Plasma In Lieu of Whole Blood
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Acknowledgements

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- Bothers in Arms/Heroes in Arms donors

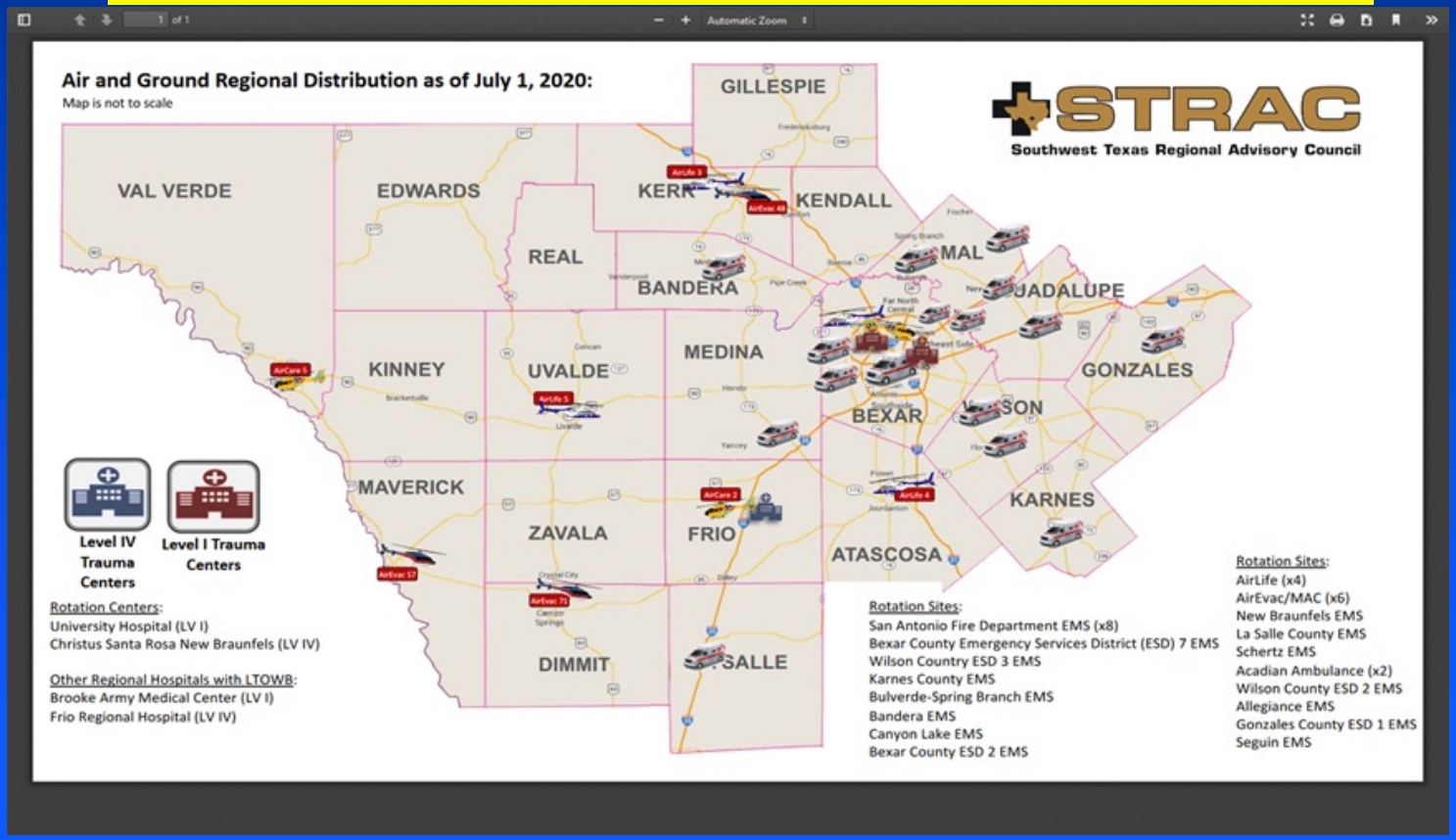
Regional Whole Blood Consortium

South Texas Blood & Tissue

Dr. Samantha Gomez Ngamsuntikul – Medical Director
South Texas Blood & Tissue

William Bullock - Specialized Program Coordinator,
BA Paramedic

22 Counties covering 26,000+ sq miles
Population 2.5 million
4 hour drive time end to end (80 mph)



PAR Levels and Use

- STBT >/= 60 units
- UHS >/= 35 units
- Distributed across EMS/rural hospitals=68
- Daily use EMS =2
- Rotated units = 4/day
- STBT = 25 donors/day
- Overall use 1/20,000 population/day
- Waste = ~2.5%

