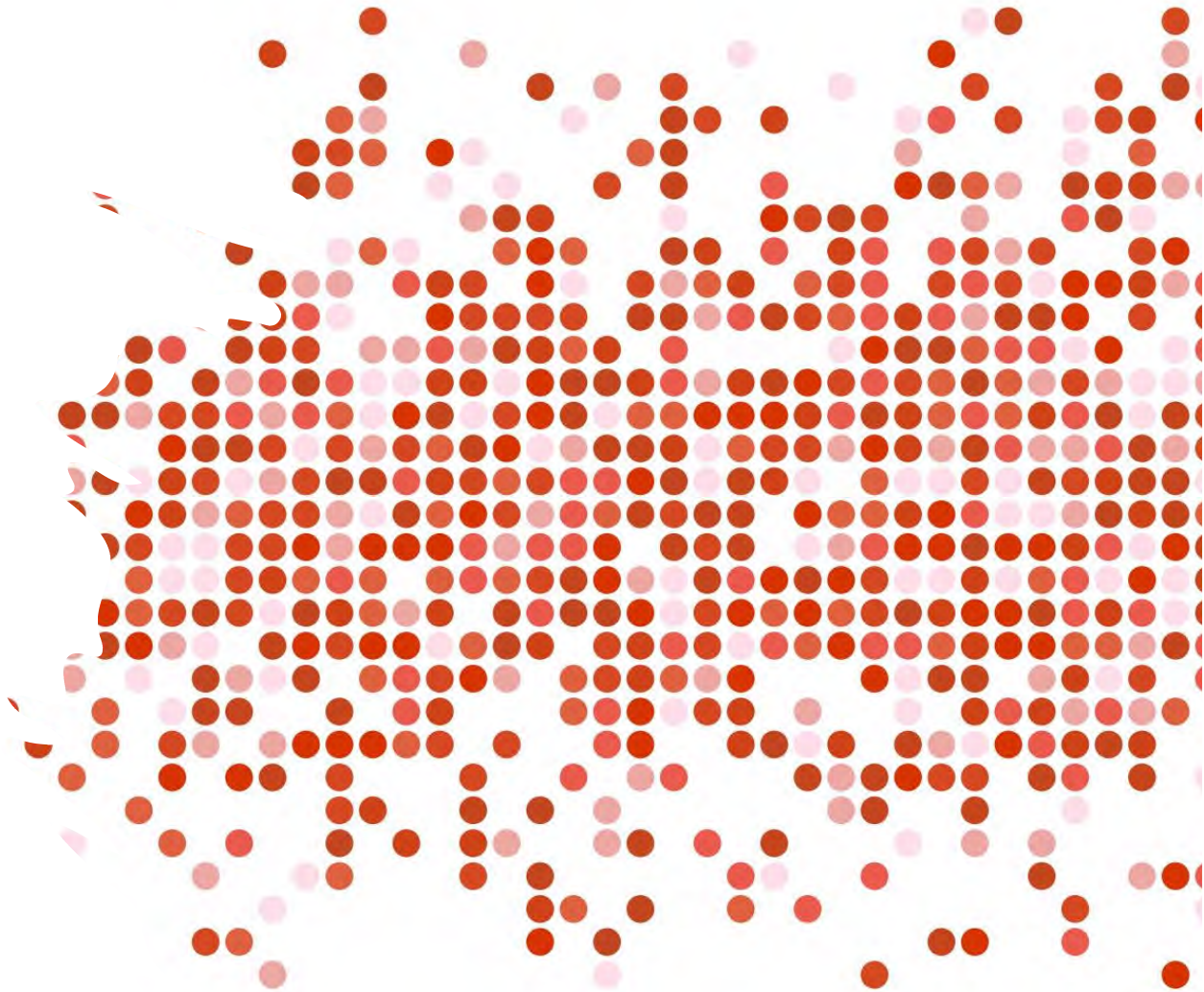
Bleeding, Shock, Acidosis

Labs

- PT, PTT, INR
- Fibrinogen
