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Multicenter Observational Prehospital Resuscitation on Helicopter Study (PROHS)

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Abstract

BACKGROUND—Earlier use of in-hospital plasma, platelets and red blood cells (RBCs) has improved survival in trauma patients with severe hemorrhage. Retrospective studies have associated improved early survival with prehospital blood product transfusion (PHT). We hypothesized that PHT of plasma and/or RBCs would result in improved survival after injury in patients transported by helicopter.

METHODS—Adult trauma patients transported by helicopter from the scene to nine Level 1 trauma centers were prospectively observed from Jan–Nov 2015. Five helicopter systems had plasma and/or RBCs while the other four helicopter systems used only crystalloid resuscitation. All patients meeting predetermined high risk criteria were analyzed. Patients receiving PHT were compared to patients not receiving PHT. Our primary analysis compared mortality at 3 hours, 24 hours, and 30 days, using logistic regression to adjust for confounders and site heterogeneity to model patients who were matched on propensity scores.

RESULTS—25,118 trauma patients were admitted, 2341 (9%) were transported by helicopter, of which 1058 (45%) met the highest risk criteria. 585/1058 patients were flown on helicopters carrying blood products. In the systems with blood available, prehospital median systolic blood pressure (125 vs 128) and GCS (7 vs 14) was significantly lower, while median ISS was significantly higher (21 vs 14). Unadjusted mortality was significantly higher in the systems with blood products available, at 3 (8.4% vs 3.6%), 24 (12.6% vs 8.9%) hours and 30 days (19.3% vs 13.3%). 24% of eligible patients received a prehospital transfusion. A median of 1 unit of RBCs and plasma were transfused prehospital. Of patients receiving PHT, 24% received only plasma, 7% received only RBCs and 69% received both. In the propensity score matching analysis (n=109), PHT was not significantly associated with mortality at any time point, although only 10% of the high risk sample were able to be matched.

CONCLUSIONS—Because of the unexpected imbalance in systolic blood pressure, GCS and ISS between systems with and without blood products on helicopters, matching was limited and the results of this study are inconclusive. With few units transfused to each patient and small outcome differences between groups, it is likely large, multicenter, randomized studies will be required to detect survival differences in this important population.

Keywords

trauma; transfusion; prehospital; plasma; resuscitation; damage control resuscitation

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Background

Injury is the leading cause of death in adults and children between the ages of 1 and 44 years.[1] The staggering numbers of years of productive life lost due to 199,800 deaths (with 20–30% potentially preventable) annually from injuries demands more urgent attention be paid to this major public health problem.[2] Approximately 40% of in-hospital deaths among injured patients involve massive truncal hemorrhage that is considered potentially salvageable.[3–5] Multiple retrospective military and civilian studies have reported that blood component ratios (i.e., Plasma: Platelets: red blood cells [RBC]) approaching whole blood (1:1:1) are associated with significant decreases in 24-hour and 30-day mortality among injured patients.[6–20] However, platelets are virtually impossible to pre-position prehospital or in the emergency department (ED). Therefore, many centers have placed thawed or liquid plasma and RBCs in the ED and in pre-hospital settings, allowing earlier infusion of blood products and avoiding delayed achievement of a balanced transfusion.[21–23] Recent prehospital transfusion (PHT) studies from the military and civilian hospitals have shown that prehospital plasma and RBCs are not only feasible, but associated with improved coagulation status on arrival and subsequent early outcomes.[24–29]

Prehospital resuscitation practices in the US differ significantly in approach, with most systems using crystalloids while a few offer red blood cells (RBCs) or a combination of plasma and RBCs. Use of blood product concentrates is much less common. To date, no large multicenter civilian studies have evaluated the use of prehospital plasma and RBCs in severely injured patients compared to crystalloids. Thus we proposed a pragmatic, multicenter, observational study to compare two different prehospital resuscitation approaches. The hypothesis of this study was that patients with severe traumatic injuries evacuated to level 1 trauma centers on air ambulances who received prehospital red blood cells and/or plasma would have lower in-hospital mortality compared to patients transferred by air ambulance who received only crystalloid.

Methods

Study Population

The Prehospital Resuscitation on Helicopter Study (PROHS) was a multicenter, prospective pragmatic, observational study of prehospital resuscitation approaches. Patients estimated to be greater than 15 years old (or greater than 50kg if age unknown) with traumatic injuries, who were transported by helicopter directly from the scene of injury to one of nine Level I trauma centers between January 26, 2015 and November 2, 2015 were eligible for the study. Of the 9 centers, 5 helicopter systems had plasma and/or red blood cells available on the helicopter and 4 helicopter systems used only crystalloid resuscitation. The study excluded prisoners and any transfers between hospitals. As this was an observational study, there were no study guidelines dictating resuscitation practice (i.e., blood products, crystalloids, or end of resuscitation). Sites agreed not to change resuscitation practices for the duration of the study. A subset of patients considered the highest risk population were directly observed by study staff based on at least one of the following criteria measured during prehospital helicopter transport: 1) heart rate greater than 120 beats per minute, 2) systolic blood pressure less than or equal to 90mmHg, 3) penetrating truncal injury, 4) tourniquet applied, 5) pelvic binder applied, 6) intubated prehospital, or 7) received blood products during transport. All analyses were performed among this highest risk population. All sites received appropriate approvals from their local institutional review boards and the US Army Human Research Protections Office.