Current State

Collection Information *(through 6/30/2025)*

Heroes in Arms units collected since program inception: **36900**

Heroes in Arms units collected in 2025: **3462**

Heroes in Arms units from male donors in 2025: **2650**

Heroes in Arms units from female donors in 2025: **812**

Donor Information

Total number of Heroes in Arms donors since program inception: **7495**

Total number of Heroes in Arms female donors since program inception: **1105**

Total number of Heroes in Arms male donors since program inception: **6390**

Total number of active Heroes in Arms donors (12 Months): **3,641**

University Hospital Distribution

LTOWB units sent to University Hospital since program inception: **14402**

LTOWB units sent from STBT to University Hospital 2025 (YTD): **1074**

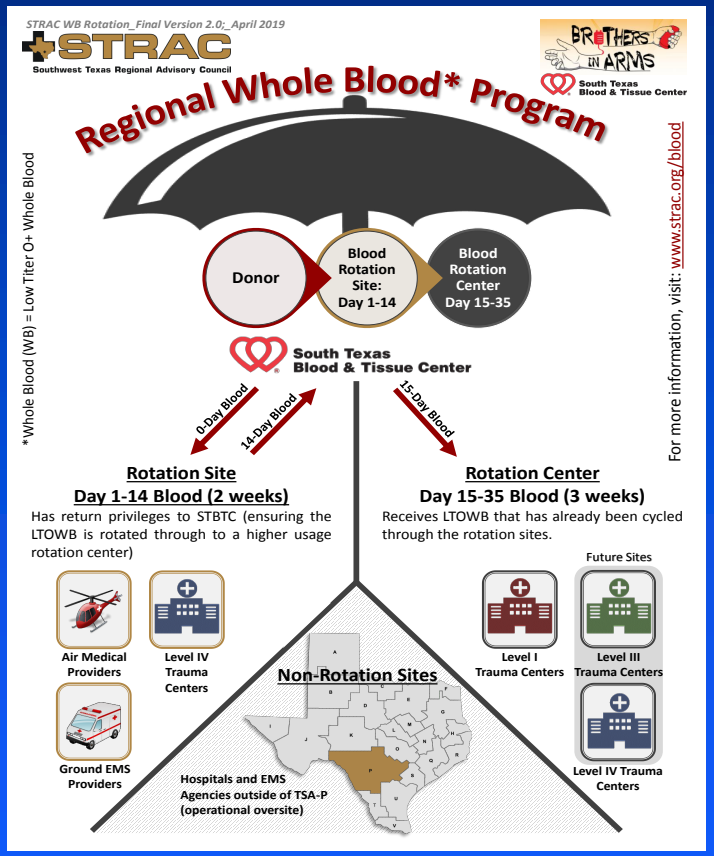
LTOWB units returned to STBT from University since program inception: **444**

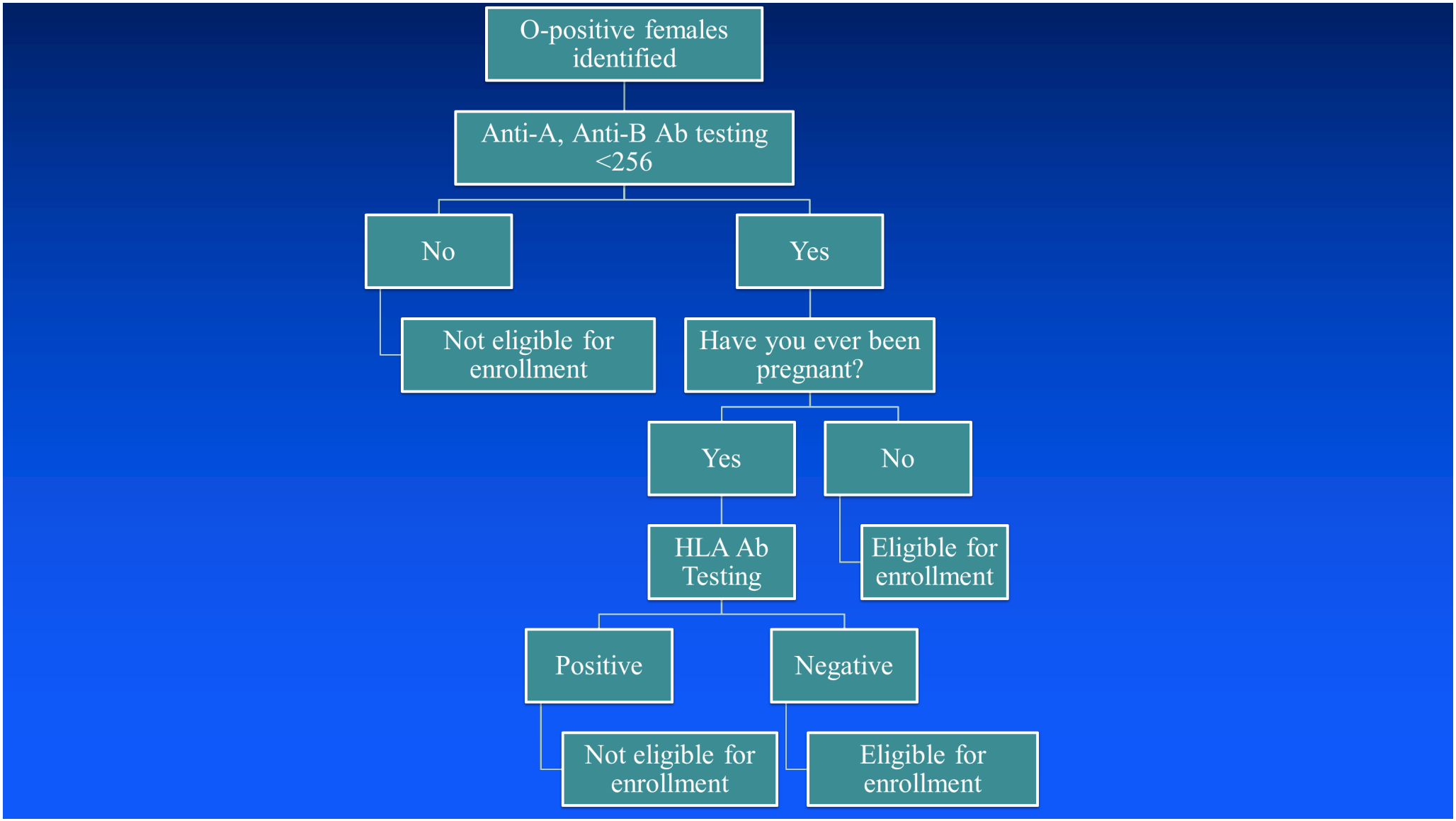
LTOWB units returned to STBT from University 2025 (YTD): **9**

(Note: Zero LTOWB+ units returned to STBT from UH in April, May, June)