- Hemoglobin, Hematocrit, Platelets
- TEG, ROTEM

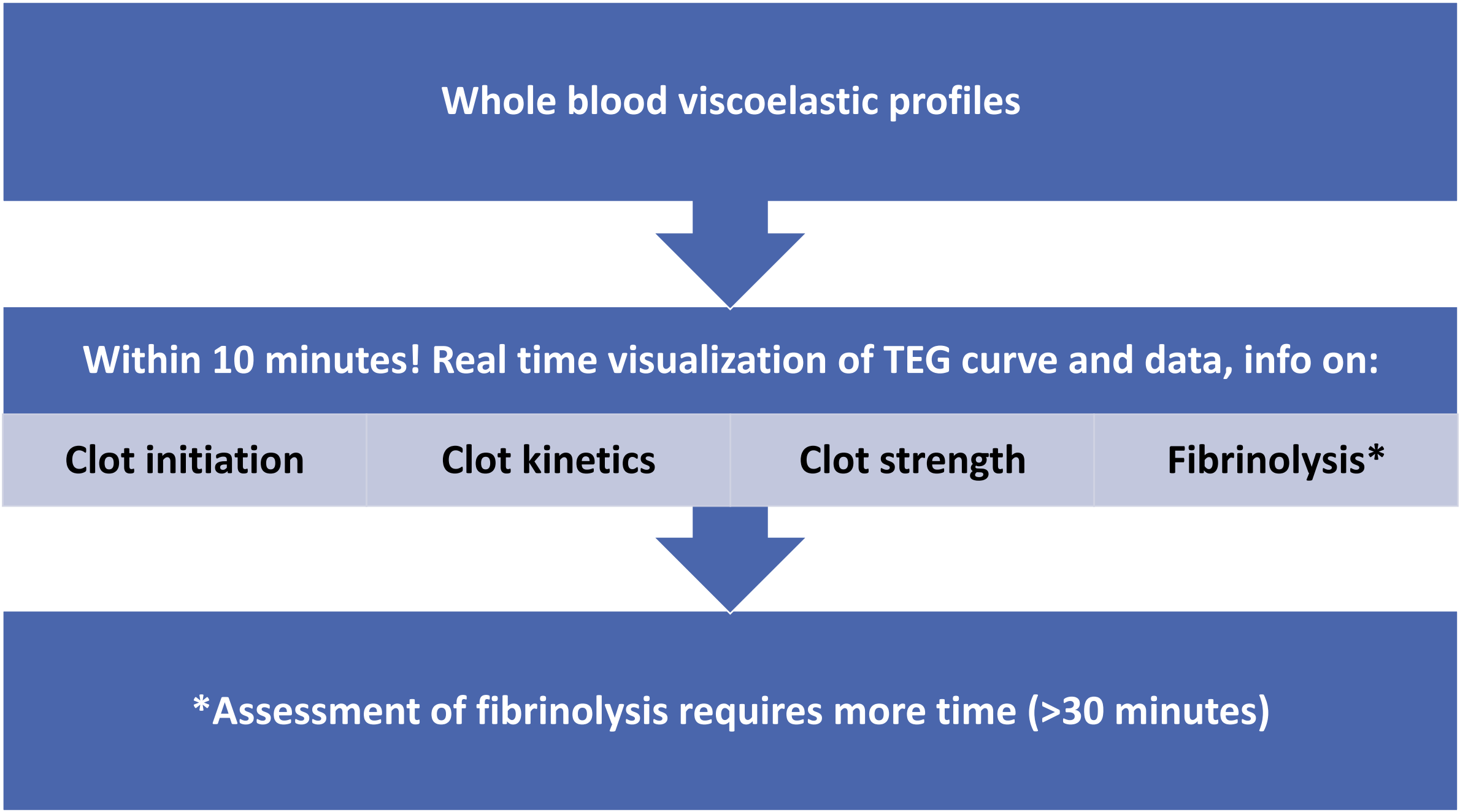