Statistical Methods

Clinical data were entered and stored in a web based database, OpenClinica 3.9 Enterprise Edition. Unadjusted comparisons between the groups were performed using Wilcoxon rank sum tests on continuous variables and chi-squared tests to test proportions. Propensity score analysis, logistic regression, and Cox proportional hazards models were employed to analyze the primary outcome. Data analysis was performed using SAS 9.4 and R versions 3.2.3 and 3.3. Propensity scores were computed using the TWANG package.[30] All analyses used a two-sided type 1 error level of 0.05.

Primary Analysis—The primary analysis utilized propensity scoring to estimate the average treatment effect of prehospital blood use on 3 hour, 24 hour and 30 day mortalities. The propensity for receiving prehospital blood products was modeled as a function of potential demographic and clinical confounders: age, gender, race (white, black, other), injury severity score (ISS), prehospital vital signs (systolic blood pressure, diastolic blood pressure, pulse), whether or not patients satisfied more than one of the highest risk criteria (yes/no), presence of any penetrating injury (yes/no), use of a prehospital lifesaving intervention (yes/no), time from the air team call to arrival to the ED (in minutes), whether the bleeding source was identified prehospital (yes/no) and site volume (the total number of trauma patients arriving via helicopter). Generalized boosted modeling (GBM) was used to compute the propensity score,[31] which was defined as the predicted probability of receiving blood on the helicopter given baseline variables. After computing each patient's propensity score, patients were matched using nearest neighbors matching without replacement with a caliper of 0.2, and with a 2:1 ratio of no prehospital blood received to prehospital blood received. Balance was obtained for the variables in the propensity model.

Matched patients were analyzed using generalized estimating equations (GEE), a procedure that accounts for the matching.[32] The outcome was mortality (yes/no) and the covariate of interest was treatment; we present the average treatment effect for the treated (ATT) who received PHT. All models adjusted for site heterogeneity and results show the adjusted odds of death at 3 hours, 24 hours, or 30 days.

Pre-Planned Secondary Analyses—To investigate sensitivity of results to the propensity model, additional analyses were performed using all highest risk patients (unmatched). Logistic regression with a random intercept for site to adjust for heterogeneity, and Cox regression with a random intercept were both used to examine 3 hour, 24 hour and 30 day mortality. Residuals were assessed to verify model assumptions. For Cox regression, the proportional hazard assumption was assessed using the Supremum test and violations were further investigated using standard techniques. Age, sex and race were included in both models regardless of significance. All other covariates were retained if the Wald statistic p-value was less than 0.15. For logistic regression, ISS was categorized (1–8, 9–15, 16–24 and greater than 24). Final models included age, gender, race, and significant covariates, detailed in the result section. Odds ratios (OR) and 95% confidence intervals (95% CI) are reported for logistic regression models while hazard ratios (HR) and the 95% CIs are reported for Cox regression.

Results

A total of 25,118 trauma patients were admitted during the 10 month enrollment period to the nine participating centers, of which 2341 arrived by helicopter, and 1,058 met the highest risk criteria. Of the high risk sub-set, 585 arrived on helicopters with blood products available and 473 patients arrived via helicopters without blood available. (Table 1). One hundred forty two patients (24%) of patients transported on helicopters with blood products available actually received PHT and 916 patients did not (Table 2).

Comparison of systems with prehospital blood available vs. not available

Comparing patients with prehospital blood available versus not available (Table 1), there were no significant differences in age, gender, prehospital diastolic blood pressure or pulse, any penetrating injury or having met more than one highest risk criteria. However, there was a lower proportion of patients classified as other race (not white or black) in the no blood available group compared to the blood available group. Median prehospital systolic blood pressure and GCS were higher among patients who did not have prehospital blood available, while median ISS was lower. Patients on helicopters with blood available had shorter median time from air team call to arrival in the ED. Patients with blood available on the helicopter also had a significantly higher use of prehospital lifesaving interventions and fewer patients whose bleeding sources were identified compared to those without blood available. Figure 1 presents the boxplots for ISS of the patients from each site, showing the higher ISS among sites with blood available. This difference created substantial difficulty in balancing the group of patients who received PHT with those who did not. The imbalance in GCS, SBP and ISS contributed to the difference in unadjusted mortality. In the systems with blood products available, unadjusted mortality was significantly higher at 3 hours (8.4% vs 3.6%, $p<0.01$) and 24 hours (12.6% vs 8.9%, $p=0.05$) and at 30 days (19.3% vs 13.3%).

Comparison of patients with PHT and those not administered PHT

Considering patient characteristics in those receiving PHT (Table 2), there were no differences in age, gender or prehospital GCS versus those who did not. Those who did not receive PHT had significantly higher median prehospital systolic and diastolic blood pressures, a longer median number of minutes from air team call to ED arrival, and lower median ISS and prehospital heart rate than those who received PHT. The group who did not receive PHT also had a higher proportion of whites, fewer penetrating injuries, received fewer lifesaving interventions, had fewer bleeding sources identified and had a lower proportion of patients who met more than one of the highest risk criteria. Of patients receiving prehospital transfusion, 24% received only plasma, 7% received only RBCs and 69% received both. Those receiving PHT had a higher unadjusted mortality at 3 hours (16.2% vs 4.7%) and 24 hours (19.0% vs 9.7%) and at 30 days (25.4% vs 15.3%), all $p < 0.01$.