Methods

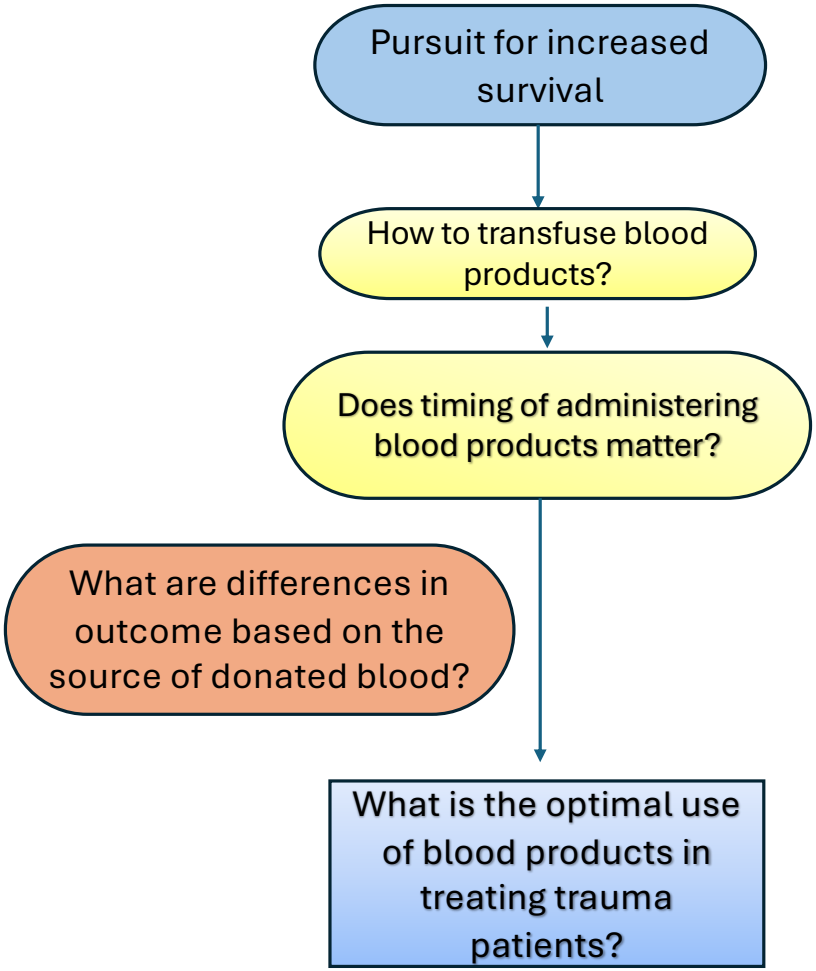
- LTOWB Rotation System to push DCR capability to all geographic areas, minimize costs to EMS agencies, and be good stewards of the "gift of life"
- Standardized transfusion criteria
- Regionally approved equipment list
- Region wide clinical documentation and data collection processes
- Develop a robust, loyal blood donor population

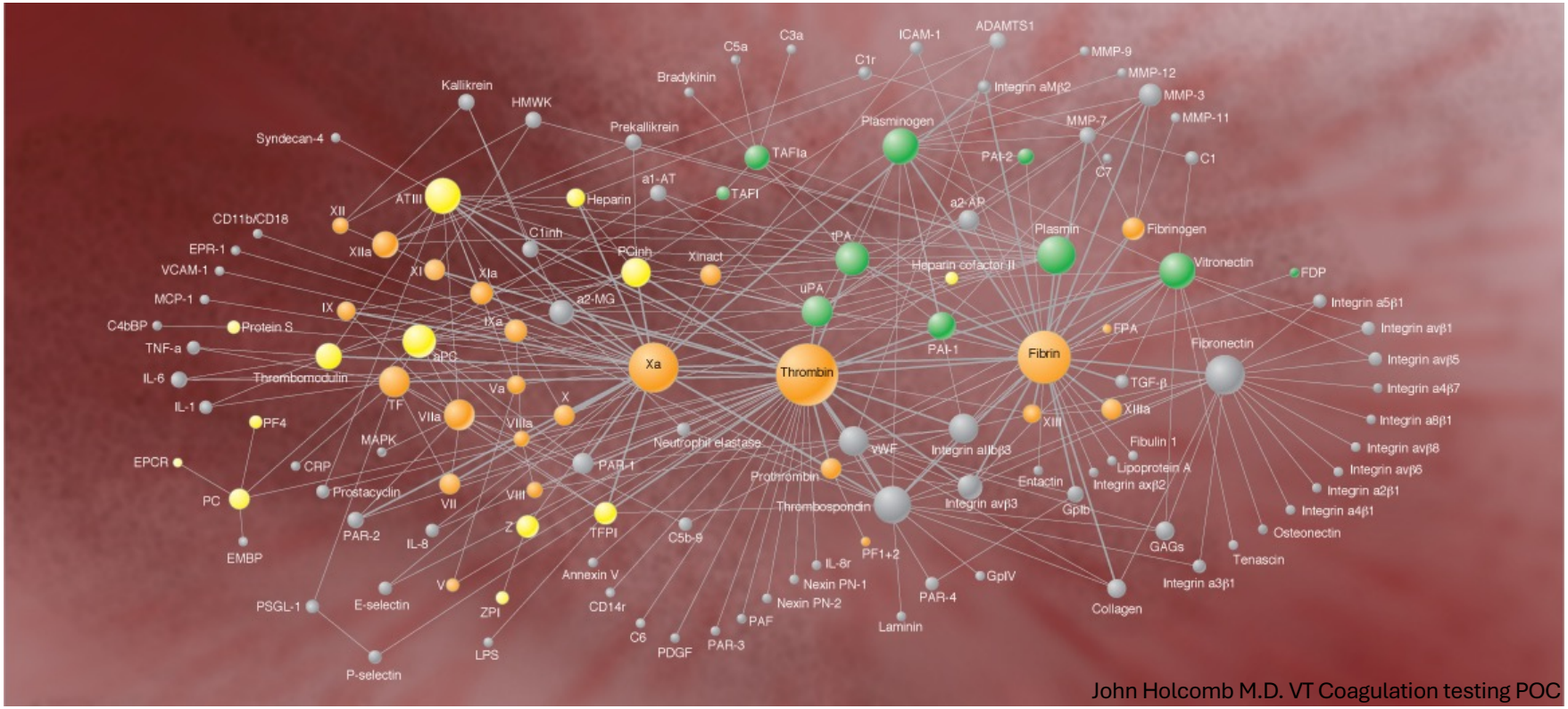



O-positive females identified
Anti-A, Anti-B Ab testing <256
No
Yes
Not eligible for enrollment
Have you ever been pregnant?
Yes
No
HLA Ab Testing
Eligible for enrollment
Positive
Negative
Not eligible for enrollment
Eligible for enrollment