Thromboelastography
TEG 101

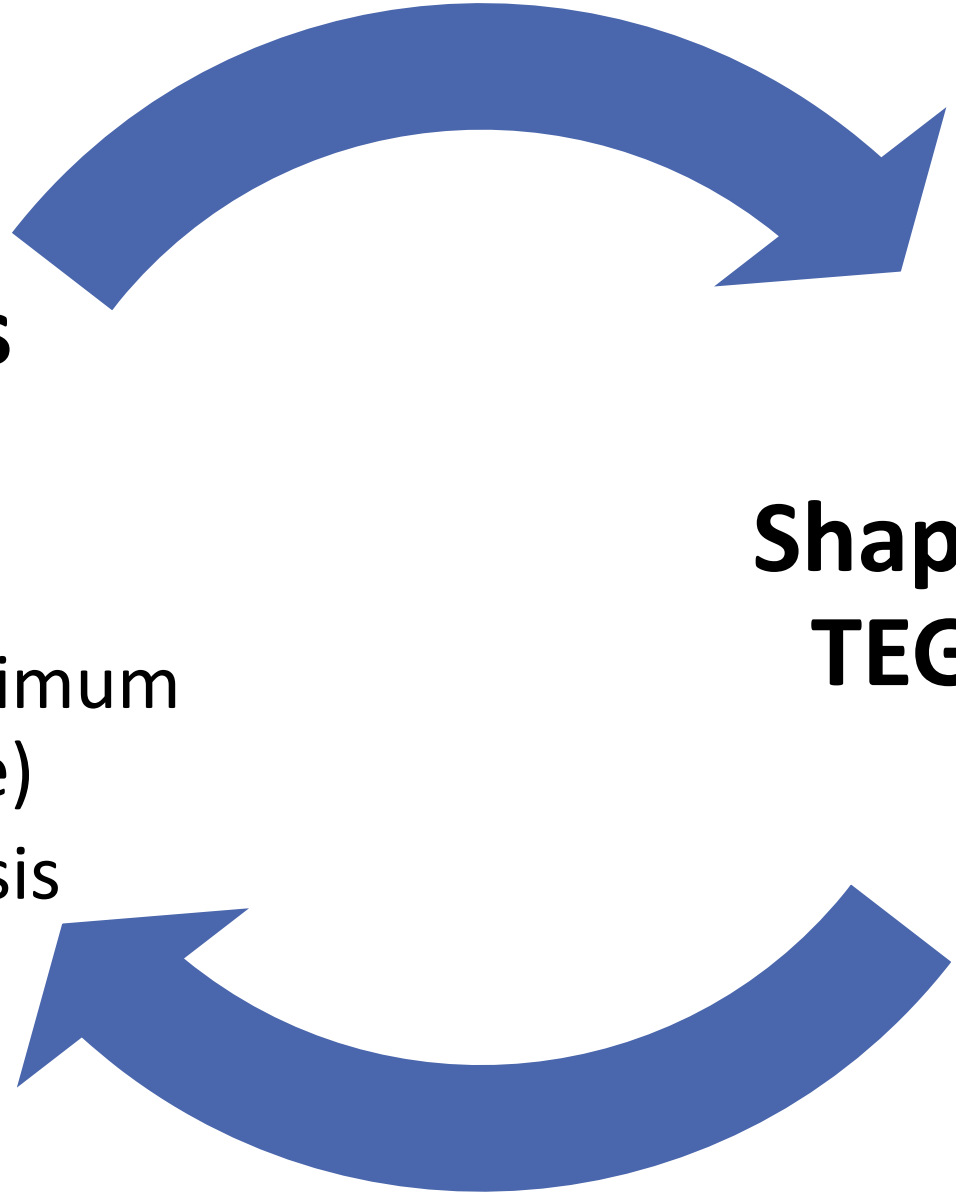
“TEG Talks”



When to Use TEG?