Results of the preplanned primary analysis

Patients were matched based on their propensity score, resulting in only 43 patients who received PHT and 66 patients who did not, for a total sample of 109 subjects (10% of our total sample). Although the statistical design called for matching 2 patients who did not receive prehospital blood products to one patient who did receive prehospital blood products, there were not enough matches within the caliper of 0.2 to maintain a 2:1 ratio for all patients who received prehospital blood products. The distributions of the propensity scores for the full data set (panel a) and the matched data set (panel b) are shown in Figure 2. The distribution of propensity scores among those who received blood (red bars) had definitive characteristics that gave them mostly high propensity scores, while those who did not receive blood had primarily low propensity scores (blue bars), including those who did not have blood available on the helicopters. Once matched, the propensity scores had more overlap, (figure 2, panel b) but there are still fewer patients who received blood and had a low propensity score (red bars), and likewise fewer patients who did not receive blood with a high propensity score (blue bars). After matching, the twelve variables included in the propensity score (see table 3) were balanced, except for age. A difference in median age, of close to 9 years, remained.

The results of the generalized estimating equation models after matching on propensity scores are presented in Table 4. There were no significant associations with receiving prehospital blood products on 3-hour mortality (OR 0.74, 95% CI 0.24–2.26, p=0.60), 24-hour mortality (OR 0.74, 95% CI 0.25–2.17, p=0.58), or 30-day mortality (OR 0.85, 95% CI 0.32–2.28, p=0.75).

Results of the pre-planned secondary analyses

Additional preplanned secondary analyses were performed to further examine any potential association of mortality with PHT in all highest risk patients adjusting for baseline covariates. The logistic regression models for each mortality endpoint (3 hours, 24 hours, and 30 days) differed in the covariates included (shown in the footnotes of Table 4). Receiving blood prehospital was not significantly associated with mortality at 3 hours (OR 1.69 95% CI 0.88–3.26, p=0.12) in the adjusted logistic regression model. Similarly, there was no significant association in the logistic regression models for 24 hour (OR 0.83, 95% CI 0.44–1.57, p=0.56) or 30 day mortality (OR 0.75, 95% CI 0.40–1.42 p=0.38) after adjustment for covariates.

Each of the three adjusted Cox regression models also differed in the covariates included in the models depending on the significance of covariates for that model/ timepoint (see footnotes of Table 4). The Cox proportional hazard model failed to converge when modeling deaths within 3 hours of arrival because one site did not have any patient deaths within 3 hours. Therefore, the model for 3 hour survival excluded the random effect for site, and prehospital blood product administration was not significantly associated with mortality at 3 hours (HR 1.40, 95% CI 0.82–2.39, p=0.22). No significant associations in the Cox models were seen at 24 hours (HR 1.12, 95% CI 0.41–3.06, p=0.83) or 30 days (HR 1.97, 95% CI 0.81–4.79, p=0.13) after adjustment for covariates including site.

Discussion

This study investigated the effect of the use of prehospital blood products in resuscitation at nine different sites. It is well known that as a group, patients arriving to level 1 trauma centers via helicopter have greater injury severity compared to those arriving by ground ambulance.[33–35] The design of this study was based on the assumption that the distribution of severely injured patients on helicopters was independent of prehospital blood product availability. However, in this study, the patient population arriving on helicopters with prehospital blood products available were more severely injured than those arriving on helicopters without prehospital blood available. This created substantial difficulty in balancing the groups using propensity score matching, which resulted in a very small number of patients who were able to be matched on a similar propensity score (10%), despite using a large caliper of 0.2. In the primary analysis, prehospital blood product use was not significantly associated with 3 hour, 24 hour or 30 day mortality. However, the unexpected and significant differences in injury severity score, GCS and SBP resulted in lower power and therefore, the results are inconclusive.

The preplanned secondary analysis utilizing logistic and Cox regression models were also not able to correctly adjust for differences between the patients receiving and not receiving PHT. In these models, different covariates were necessary in each model to adjust for baseline differences. These models also revealed nonsignificant results in the opposite direction as the primary analysis using propensity score matching, suggesting that a large randomized trial will be required to answer this question. Using the estimated mortality rates from the 109 matched individuals and the proportion of patients with and without PHT in our study, to obtain 80% power to detect a 4% absolute reduction in all-cause mortality would require 3996 patients for 3 hour, 4970 patients for 24 hour and 6672 patients for a 30 day survival study.

Prehospital transfusion is a logical extension of the concept of damage control resuscitation. In 2007, several authors of this current study proposed that damage control resuscitation (DCR) resuscitation for rapidly bleeding patients should include limited crystalloid and increased amounts of plasma and platelets.[6] Over the last decade, many investigators have validated this concept by publishing single and multicenter retrospective, prospective observational studies, and prospective randomized clinical trials.[7–20] These studies have been performed at multiple combat and civilian sites totaling many thousands of hemorrhaging patients. As a result, hospital-based transfusion practice for injured patients has changed, with decreased use of crystalloid and increased use of blood products as a primary resuscitation modality, resulting in decreased complications and improved survival.[37–43]

