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Comparative Outcomes of Whole Blood Plus Component Therapy Versus Component Therapy Alone in Hemorrhagic Shock: A Propensity-Matched Analysis

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Introduction

- **Trauma mortality burden**
  - Death following trauma is the leading cause of death in people <46 years old [1].
  - Exsanguination is the most common preventable cause of trauma death [2].
- **Historical transition in transfusion practice:**
  - Whole blood (WB) was the standard during WWI, WWII, and Korea, but was replaced by component therapy (CT) during the Vietnam War era due to cost/logistics rather than evidence [3,4].
  - Modern conflicts (Iraq, Afghanistan) show superior efficacy of WB over CT in combat casualty care [5,6].
- **Civilian implementation and benefits:**
  - Community trauma centers have shown WB can improve survival compared to CT [7].
- **Logistical challenges:**
  - WB has shorter shelf life, larger volume requirements, and high expiration rates—with one study reporting ~42% expiration in a year [8,9].
  - Shortages due to WB volume demands can delay resuscitation and increase morbidity [10,11].
- **Emergence of hybrid (CT + WB) model:**
  - A hybrid approach can optimize resources and improve outcomes when WB supply is limited [12].
- **Study goal and hypothesis:**
  - Compare CT + WB vs CT alone in adult trauma patients with hemorrhagic shock.
  - Hypothesis: CT + WB yields **similar or improved outcomes** with no increase in adverse events.

Methods

- **Design:** Retrospective cohort study of adult trauma patients (≥18 yr) with hemorrhagic shock at a Level 1 Trauma Center (July 2019–Dec 2023, IRB #2117).
- **Inclusion:** Patients requiring urgent transfusion within 24 h of injury due to hypotension, tachycardia, shock index > 1, or abnormal lactate/base deficit.
- **Groups:** Compared CT (n=85) vs CT + WB (n=144) during initial resuscitation.
- **Exclusion:** Minors, vulnerable populations, or incomplete data.
- **Variables:** Demographics (age, sex, race, BMI), injury characteristics (mechanism, head AIS, ISS), transfusion data (WB, pRBC, FFP, Plt, Cryo volumes within 24 h), and outcomes (mortality, LOS, ventilator days, ARDS, VAP, sepsis, TACO, TRALI, AKI).
- **Matching:** 2:1 propensity match (CT + WB : CT) using exact matching for sex, race, mechanism, and greedy algorithm for age, BMI, head AIS, ISS.
- **Analysis:** Chi-square/Fisher for categorical and t-test or Mann-Whitney U for continuous variables (SAS v9.4). Significance = $p < 0.05$.

References

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Data

Table 1. Patient Demographics and Clinical Characteristics

	CT (N=85)	CT + WB (N=144)	p-value
Sex, % (n)			0.758
Male	75.3 (64)	77.1 (111)	
Female	24.7 (21)	22.9 (33)	
Race/Ethnicity, % (n)			0.702
White/Caucasian	28.2 (24)	32.6 (47)	
Black/African American	64.7 (55)	63.2 (91)	
Hispanic	5.9 (5)	3.5 (5)	
Other	1.2 (1)	0.7 (1)	
Age (years), mean (SD)	39.8 (18.0)	38.9 (18.3)	0.719
BMI (kg/m^2), means (SD)	26.6 (6.9)	27.1 (6.8)	0.627
ISS, mean (SD)	21.6 (14.7)	21.2 (12.5)	0.812
Head AIS, % (n)			0.523
0	60.0 (51)	62.5 (90)	
2	7.1 (6)	6.9 (10)	
3	12.9 (11)	16.7 (24)	
4	9.4 (8)	8.3 (12)	
5	8.2 (7)	5.6 (8)	
6	2.4 (2)	0 (0)	
Injury type, % (n)			0.579
Blunt	60.0 (51)	56.3 (81)	
Penetrating	40.0 (34)	43.8 (63)	

AIS= Abbreviated Injury Scale; BMI= body mass index; CT= component therapy alone; CT + WB = component therapy plus whole blood; ISS= Injury Severity Scale; SD = standard deviation.

Table 2. Blood Components and Whole Blood Transfused Volumes

	CT (N=85)	CT + WB (N=144)	p-value
Whole blood (ml), median (IQR)	0 (0)	1,059 (545 – 1,127)	--
FFP (ml), median (IQR)	209 (0 – 794)	0 (0 – 1,254)	--
pRBC (ml), median (IQR)	691 (368 – 1,381)	333 (0 – 2,065)	--
Platelet (ml), median (IQR)	0 (0 – 60)	0 (0 – 203)	--
CYP (ml), median (IQR)	0 (0 – 0)	0 (0 – 0)	--
Total components, median (IQR)	1,003 (566 – 2,279)	578 (0 – 3,517)	0.021
All volume, median (IQR)	1,003 (566 – 2,279)	1,824 (940 – 4,518)	0.0002
MTP, % (n)	18.82 (16)	37.50 (54)	0.003

CT= component therapy alone; CT + WB = component therapy plus whole blood; CYP= Cryoprecipitate; FFP= Fresh Frozen Plasma; IQR = inter quartile range (25^{pct} – 75^{pct}); MTP = Massive Transfusion Protocol; pRBC= packed red blood cells.