- Severe trauma, activation of MTP
- Blood given in trauma bay
- To gain comfort with use and interpretation
  - High grade solid organ injury
  - Severe TBI

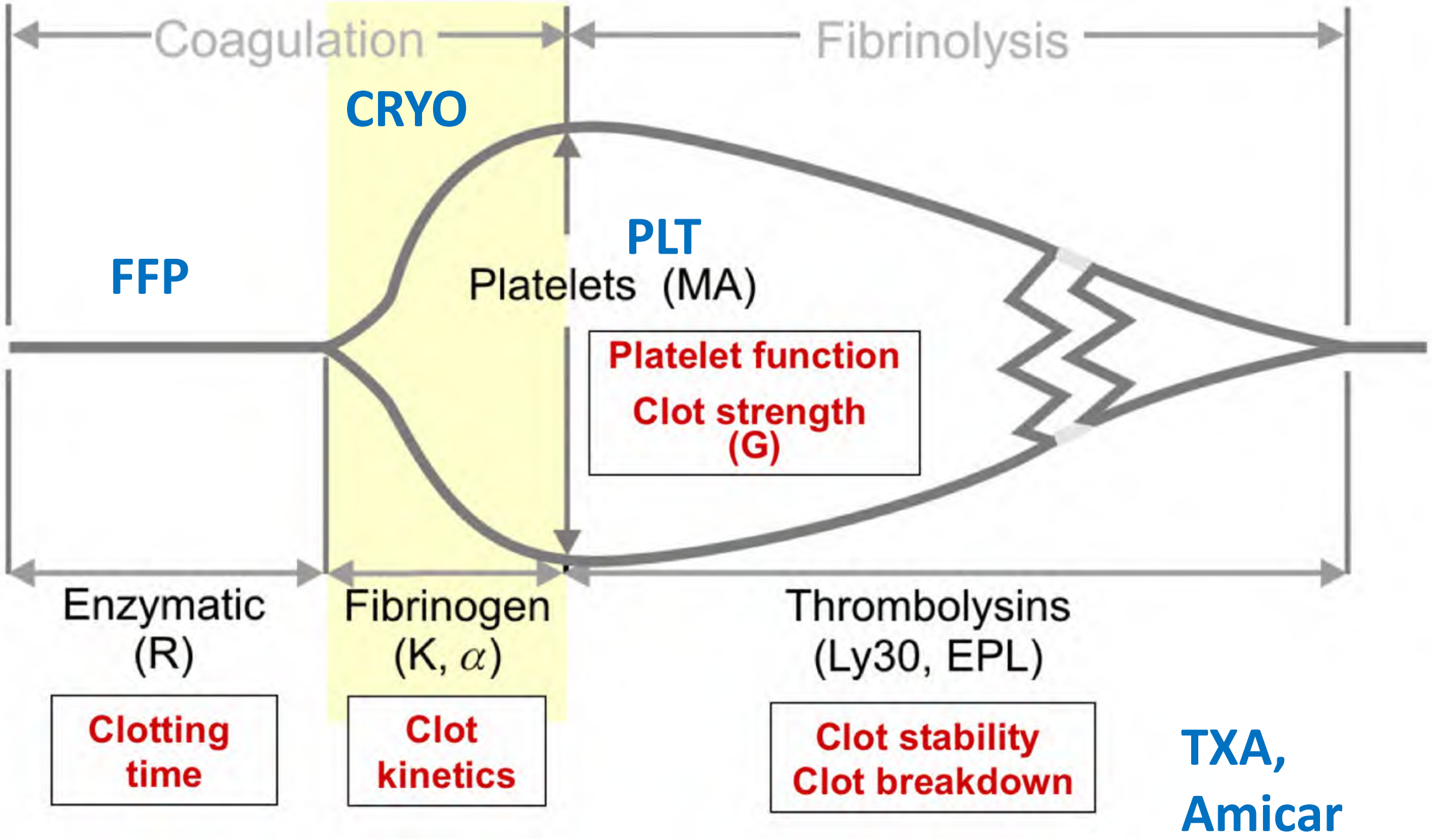

Whole blood viscoelastic profiles
Within 10 minutes! Real time visualization of TEG curve and data, info on:
Clot initiation
Clot kinetics
Clot strength
Fibrinolysis*
*Assessment of fibrinolysis requires more time (>30 minutes)



Numbers

- ✓ R time
- ✓ Angle
- ✓ MA (maximum amplitude)
- ✓ Fibrinolysis

Shape of the TEG curve


Coagulation
Fibrinolysis
CRYO
FFP
PLT
Platelets (MA)
Platelet function
Clot strength
(G)
Enzymatic
(R)
Fibrinogen
(K, α)
Thrombolysins
(Ly30, EPL)
Clotting
time
Clot
kinetics
Clot stability
Clot breakdown
TXA,
Amicar