To reach the ideal of a seamless continuum of care between the prehospital and hospital environments, the concept of damage control resuscitation has been extended to the prehospital arena.[44–51] The military has led this approach by carrying red blood cells (RBCs) and plasma on some of their helicopters in Afghanistan, publishing a prehospital transfusion rate of greater than 15% and a significant association with improved outcomes.[24] Subsequently, multiple civilian centers have placed plasma and/or RBCs on their helicopters and published improved outcomes.[25–29] Building on this military and civilian experience, in 2011 Memorial Herman Hospital- Texas Medical Center placed 2 units of thawed/liquid plasma and 2 units of RBCs on their 4 civilian helicopters. They documented a 19% transfusion rate in severely injured civilian trauma patients, and similar to the military experience there was an association with improved outcomes.[25] The Pittsburg and Mayo trauma groups have likewise documented an association between prehospital transfusion and improved outcomes.[26–29]

Prehospital plasma and RBCs are now the standard of care on many helicopter and several ground EMS systems, with rates of transfusion in line with the 24% shown in the present study. Liquid and thawed plasma are now used early in the prehospital environment in a number of health care systems. In several centers, dried plasma, PCCs, cryoprecipitate and fibrinogen concentrates are available for prehospital use as well.[52–56] Finally, position papers from civilian and military thought leaders have been recently published, clearly stating the desire for prehospital blood products and high quality studies to determine their efficacy.[44– 51, 57, 58] In summary, a series of retrospective studies have shown associations with improved outcomes with blood product based resuscitation compared to crystalloid. However a recent comprehensive review of this subject by Smith et al has concluded that there is no effect, albeit the quality of all available data are very low.[59] To help answer this issue, over the last two years the Department of Defense (DoD) has initiated two multicenter randomized studies of prehospital plasma versus crystalloid resuscitation in severely injured patients.[60–61]

In our study, in the systems that have blood available prehospital, 142 patients received a transfusion, with site specific rates of transfusion ranging from 4–47% for an average of 24% (142/585). This rate is similar to earlier studies, and that reported by the military in the experience in Afghanistan. There was a significant difference (3 minutes) between groups in call time to ED arrival (median 58 minutes), with PHT patients arriving faster than those not receiving blood (Table 2). It appears that PHT does not negatively affect flight time. A median of 1 unit of RBCs and plasma were transfused prehospital during a flight time of 18 minutes. Of patients receiving PHT, 24% received only plasma, 7% received only RBCs and 69% received both. It will be interesting in future studies to evaluate the impact of different PHT strategies on outcome.

The strengths of our study are its prospective and observational design, with in house 24/7 research personnel observing the patients, facilitating the collection of high quality data at nine centers over a short period of time. The major weakness of the study was the unexpected difference in SBP, GCS and ISS between sites with and without blood products available. It is unclear why this occurred, as our previous multicenter trauma transfusion studies did not demonstrate significant site differences in severity of injury.[9, 18, 19] In regions with helicopter agencies that have the capability of PHT, there might be a bias for prehospital personnel to call those helicopter services with blood products on board to transport more severely injured patients, however trying to define this issue at nine different trauma regions across the country is beyond the scope of this effort. Clearly, future studies must take this issue into account when designing non-randomized studies.

Conclusion

Because of the unexpected imbalance in injury severity between systems with and without blood products on helicopters, all analyses were inconclusive. With few units transfused to each patient and small outcome differences between groups, large randomized studies will be required to detect significant survival differences in this important population.

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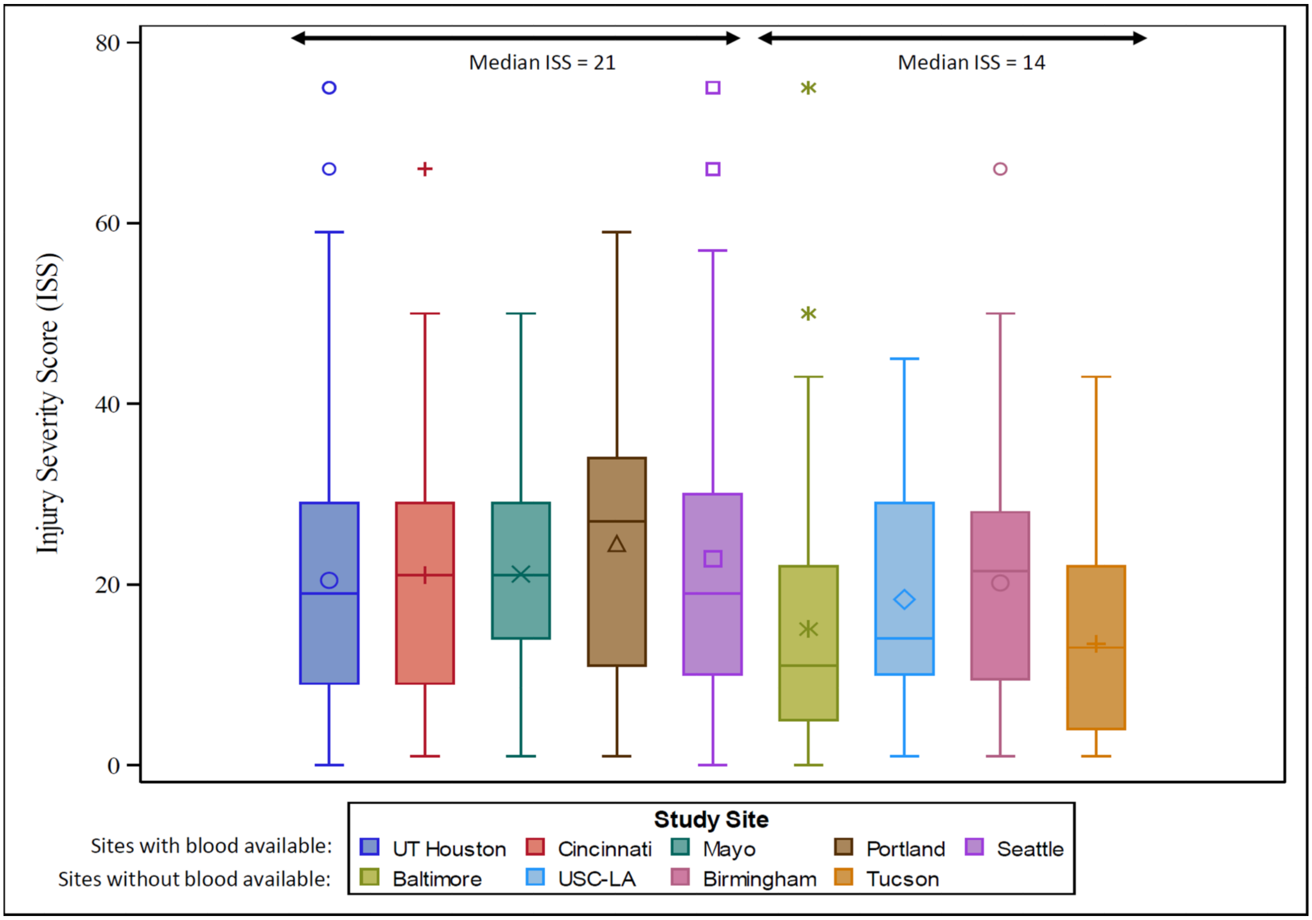