How to Double Your Donors

- **Heroes in Arms (re-named after the addition of female donors)**
- In the three months since adding women, the program has screened 352 women and has found that 69% of the women are considered low-titer and are thus eligible for the LTOWB program.
- Several of the women who have been enrolled were originally screened as positive for prior pregnancy and underwent the additional HLA testing prior to enrolment.
- South Texas Blood and Tissue Center screened 2,151 previously pregnant females in 2022 for HLA Ab testing and 1,789 (83%) tested negative while only 362 (17%) tested positive.
- Nearly 2000 O+ women screened over 1000 low titer
  70% h/o pregnancy 14% HLA+


Pursuit for increased survival
How to transfuse blood products?
Does timing of administering blood products matter?
What are differences in outcome based on the source of donated blood?
What is the optimal use of blood products in treating trauma patients?



John Holcomb M.D. VT Coagulation testing POC

Impact of Donor Sex on Transfusion Outcomes

A Literature Review

Endotheliopathy of Trauma

The Endothelium's Homeostatic Role:

- Under normal conditions, endothelial cells (ECs) are crucial for vascular health, actively regulating:
  - **Coagulation:** Maintaining an antithrombotic surface (via heparan sulfates, thrombomodulin, TFPI).
  - **Inflammation:** Preventing leukocyte/platelet adhesion (via NO, PGI2), maintaining EC quiescence.
  - **Barrier Function:** Regulating vascular permeability between blood and tissue (via cellular junctions).

Endotheliopathy of Trauma (EoT):

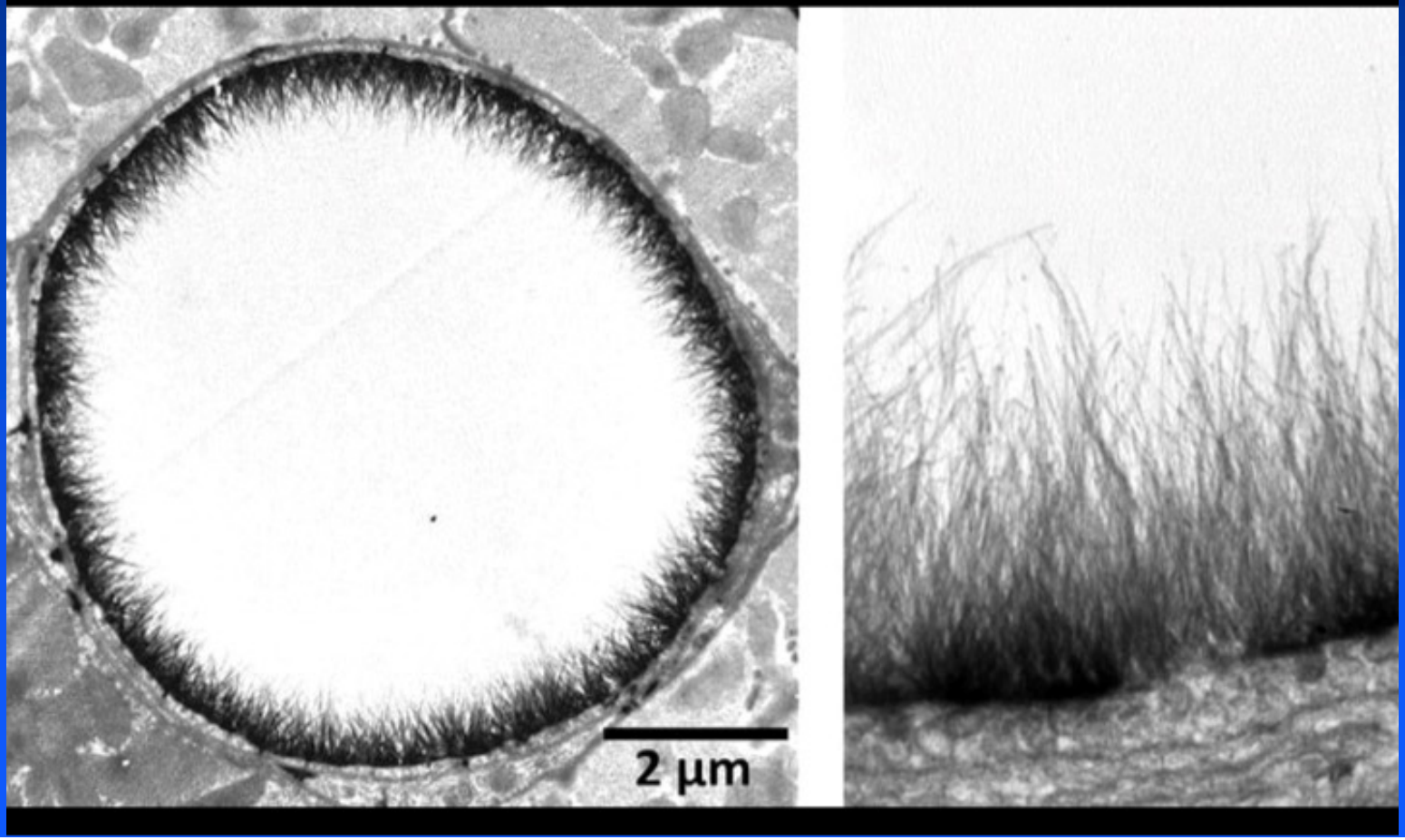
- EoT describes the **injury, activation, and maladaptive responses of endothelial cells** to major trauma (e.g., tissue damage, hemorrhagic shock, burns).
- **Initial pathological event** that drives systemic complications.
- **Clinical Significance:** EoT biomarkers (e.g., syndecan-1, soluble TM, E-selectin) are strongly linked to poor outcomes (mortality, morbidity, organ failure) after trauma. EoT develops rapidly and persists.