Table 3. Outcomes

	CT (N=85)	CT + WB (N=144)	p-value
Ventilation, % (n)	37.7 (32)	44.4 (64)	0.314
ARDS, % (n)	4.8 (4)	2.1 (3)	0.428
Sepsis, % (n)	1.2 (1)	2.1 (3)	1.000
TACO, % (n)	0 (0)	0.7 (1)	1.000
Blood transfusion reaction (0 – 24 hr), % (n)	1.2 (1)	0 (0)	0.363
Surgery (0 – 24 hr), % (n)	77.7 (66)	67.4 (97)	0.097
Mortality (0 – 24 hr), % (n)	9.5 (8)	19.4 (28)	0.048
Mortality prior to discharge, % (n)	19.1 (16)	31.3 (45)	0.045
AKI, % (n)	4.7 (4)	1.4 (2)	0.198
Hospital LOS (days), median (IQR)	9 (5 – 26)	7 (2 – 19)	0.010

AKI= acute kidney injury; ARDS = acute respiratory distress syndrome; CT= component therapy alone; CT + WB = component therapy plus whole blood; IQR = inter quartile range (25^{pct} – 75^{pct}); LOS = length of stay; SD = standard deviation; TACO = transfusion-associated circulatory overload.

Data was unavailable for: ARDS (n=1), Sepsis (n=1), TACO (n=1), transfusion reaction (n=3), mortality (n=1), and pre-discharge mortality (n=1).

Results

- **Baseline:** Groups were well matched for sex, race, age, BMI, head AIS, ISS, and mechanism of injury ($p > 0.05$).
- **Transfusions:**
  - Total transfusion volume higher in CT + WB (1824 mL [IQR 940–4518]) vs CT (1003 mL [IQR 566–2279]); $p = 0.0002$.
  - Massive transfusion protocol (MTP) activation more frequent in CT + WB (37.5 % vs 18.8 %; $p = 0.003$).
  - Median WB volume = 1059 mL [IQR 545–1127].
- **Outcomes:**
  - Hospital LOS shorter in CT + WB (7 days [IQR 2–19]) vs CT (9 days [IQR 5–26]); $p = 0.010$.
  - 24-hour mortality higher in CT + WB (19.4 %) vs CT (9.5 %); $p = 0.048$.
  - Overall mortality: 31.3 % (CT + WB) vs 19.1 % (CT); $p = 0.045$.
  - No significant differences in ARDS, VAP, sepsis, TACO, TRALI, or AKI ($p > 0.05$).

Discussion

- **Efficiency:** CT + WB patients required higher transfusion volumes but had shorter hospital stays, suggesting more effective hemostasis and faster stabilization.
- **Safety:** No increase in ARDS, sepsis, renal injury, or transfusion reactions, supporting the safety of hybrid WB + CT in civilian trauma.
- **Mortality pattern:** Higher early mortality in the CT + WB group may reflect selection bias or unmeasured physiologic severity, as WB was often administered in cases requiring rapid, high-volume resuscitation (more MTP activations).
- **Mechanistic rationale:** WB provides a balanced combination of RBCs, plasma, and platelets, maintaining clotting factor activity and platelet function compared with stored components [5,7,10,13–17].
- **Challenges:** WB's short shelf life and storage demands remain major logistical barriers to broader implementation [8–9].

Conclusion

- Hybrid WB + CT transfusion is a safe, feasible, and effective strategy for resuscitating hemorrhagic shock.
- Despite higher initial transfusion volumes, CT + WB was associated with reduced hospital length of stay and comparable complication rates relative to CT alone.
- These findings support integrating WB into civilian trauma protocols as a complement to component therapy.
- The higher early mortality observed likely reflects clinical selection for WB in patients requiring more urgent resuscitation rather than baseline injury differences.
- Limitations & Future Directions:
  - Retrospective single-center design limits generalizability. Future multi-center prospective studies should examine timing, dosing, and selection criteria for WB use and assess long-term functional outcomes.
- Overall, WB + CT represents a promising, resource-aware approach that aligns with evidence from both military and civilian literature [5–7, 13–17].