



2.0
ANCC
Contact
Hours'

Whole Blood Program: Implementation in a Rural Trauma Center

Lanny C. Orr, RN[®] ■ Alexa L. Peterson, BSN, RN[®] ■ Tessa C. Savell, BSN, RN[®] ■
Elizabeth L. McCotter, BSN, RN[®] ■ Craig E. Palm, MSN, RN[®] ■ Sadie L. Arnold, MLS, (ASCP),
CM, SBB, CM[®] ■ Gordon M. Riha, MD, FACS[®] ■ Simon J. Thompson, PhD[®]

BACKGROUND: The balanced transfusion of blood components plays a leading role in traumatic hemostatic resuscitation. Yet, previous whole blood studies have only focused on urban trauma center settings.

OBJECTIVE: To compare component vs whole blood therapy on wastage rates and mortality in the rural setting.

METHODS: This study was a nonrandomized, retrospective, observational, single-center study on a cold-stored whole blood program implementation for adult massive transfusions from 2020 to 2022 at a Level II trauma center. Trauma registry data determined the facility's whole blood needs and facilitated sustainable blood supplies. Whole blood use protocols were established, and utilization and laboratory compliance for incompatible ABO antibody hemolysis was monitored and reviewed monthly at stakeholder and trauma services meetings.

RESULTS: From 2018 to 2019, the facility initiated component therapy massive transfusions every 9 days ($n = 41$). Therefore, four units of low-titer, O-positive whole blood delivered fortnightly was determined to provide patient coverage and minimize wastage. Across the study time frame (2020–2022), there were $n = 68$ hemodynamically unstable patients, consisting of those receiving whole blood, $n = 37$, and patients receiving component therapy, $n = 31$. Mortality rates were significantly lower ($p = .030$) in the whole blood population ($n = 3$, 8%) compared to those solely receiving component therapy ($n = 9$, 29%). Wastage rates were constantly evaluated; in 2021, 43.4% was not utilized, and in 2022, this was reduced to 38.7%. Anecdotally, nurses appreciated the ease of administration and documentation of transfusing whole blood, as it negated ratio compliance.

CONCLUSION: This evidence-based whole blood program provides vital care to severely injured trauma patients in a vast, rural region.

KEY WORDS: Blood transfusion, Critical care, Evidence-based, Massive transfusion protocol, Rural trauma, Whole blood

Cite as: Orr, LC., Peterson, AL., Savell, TC., McCotter, EL., Palm, CE., Arnold, SL., Riha, GM., & et al. (2024). Whole blood program: implementation in a rural trauma center. *Journal of Trauma Nursing*, 31(5), 258-265. <https://doi.org/10.1097/JTN.0000000000000810>

BACKGROUND

The balanced transfusion of blood components plays a leading role in traumatic hemostatic resuscitation. The original application of whole blood resuscitation in the military (McCoy et al., 2021) moved into the domestic paradigm within large urban academic trauma

centers in the United States (Walsh et al., 2021) and is now surging to prominence within the civilian trauma arena (Hanna et al., 2022; Hazelton et al., 2022).

Until the Pragmatic, Randomized Optimal Platelet and Plasma Ratios trial (Holcomb et al., 2015), there were no large, multicenter, randomized clinical trials with survival as a primary end point. The aim of the Pragmatic, Randomized Optimal Platelet and Plasma Ratio trial was to address the effectiveness and safety of a 1:1:1 transfusion ratio (red blood cell:plasma:platelet) compared with a 1:1:2 transfusion ratio in patients with trauma who were predicted to receive a massive transfusion (Holcomb et al., 2015). This demonstrated that a fixed ratio of blood components (1:1:1) improves mortality at 24 hr. As whole blood has an innate 1:1:1 ratio, the previous literature suggests that whole blood is at least equivalent if not preferable to component therapy in severe hemorrhage resuscitation (Cap et al., 2018).

Whole blood is quickly and easily administered, negating the need for ratio tracking within the trauma bay. However, only a small number of Level I trauma centers in the United States utilize whole blood (Yazer, Spinella, et al., 2021), and the majority of these facilities

Dates: Received January 29, 2024; Revised June 13, 2024; Accepted: June 19, 2024.

Author Affiliations: Trauma Services, (Mr Orr, Mrs Peterson, Mrs Savell, Mrs McCotter, and Mr Palm); Lab—Blood Bank, (Mrs Arnold); Trauma & Critical Care Surgery, (Dr Riha); and Collaborative Science & Innovation, Billings Clinic, Billings, Montana (Dr Thompson).

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

The authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

L.C.O., S.L.A., and G.M.R. contributed to the design and implementation of the research. A.L.P. and S.J.T. contributed to the analysis of the results. T.C.S., E.L.M., C.E.P., and S.J.T. contributed to the writing of the manuscript. L.C.O. and G.M.R. conceived the original project.

Correspondence: Simon J. Thompson, PhD, Collaborative Science & Innovation, Billings Clinic, 2800 10th Ave North, Billings, MT 59101 (sthompson11@billingsclinic.org).

KEY POINTS

- Balanced blood component transfusion plays a leading role in traumatic hemostatic resuscitation.
- Key stakeholders developed clinical practice guidelines for administration and sustainability.
- Consistent whole blood administration without lapse in product availability since establishment.
- To limit end of shelf-life wastage, additional whole blood uses were explored outside of trauma.
- Nurses appreciated the ease of administration and documentation of transfusing whole blood.

are urban academic trauma systems with short transport times (Walsh et al., 2021). Thus, as a trauma facility in a large, sparsely populated state with consequently long transit times, we aspired to initiate a cold-stored whole blood program to benefit trauma patients.