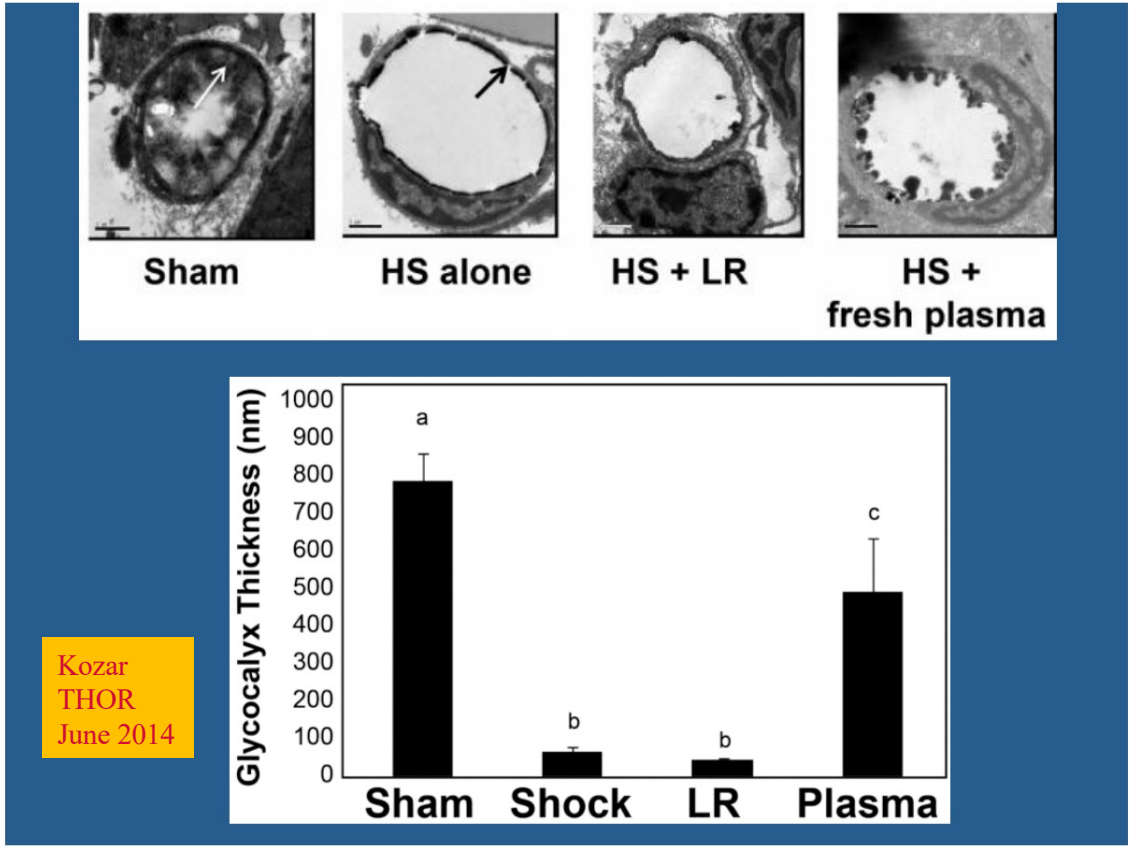
Cardenas, Jessica C et al. “Injury-induced endotheliopathy: What you need to know.” *The journal of trauma and acute care surgery* vol. 95,4 (2023): 454-463.

- **Key Mechanisms Driving EoT:**
  - **Glycocalyx Damage:** Traumatic injury and inflammation lead to rapid shedding of the glycocalyx, creating a procoagulant surface, exposing the endothelium to inflammatory mediators, and causes vascular leakage/tissue edema.
  - **Extracellular Vesicle (EV) Release:** Activated/apoptotic ECs release EVs that:
    - Promote coagulation (via anionic phospholipids, tissue factor).
    - Induce vasoconstriction and disseminate injury.
    - Carry bioactive factors that activate or injure other ECs.
  - **Dysregulated Von Willebrand Factor (VWF):** Trauma disrupts the balance of hyperadhesive ultra-large VWF (ULVWF) multimers and its cleaving enzyme ADAMTS-13. This leads to ULVWF accumulation, promoting spontaneous platelet binding and microvascular thrombosis.

All the above lead to consumptive coagulopathy and hyperfibrinolysis (tPA release), which may later shift to a hypercoagulable state.

Protect the Glycocalyx !




Sham
HS alone
HS + LR
HS + fresh plasma
Kozar
THOR
June 2014
Glycocalyx Thickness (nm)
1000
900
800
700
600
500
400
300
200
100
0
a
b
b
c
Sham
Shock
LR
Plasma

The role of biological sex in severely traumatized patients on outcomes: a matched-pair analysis

- **Study Overview and Context**

Background:

- Trauma-Associated Severe Hemorrhage (TASH) score identifies male sex as an independent risk factor for massive transfusion.
- Previous trauma studies not associating female sex with increased survival often included low-risk cohorts (mean ISS <16, mortality <10%), limiting generalizability.

Study Cohort:

- 20,288 trauma patients (ISS ≥9) from TR-DGU registry.
- 72.6% males (n=14,720) and 27.4% females (n=5,568).
- Mean ISS = 25, mortality = 17% — higher-risk cohort enabling robust analysis.

Trentzsch H, Lefering R, Nienaber U, Kraft R, Faist E, Piltz S. The role of biological sex in severely traumatized patients on outcomes: a matched-pair analysis. Ann Surg. 2015

Key Findings:

Females have increased survival post trauma

- Females had a **1.7% absolute reduction in mortality** compared to males.
- Males had **1.14× higher odds of death** ($P = 0.037$, χ^2 test; $P = 0.014$, McNemar test).
- Mortality differences most pronounced in **age group 16–44 years**, possibly linked to sex steroids.

Further supported by:

Evidence of hormonal basis for improved survival among females with trauma-associated shock: an analysis of the National Trauma Data Bank

A retrospective NTDB analysis (2001–2005) of trauma patients (ISS ≥16, hypotension) found that hormonally active females (13–64 yrs) had significantly lower mortality than similarly injured males. No survival advantage was seen at hormonal extremes (≤12 or ≥65 yrs), suggesting a hormonal contribution to sex-based differences in trauma outcomes.