Figure 1. Distribution of ISS for study sites

Figure 1 presents boxplots of the distribution of ISS for each center of the study. Note that the medians of the sites with blood available on the helicopter all have distributions that are shifted higher than those of the sites without blood available. This shift shows that the ISS of patients arriving to sites with blood available prehospital are generally higher than the ISS of patients arriving to sites without blood available prehospital.

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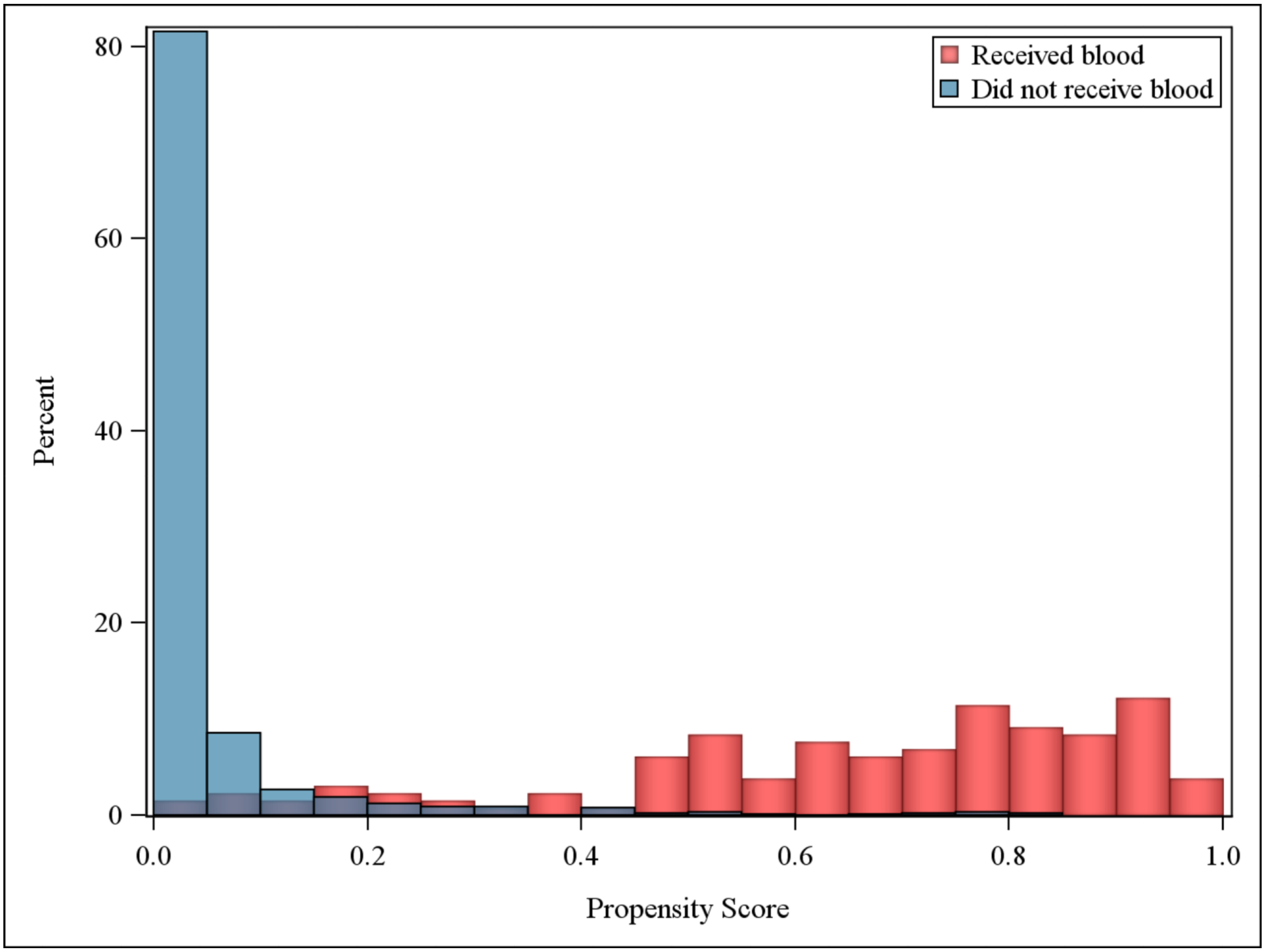