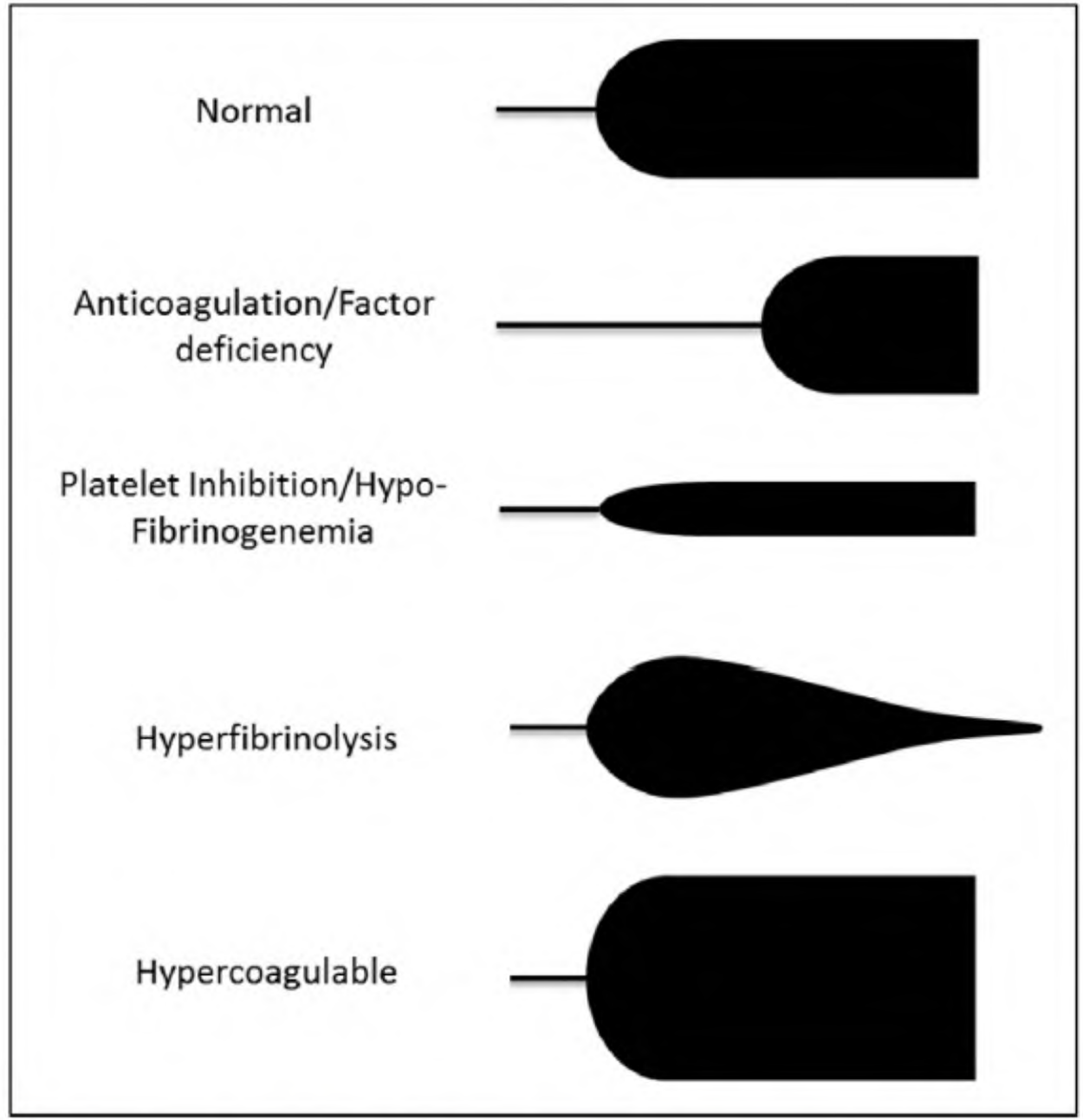


Fig. 2. Graphical representation of viscoelastic analysis. The general shapes of coagulation abnormalities are similar on both TEG and ROTEM.