Haider, Adil H et al. "Evidence of hormonal basis for improved survival among females with trauma-associated shock: an analysis of the National Trauma Data Bank."

Hormonally active women tolerate shock-trauma better than do men: a prospective study of over 4000 trauma patients

Tolerate shock better

Ann Surg 2007 Edwin A Deitch

- Retrospective analysis of trauma patients stratified by age and hormonal status.
- Serum lactate measured as a marker of tissue perfusion.
- Adjustments made for BMI to control for differences in body size and muscle mass between sexes.

Key Findings:

- **Premenopausal and perimenopausal women** had **lower lactate levels** after trauma than men.
- **No sex differences** in lactate levels among patients <14 years or >55 years (low hormonal activity groups).
- Despite **higher Injury Severity Scores (ISS)**, women required **fewer blood transfusions** than men.

Hormonally active women show better hemodynamic homeostasis and oxygen delivery after trauma, suggesting superior adaptation to early physiologic stress.

Deitch, Edwin A et al. “Hormonally active women tolerate shock-trauma better than do men: a prospective study of over 4000 trauma patients.” *Annals of surgery* vol.

Further evidence in how biological differences favors female trauma survival,

More Hypercoagulable

Hypercoagulability was found to be most prevalent early after injury and in female patients

- J Trauma 2005 Martin A Schreiber

- **Prospective cohort study** found >80% of women were hypercoagulable on **day 1 post-injury**.
- Hypercoagulability in females **rapidly normalized by day 2**, becoming equivalent to males.
- Early, transient hypercoagulable state may **confer survival advantage** in females after trauma.

The early hypercoagulability observed in women offers a **survival advantage by rapidly controlling bleeding**, reinforcing that **timely, targeted resuscitation with appropriate blood products** is critical to optimizing trauma outcomes.

Schreiber MA, Differding J, Thorborg P, Mayberry JC, Mullins RJ. Hypercoagulability is most prevalent early after injury and in female patients

Trauma Resuscitation Considerations: Sex Matters

J Am Coll Surg 2019 Julia R Coleman

Objective:

- Evaluate sex-based differences in coagulation (TEG) after trauma and their effect on transfusion needs and mortality.

Study Design:

- **Prospective observational study** at two Level-1 trauma centers.
- All trauma activation patients had admission TEG performed; blood product resuscitation adjusted based on TEG.

Resuscitation protocol: Initial ratio 2U FFP:4U RBC, followed by TEG-directed therapy.

Primary outcomes:

- Massive transfusion (>10 RBC units in 6h or death within 6h).
- 30-day mortality.
- Hypercoagulable complications (VTE, PE, DVT, CVA).

Hypothesis:

- Females are more hypercoagulable post-injury, leading to reduced massive transfusion rates and mortality compared to males.

Coleman, Julia R et al. "Trauma Resuscitation Consideration: Sex Matters." *Journal of the American College of Surgeons* vol. 228,5 (2019)

Results:

- **Female sex conferred a survival advantage** (adjusted OR for death: males 2.89 vs females 0.65).
- Admission TEG profiles showed **females had shorter R times and higher maximum amplitude (MA)**, consistent with a hypercoagulable state.
- These sex-based differences were **not solely explained** by current hormonal status (pre- vs post-menopausal).

Possible Mechanisms:

- Lifelong exposure to female sex hormones may induce **genomic and epigenetic changes** enhancing coagulation responses.
- Hypercoagulability early after injury likely aids **rapid hemostasis**, decreasing transfusion needs and mortality.

Conclusion:

Sex-specific coagulation patterns provide a biologic basis for the **improved survival seen in females** after severe trauma.

Untangling sex dimorphisms in coagulation

Ann Surg. 2020 Julia R Coleman

- Females exhibit **relative hypercoagulability** post-trauma and a **survival advantage**, but the physiologic basis was unclear.

Study Design:

- 121 healthy volunteers (49% female, <55 years) underwent comprehensive hemostatic profiling.
- **Battery of 9 TEG-based assays** including novel **tPA-challenged TEG** (fibrinolysis sensitivity) and **DIFF-TEG**(TXA-reversible fibrinolysis).

.

Key Laboratory Findings:

- Females showed:
  - Higher platelet counts and Von Clauss fibrinogen.
  - **Shorter time to clot initiation** and **faster clot propagation** (CN-, CK-, CR-TEG).
  - **Higher clot strength** (MA) largely driven by fibrin contribution (CFF-TEG).
  - Increased platelet reactivity to ADP and AA, but no overall difference in maximal platelet contribution to clot strength.

Coleman, Julia R et al. “Untangling Sex Dimorphisms in Coagulation: Initial Steps Toward Precision Medicine for Trauma Resuscitation.” *Annals of surgery*vol. 271,6 (2020)

Physiologic Insights:

- Despite higher fibrinogen, females did **not** have reduced fibrinolysis rates or greater resistance to exogenous tPA.
- Females had **more functional fibrinogen** and **faster enzymatic coagulation activation**.
- Sex differences were **more pronounced** in functional assays (CFF-TEG) than standard fibrinogen measurements.

Clinical Implications:

- **Female hemostasis is distinct**, characterized by stronger, faster clot formation without fibrinolysis resistance.
- Baseline differences may explain sex-based differences in trauma outcomes and response to bleeding or anticoagulation.
- Current resuscitation goals are based on male norms; this study supports developing **sex-specific hemostatic resuscitation guidelines**.

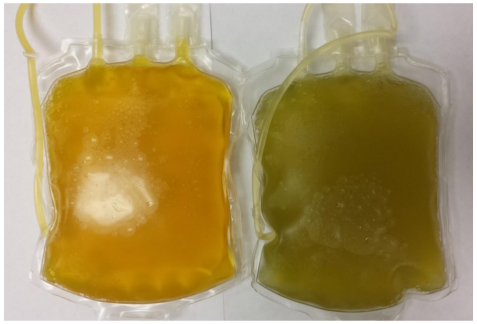
Green Plasma Has a Superior Hemostatic Profile Compared With Standard Color Plasma

Am Surg 2022 Bryan A Cotton

Background:

- Plasma from **pregnant donors or those on oral contraceptives** often appears green due to elevated **ceruloplasmin levels**.
- Despite normal safety, GREEN plasma units are often discarded based solely on appearance.