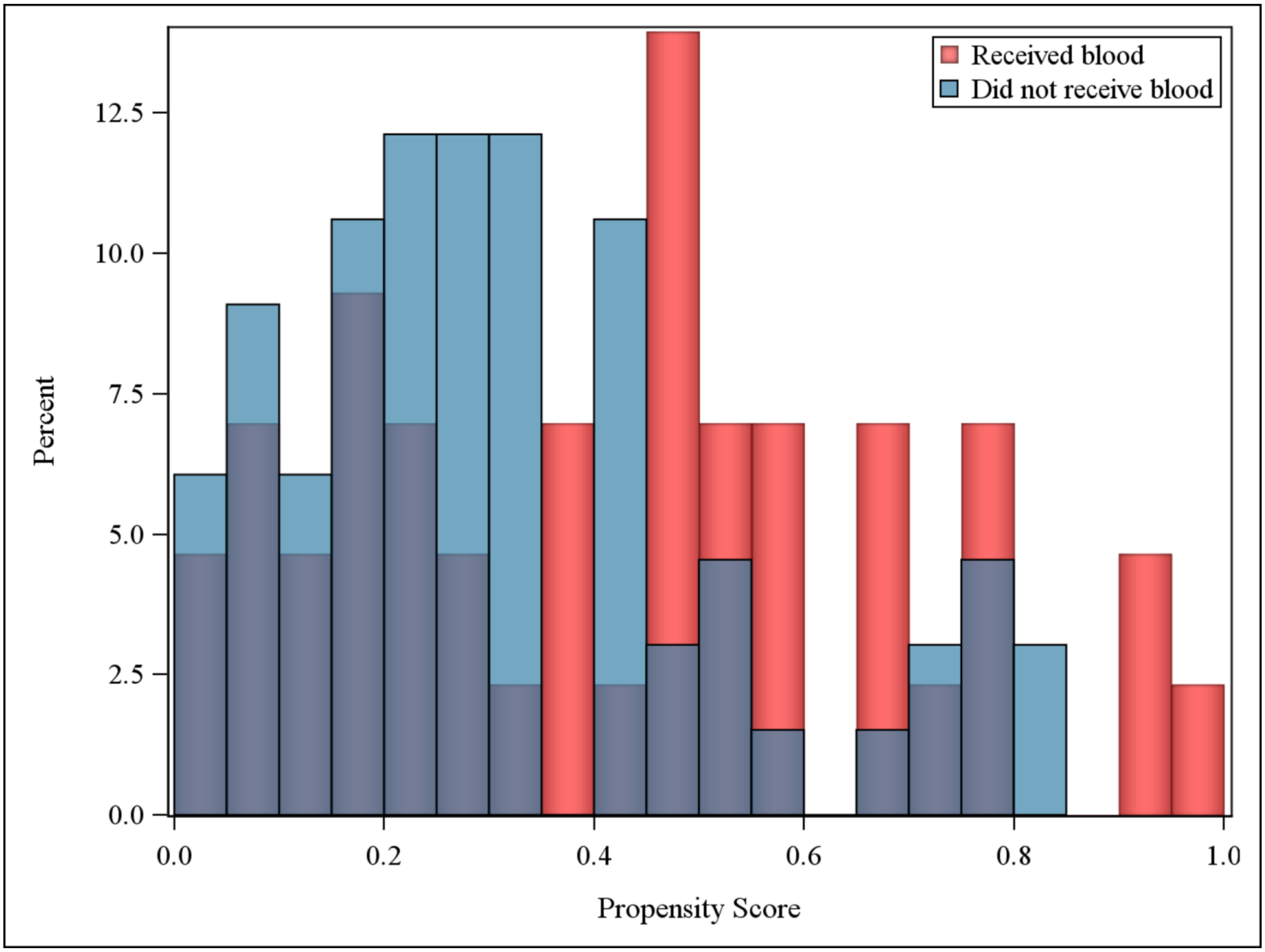

Figure 2. Distributions of propensity scores among matched and unmatched patients

Panel A shows the distribution of propensity scores for all patients in the highest risk group who did not receive prehospital transfusion (PHT) (n=916, blue bars) relative to the distribution of propensity scores for all patients in the highest risk group who did receive PHT (n=142, red bars). Panel B shows the distribution of propensity scores in the matched patients who did not receive PHT (n=66, blue bars), relative to the distribution of propensity scores in the matched patients who received PHT (n=43, red bars). Among those patients who did not receive a PHT, very few had a high propensity score. Similarly, among those patients who did receive a PHT, very few had a low propensity score. This striking difference produces a small area of overlap between the two distributions (denoted by the purple area), representing the limited pool of similar patients across treatment groups from which to form suitable matched pairs. As expected, the distribution of the matched sample shows better overlap in purple, but still represents a small number of patients compared to the total population. Also note that the scale on the y-axis is different for panels A and B.