Pragmatic Use

- Rapidly available
- Viewed in real time
- Prolonged R time = FFP
- Low angle = cryoprecipitate
- Low maximum amplitude (MA) = platelets
- Maximum lysis (>3-7.5%) = tranexamic acid

MTP
1:1:1 Resuscitation

Massive Transfusion

- **Prevent the anticipated complications that occur as a result of massive transfusion:**
  - ✓Thrombocytopenia
  - ✓Depletion of coagulation factors
  - ✓Electrolyte and acid/base disturbances (*calcium, potassium)
  - ✓Hypothermia
  - ✓Conserve valuable blood components while ensuring safe and rapid administration of blood

Leadership, Communication, Team Work


COMMUNICATION
Crew
Skills
SITUATION AWARENESS
CO-OPERATION

Crisis Resource Management
Healthcare Simulation

ROLE CLARITY 1
Team leaders are responsible for assigning specific roles to other team members and monitoring their actions.

Effective communication is critical to the success of any team.
2 **COMMUNICATION**

PERSONNEL SUPPORT 3
Be aware of barriers to asking for help. Call for support early.

teams should continually survey their environment to identify all available resources.
4 **RESOURCE UTILIZATION**

GLOBAL ASSESSMENT 5
Leaders should maintain a global view during a crisis and avoid fixating on isolated details.

It takes an interprofessional team to insure best practice and patient safety.
6 **TEAMWORK**

Manser et al. *Anesth Analg*. 2009;108(5):1606-1615.

Leadership & Management

- Multiple teams
- Roles
- Prioritize, resource allocation
- Listening to input and asking for input
- Recap, summary
- Crowd control, noise level

Communication

- **Introductions**
- **Role clarity**
- **Closed loop communication**
- **Action linked phrases**
  - ✓ There is no pulse, start compressions
  - ✓ That is a shockable rhythm, prepare to shock
  - ✓ Shock delivered, start compressions
- **Shared mental model**
  - ✓ What PALs algorithm are we in? – say it out loud
- **Debrief**