Female plasma is more hypercoagulable



Study Goal:

- Assess the **hemostatic capacity** of GREEN plasma versus standard plasma.

Key Findings:

- **GREEN plasma** showed:
  - **Lower R-values** (faster clot initiation)
  - **Higher alpha-angles, MA, A30, A60** (stronger and more stable clot formation)
  - **Trend toward shorter K-time** (faster clot strengthening)
- Conventional labs (PT/INR, fibrinogen) confirmed **greater hemostatic potential** in GREEN plasma; only D-dimer trended lower.

Conclusion:

- GREEN plasma demonstrates **superior hemostatic properties** and should not be discarded based on color alone.

Kalkwarf KJ, Cardenas JC, Wade CE, Cotton BA. Green Plasma Has a Superior Hemostatic Profile Compared With Standard Color Plasma. *The American Surgeon*

Endotheliopathy of Trauma

- Happens in tissue injury and hemorrhage
- Shabani and Kozar have shown this in research
- Can be treated with plasma and/or platelets
  - Plasma is available in large quantity
  - Platelets are harder to come by than whole blood and have very limited shelf life (5 days)
  - Whole blood has all of that
- But do we absolutely need whole blood?

Logistics

- Whole blood, red cells and plasma share commonalities
  - Cold chain storage requirement
  - Education
  - Training
  - Equipment
  - Supplies
  - Documentation
  - Warming

Resuscitation

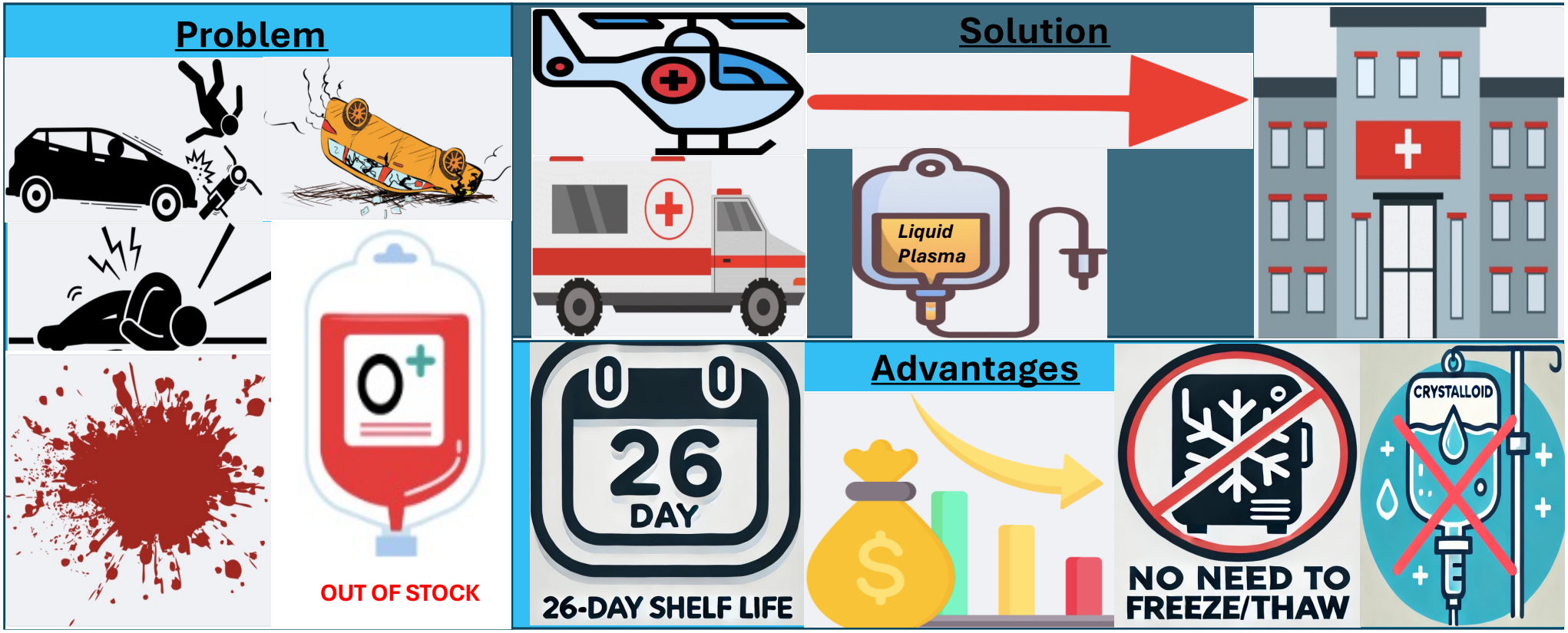
- Volume of resuscitation is of value
- Whole blood is approximately 500 ml volume
- Plasma is approximately 250 cc volume
- Usual pre-hospital cooler holds ~ 500 cc volume
- Resuscitation volume of 250 cc x 2 = 500 cc
- Just for volume, 1 u LTOWB = 2 u liquid plasma

Novel Recommendation

- If faced with dilemma, no transfusion because of lack of whole blood, should we:
  - Use crystalloid?
  - Use plasma? (Mayo-Kim et al and Pitt-Sperry et al)
  - Use RBC's? (Tulane-Marino/Duchesne)
- Based on science, plasma is best choice in most pre-hospital scenarios until whole blood becomes available
- Consider substituting 2 bags of liquid plasma in lieu of whole blood when whole blood is unavailable
- No need to wait to get started because everything needed for plasma administration is the same for whole blood

Dried Plasma

From Shortages to Solutions: Liquid Plasma as a Practical Alternative to Whole Blood for Prehospital Trauma Resuscitation