Table 1

Patient characteristics by blood availability

		Prehospital Blood Products Available			
		Overall (N = 1058)	**No (N = 473)**	**Yes (N = 585)**	***P*-value**[1]
Age (yrs)	Median (P25,P75)	38 (25,55)	39 (25,57)	37 (26,54)	0.36
Gender	Male N (%)	751 (71.0)	325 (68.7)	426 (72.8)	0.14
Race Group	White N (%)	770 (72.8)	371 (78.4)	399 (68.2)	<.01
	Other N (%)	164 (15.5)	34 (7.2)	130 (22.2)	
	Black N (%)	124 (11.7)	68 (14.4)	56 (9.6)	
Systolic (mmHg) Blood Pressure	Median (P25,P75)	126 (105,146)	128 (109,148)	125 (104,145)	0.04
Diastolic (mmHg) Blood Pressure	Median (P25,P75)	78 (62,91)	77 (63,91)	78 (61,92)	0.92
Pulse	Median (P25,P75)	100 (83.5,122)	102 (84,124)	98 (83,120)	0.10
GCS Score Total - Prehospital	Median (P25,P75)	12 (3,15)	14 (5,15)	7 (3,15)	<.01
Injury Severity Score (ISS)	Median (P25,P75)	17 (9,29)	14 (5,26)	21 (10,29)	<.01
ANY Penetrating Injury	Yes N (%)	210 (19.8)	84 (17.8)	126 (21.5)	0.13
Prehospital Lifesaving Interventions	Yes N (%)	632 (59.7)	197 (41.6)	435 (74.4)	<.01
Air Team Call Time to ED Arrival(minutes)	Median (P25,P75)	58 (48,73)	60 (50,77)	56 (47,70)	<.01
Air Team Departure from Scene to ED Arrival (minutes)	Median (P25,P75)	19 (15,27)	21 (16,29)	17 (14,24)	<.01
Satisfied More Than One Highest Risk Criteria	Yes N (%)	362 (34.2)	170 (35.9)	192 (32.8)	0.37
Bleeding Source Identified Prehospital	Yes N (%)	549 (51.9)	317 (67.0)	232 (39.7)	<.01
30-Day Status	Deceased N (%)	176 (16.6)	63 (13.3)	113 (19.3)	<.01
24-Hour Status	Deceased N (%)	116 (11.0)	42 (8.9)	74 (12.6)	0.05

		Prehospital Blood Products Available			
		Overall (N = 1058)	**No (N = 473)**	**Yes (N = 585)**	***P*-value**[1]
3-Hour Status	Deceased N (%)	66 (6.2)	17 (3.6)	49 (8.4)	<.01
Time to Death from ED Arrival (hours)	Median (P25,P75)	8.3 (0.8,45.8)	13.5 (0.8,51.5)	6.6 (0.8,42.0)	0.49

[1] The Wilcoxon rank sum and χ^2 tests were used to compare groups for continuous and categorical characteristics, respectively

Table 2

Patient characteristics by prehospital blood received

		Received Prehospital Blood			
		Overall (N = 1058)	**No (N = 916)**	**Yes (N = 142)**	***P*-value[1]**
Age (yrs)	Median (P25,P75)	38 (25,55)	38 (25,55)	41 (26,57)	0.63
Gender	Male N (%)	751 (71.0)	650 (71.0)	101 (71.1)	0.97
Race Group	White N (%)	770 (72.8)	680 (74.2)	90 (63.4)	<.01
	Other N (%)	164 (15.5)	128 (14.0)	36 (25.4)	
	Black N (%)	124 (11.7)	108 (11.8)	16 (11.3)	
Systolic (mmHg) Blood Pressure	Median (P25,P75)	126 (105,146)	129 (110,149)	98 (80,124)	<.01
Diastolic (mmHg) Blood Pressure	Median (P25,P75)	78 (62,91)	79 (65,92)	62 (44,88)	<.01
Pulse	Median (P25,P75)	100 (83.5,122)	99 (83,121)	107 (85,128)	0.04
GCS Score Total - Prehospital	Median (P25,P75)	12 (3,15)	11.5 (3,15)	13 (3,15)	0.88
Injury Severity Score (ISS)	Median (P25,P75)	17 (9,29)	17 (6,27)	25 (13,34)	<.01
ANY Penetrating Injury	Yes N (%)	210 (19.8)	164 (17.9)	46 (32.4)	<.01
Prehospital Lifesaving Interventions	Yes N (%)	632 (59.7)	525 (57.3)	107 (75.4)	<.01
Air Team Call Time to ED Arrival (minutes)	Median (P25,P75)	58 (48,73)	58 (48,74)	55 (48,68)	0.04
Air Team Departure from Scene to ED Arrival (minutes)	Median (P25,P75)	19 (15,27)	19 (15,27)	18 (14,24)	0.14
Satisfied More Than One Highest Risk Criteria	Yes N (%)	362 (34.2)	277 (30.2)	85 (59.9)	<.01
Bleeding Source Identified Prehospital	Yes N (%)	549 (51.9)	431 (47.1)	118 (83.1)	<.01
30-Day Status	Deceased N (%)	176 (16.6)	140 (15.3)	36 (25.4)	<.01
24-Hour Status	Deceased N (%)	116 (11.0)	89 (9.7)	27 (19.0)	<.01