Cooperation

- Roles
- Team within teams
- Choreography
- Adaptability

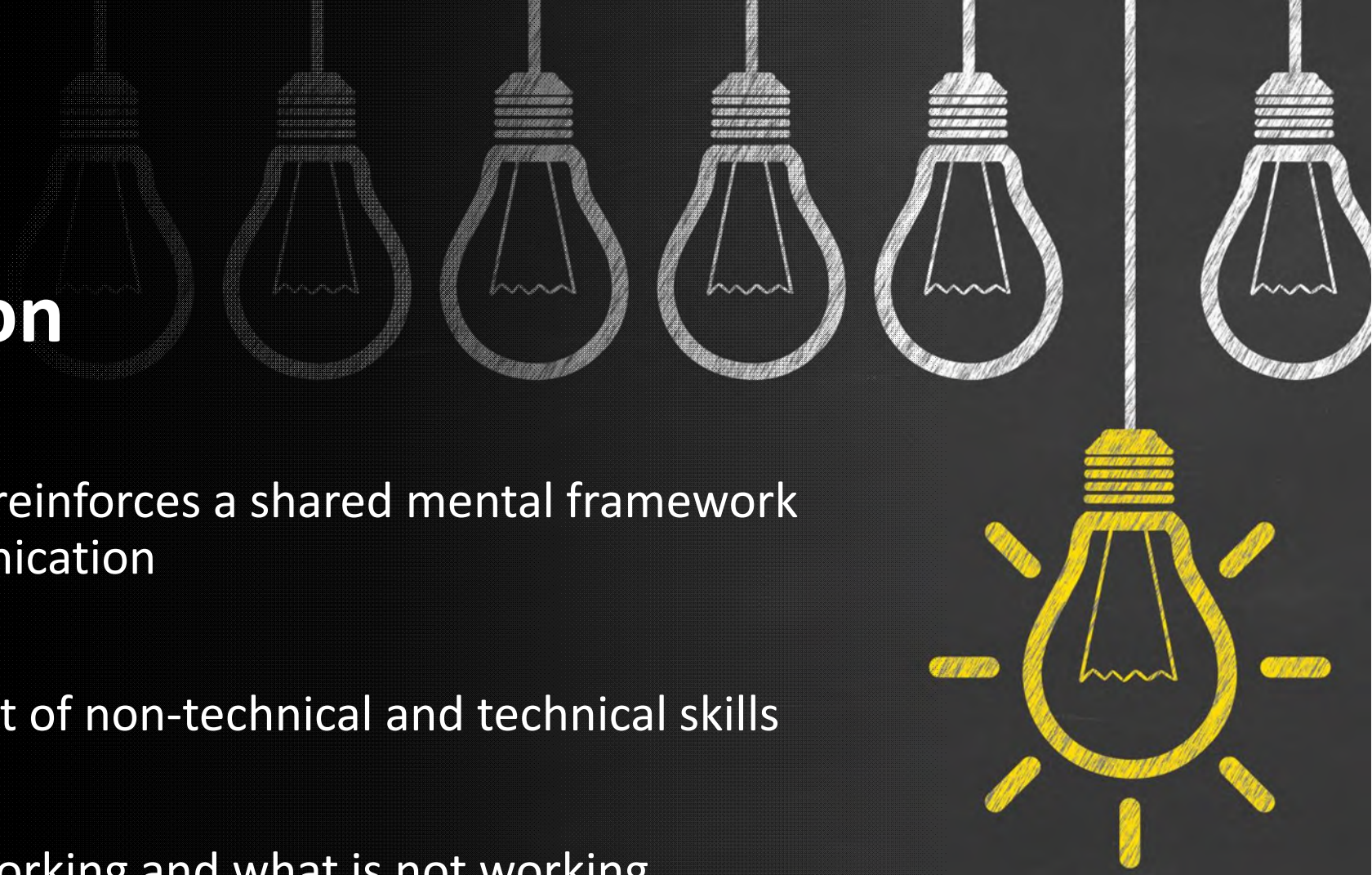
Situational Awareness

- **Room set up**
- **Choreography**
- **Equipment knowledge**
  - ✓ Location, use
- **Systems based knowledge**
  - ✓ ECMO activation
  - ✓ DART activation
  - ✓ Emergency release blood
  - ✓ Massive transfusion protocol activation

Decision Making

- Shared mental model
- Shared decision making
- Knowledge of ATLS, PALs algorithms
- Knowledge of systems
- Knowledge of critical care and trauma pathophysiology

Value of Simulation



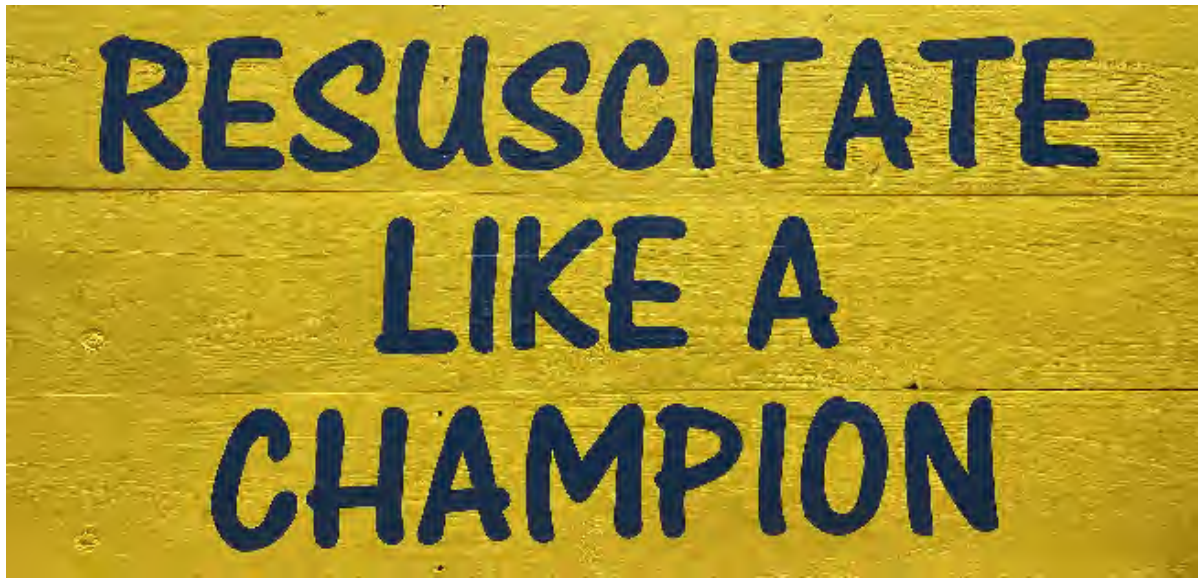
- Multidisciplinary approach, reinforces a shared mental framework and the vital role of communication
- Education and reinforcement of non-technical and technical skills
- Tool to investigate what is working and what is not working, improving systems and teams