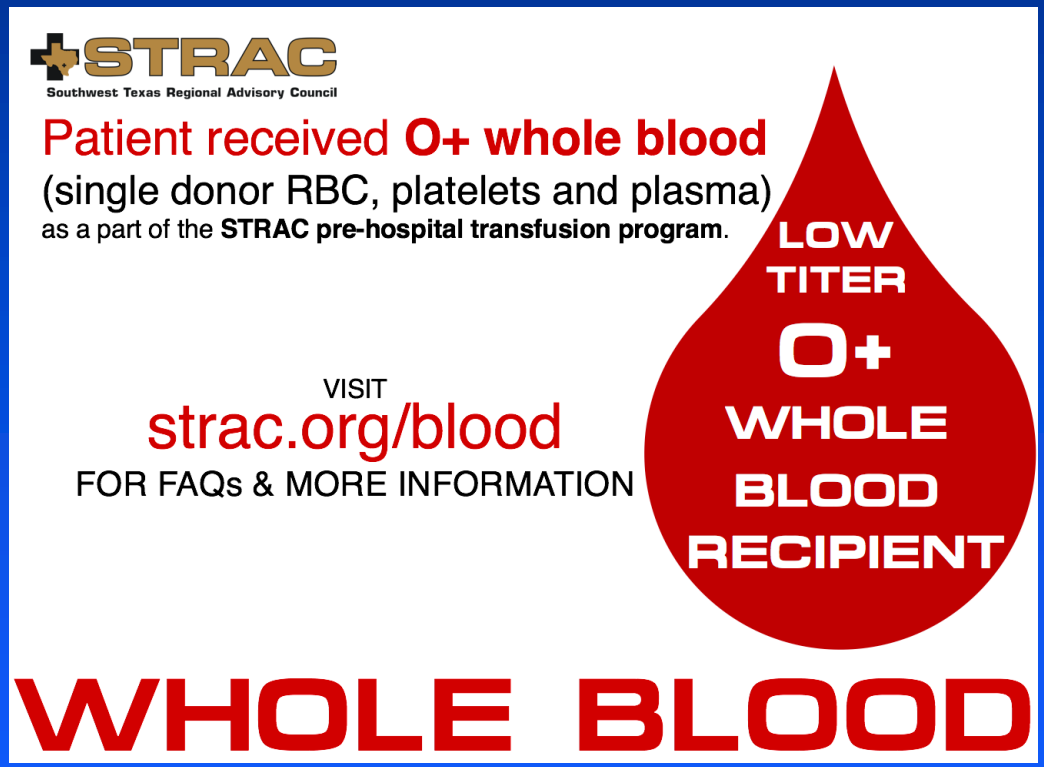


THE JOURNAL OF AABB
TRANSFUSION
transfusion.org

Rajesh et al. *Transfusion* 2025
@DonaldJenkins

UT Health San Antonio

Clinical References/Resources



www.strac.org/blood

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Jenkinsd4@uthscsa.edu

National Highway Traffic Safety Administration (NHTSA) Motor Vehicle Crash Data Querying and Reporting
Persons Killed in Fatal Crashes
Filter Selected: Person Injury Type: Fatal
State: Texas
Years: 2020-2022

Persons Killed in Fatal Crashes [1]

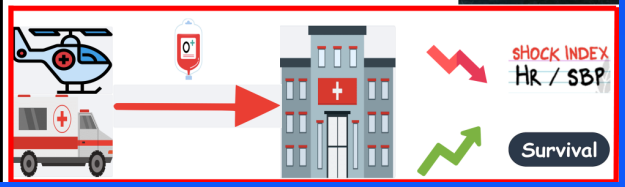
Death Location	Land Use (Rural/Urban)			
	Rural	Urban	Unknown	Total
Died at Scene of Crash	3,666	4,540	8	8,214
Died at Unknown Location	2	5	0	7
Died en Route to a Hospital or Treatment Facility	0	1	0	1
Died at Other Location	1,260	3,296	6	4,562
Percent "Alive at Scene"	26%	42%	43%	36%
Total	4,928	7,842	14	12,784

Prehospital Whole Blood Improves Probability of Survival & Shock Physiology

419 total patients (241 in prehospital WB group)

- **2.2x (54% vs 34%)** higher odds of improved survival probability
- **2.7x (10% vs 4%)** higher odds of being an unexpected survivor with severe injury
- **2.5x (34% vs 16%)** higher odds of improved shock index from >1 to <1

$15,725 spent on prehospital whole blood (17 patients each transfused one unit of WB) will produce 1 unexpected survivor



Persons Killed in Fatal Crashes
Filter Selected: Person Injury Type: Fatal
State: Texas
Years: 2020

Persons Killed in Fatal Crashes [1]

Death Location	Land Use (Rural/Urban)			
	Rural	Urban	Unknown	Total
Died at Scene of Crash	1,134	1,343	1	2,478
Died at Unknown Location	0	1	0	1
Died at Other Location	370	1,025	2	1,397
Percent "Alive at Scene"	25%	43%	67%	36%
Total	1,504	2,369	3	3,876

National Highway Traffic Safety Administration (NHTSA) Motor
Persons Killed in Fatal Crashes
Filter Selected: Person Injury Type: Fatal
State: Texas
Years: 2021

Persons Killed in Fatal Crashes [1]

Death Location	Land Use (Rural/Urban)			
	Rural	Urban	Unknown	Total
Died at Scene of Crash	1,243	1,605	4	2,852
Died en Route to a Hospital or	0	1	0	1
Died at Other Location	502	1,144	1	1,647
Percent "Alive at Scene"	29%	42%	20%	37%
Total	1,745	2,750	5	4,500

National Highway Traffic Safety Administration (NHTSA) Motor
Persons Killed in Fatal Crashes
Filter Selected: Person Injury Type: Fatal
State: Texas
Years: 2022

Persons Killed in Fatal Crashes [1]

Death Location	Land Use (Rural/Urban)			
	Rural	Urban	Unknown	Total
Died at Scene of Crash	1,289	1,592	3	2,884
Died at Unknown Location	2	4	0	6
Died at Other Location	388	1,127	3	1,518
Percent "Alive at Scene"	23%	41%	50%	34%
Total	1,679	2,723	6	4,408