			Received Prehospital Blood		
		Overall (N = 1058)	No (N = 916)	Yes (N = 142)	*P*-value[1]
3-Hour Status	Deceased N (%)	66 (6.2)	43 (4.7)	23 (16.2)	<.01
Time to Death from ED Arrival (hours)	Median (P25,P75)	8.3 (0.8,45.8)	13.2 (1.1,50.5)	2.2 (0.2,23.7)	0.03

[1]The Wilcoxon rank sum and χ^2 tests were used to compare groups for continuous and categorical characteristics, respectively

Table 3

Demographic and baseline injury characteristics of the matched sample

		Received Blood Prehospital		
		Overall (N = 109)	**No (N = 66)**	**Yes (N = 43)**
Age (yrs)	Median (P25,P75)	41 (26,60)	39 (26,56)	48 (27,62)
Gender	Male N (%)	77 (70.6)	48 (72.7)	29 (67.4)
Race Group	White N (%)	78 (71.6)	45 (68.2)	33 (76.7)
	Black N (%)	9 (8.3)	7 (10.6)	2 (4.7)
	Other N (%)	22 (20.2)	14 (21.2)	8 (18.6)
Systolic (mmHg) Blood Pressure	Median (P25,P75)	110 (88,129)	105 (88,128)	110 (88,133)
Diastolic (mmHg) Blood Pressure	Median (P25,P75)	67 (52,88)	66.5 (52,88)	67 (50,90)
Pulse	Median (P25,P75)	105 (90,123)	100 (86,123)	110 (94,125)
Injury Severity Score (ISS)	Median (P25,P75)	24 (10,34)	22 (10,34)	24 (10,34)
ANY Penetrating Injury	Yes N (%)	27 (24.8)	18 (27.3)	9 (20.9)
Prehospital Lifesaving Interventions	Yes N (%)	75 (68.8)	45 (68.2)	30 (69.8)
Air Team Call Time to ED Arrival (minutes)	Median (P25,P75)	57 (47,71)	56 (46,68)	58 (50,76)
Satisfied More than One Highest Risk Criteria	Yes N (%)	51 (46.8)	31 (47.0)	20 (46.5)
Bleeding Source Identified Prehospital	Yes N (%)	73 (67.0)	45 (68.2)	28 (65.1)
30-Day Status	Deceased N (%)	22 (20.2)	14 (21.2)	8 (18.6)
24-Hour Status	Deceased N (%)	15 (13.8)	10 (15.2)	5 (11.6)
3-Hour Status	Deceased N (%)	12 (11.0)	8 (12.1)	4 (9.3)
Time to Death from ED Arrival (hours)	Median (P25,P75)	2.6 (0.1,42.0)	2.1 (0.1,33.2)	5.6 (0.2,155)

Table 4

Results of primary and sensitivity analyses

	Primary Analysis			Sensitivity Analysis					
	Propensity Score[a] adjusted GEE (n=109)			*Logistic Regression (N=1030)*			*Cox Regression (N=1020)*		
Mortality	**Odds ratio**	**95% CI**	**P-value**	**Odds ratio**	**95% CI**	**P-value**	**Hazard ratio**	**95% CI**	**P-value**
3-hour	0.74	(0.24, 2.26)	0.60	1.69[b]	(0.88, 3.26)	0.12	1.40[e]	(0.82, 2.39)	0.22
24-hour	0.74	(0.25, 2.17)	0.58	0.83[c]	(0.44, 1.57)	0.56	1.12[f]	(0.41, 3.06)	0.83
30-day	0.85	(0.32, 2.28)	0.75	0.75[d]	(0.40, 1.42)	0.38	1.97[g]	(0.81, 4.79)	0.13

GEE Generalized Estimating Equations; CI Confidence Interval

[a]Propensity score included: age, gender, race, injury severity score (ISS), systolic blood pressure, diastolic blood pressure, pulse, whether or not the patient satisfied more than one of the highest risk criteria, presence of any penetrating injury, use of a prehospital lifesaving intervention, time from the air team call time to arrival at the emergency department (ED), if the bleeding site was identified prehospital, and site volume.

[b]Adjusted for age, race, gender, systolic blood pressure, and having a prehospital lifesaving intervention

[c]Adjusted for age, race, gender, systolic blood pressure, satisfying more than one high risk criteria, having any penetrating injury, having a prehospital lifesaving intervention, and ISS.

[d]Adjusted for age, race, gender, pulse, minutes form the air team call time to arrival at the ED, satisfying more than one high risk criteria, having a prehospital lifesaving intervention, having the bleeding source identified prehospital and ISS.

[e]Adjusted for age, race, gender, systolic blood pressure and having a prehospital lifesaving intervention

[f]Adjusted for age, race, gender, systolic blood pressure, bleeding source identified prehospital, having a prehospital lifesaving intervention, ISS, and survival time interactions with systolic blood pressure, ISS, and prehospital blood transfusion

[g]Adjusted for age, race, gender, pulse satisfying more than one high risk criteria, use of a lifesaving intervention, having bleeding source identified prehospital, ISS, and time interactions with pulse, selected more than one high risk criteria, ISS, and prehospital blood transfusion