Debriefing & Linking

Education
Quality & Safety
Wellness

Institute for Healthcare Improvement

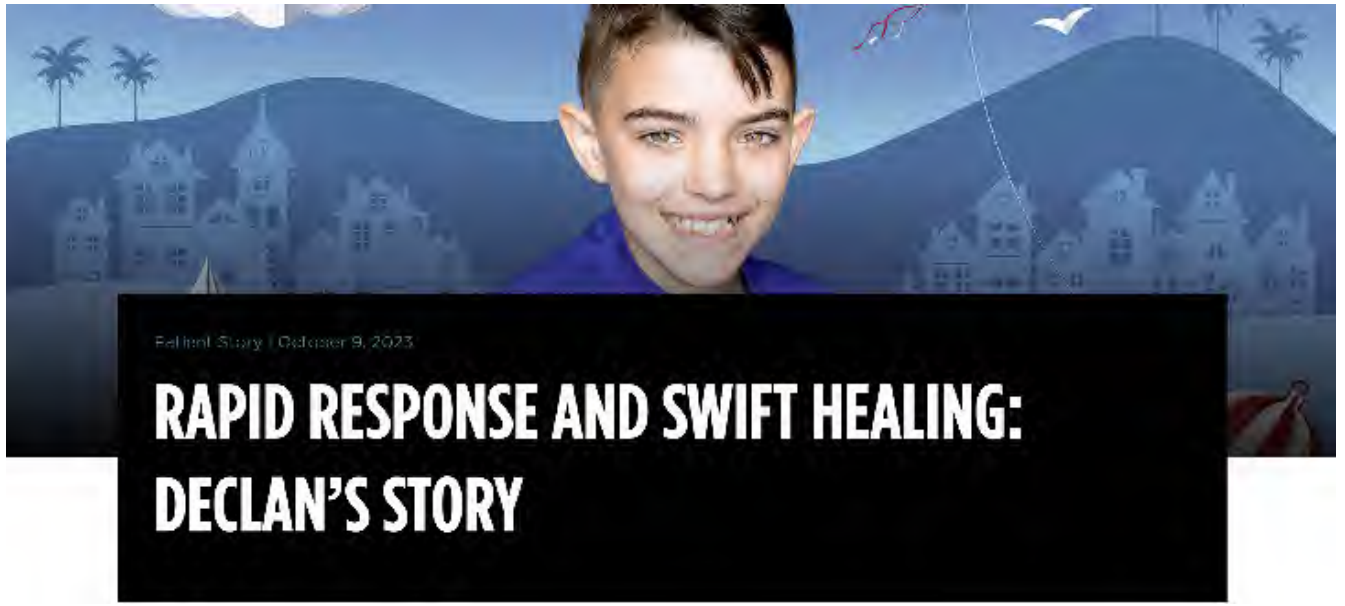
Take Home Points



- Preparation, teamwork, communication
- Early recognition and intervention
- A B C s
- Stop the bleed
- Access
- Early blood products → Emergency Release Blood! MTP!
- Recognize and treat → Trauma Induced Coagulopathy: reverse shock, acidosis, coagulopathy, hypothermia
- 1:1:1 blood products (PRBC: FFP: Platelets)
- Constant reassessment
- Lessons learned, support the team, patient, & family

Questions

Our "Why" is awesome…



Go Padres!!!