Subsequently, our challenges included: (1) Could we convince the blood product supplier to supply low-titer cold-stored whole blood? (2) How to develop a sustainable program in our rural facility? (3) Would whole blood benefit our trauma patients? and (4) How to determine an appropriate use for whole blood nearing expiration to decrease wastage?

OBJECTIVES

The purpose of this study was to compare component vs whole blood therapy on wastage rates and mortality in the rural setting.

METHODS

Study Design

This study was a nonrandomized, retrospective, observational, single-center study on the development and implementation of a whole blood program. Approval from the Institutional Review Board was requested, and the project was determined exempt (Billings Clinic Institutional Review Board, Privacy & Exemption Committee: Project #24.001). This research brief conforms to Strengthening the Reporting of Observational Studies in Epidemiology guidelines (Cuschieri, 2019).

Population and Setting

This initiative was conducted from 2018 to 2022 at a single rural 305-bed American College of Surgeons-verified Level II Trauma center that serves as a four-state referral center in the Upper Mountain West region.

Data Collection

Patient data were abstracted from the electronic health record and the trauma registry. Inclusion criteria comprised massive transfusion protocol activations,

≥18 years old. Massive transfusion activation is defined at this facility as greater than four units of blood products administered in the first 4 hr upon arrival at the facility. Patients in the whole blood cohort received at least two units of cold-stored whole blood. Patients in component therapy cohort did not receive any whole blood. The exclusion criteria consisted of patients who survived less than 48 hr after whole blood transfusion.

Instruments

Patient data

Two automatically calculated measures recorded for each patient in triage were included to assess patient data. First, the Shock Index, a ratio of heart rate and systolic blood pressure, with a value >1, predicts increased risk of mortality (Koch et al., 2019); Second, the Injury Severity Score is an established medical score used to assess trauma severity based upon the six-point ordinal abbreviated injury scale; distance was determined by the shortest mileage between injury site and tertiary trauma facility; mortality only includes massive transfusion protocol-activated patients (greater than four units of blood products administered in the first 4 hr upon arrival), excluding: (1) emergency department to morgue patients and (2) patients with the maximum Injury Severity Score (=75).

Compliance

Trauma services monitored that appropriate laboratory tests (lactate dehydrogenase, total bilirubin, and haptoglobin) were ordered after each transfusion. Specifically, hemolysis testing was ordered for incompatible ABO blood group system antibodies at 12, 24, and 48 hr (±1 hr) post-transfusion, as recommended by the Association for the Advancement of Blood & Biotherapies (AABB) (2022).

Intervention

This project (summarized in a temporal [Figure 1A] and an organizational [Figure 1B] way) was staged in the following manner: (1) Worked with the blood product supplier to provide low-titer whole blood. Discussions with the blood supplier began in 2020 to determine plausibility of bringing whole blood product to the rural trauma facility. Data from the trauma registry were abstracted across 2 years (2018–2019) to determine the total number of massive transfusions at the facility. These data supported blood product supplier negotiations to determine a sustainable volume of whole blood to be requested and maintained at the facility.

(2) Determined the sustainability of a cold-stored whole blood program and developed appropriate guidelines and protocols (Figure 2A and B). As blood supplier discussions progressed, the multidisciplinary Blood Utilization Committee (BUC), consisting of a pathologist,

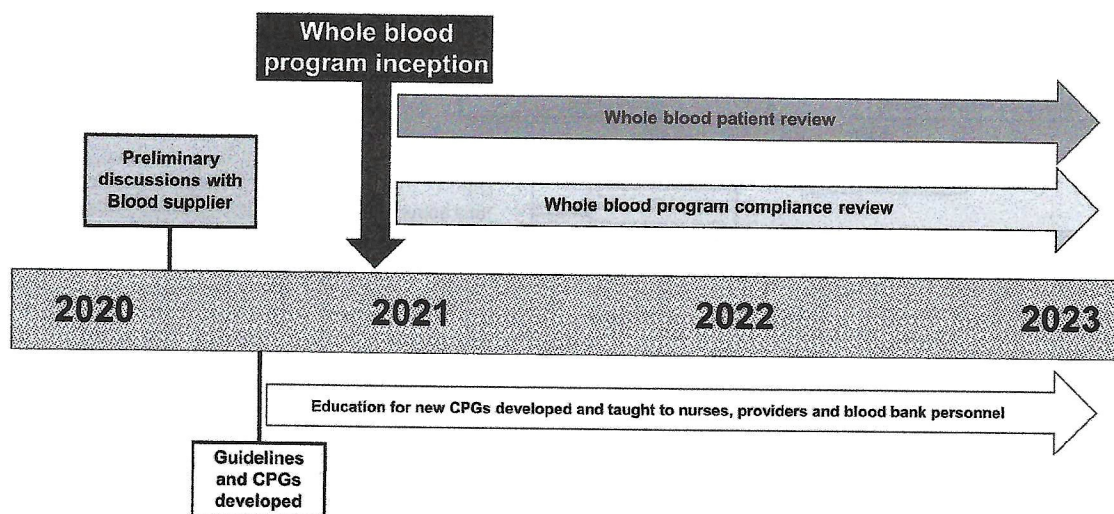
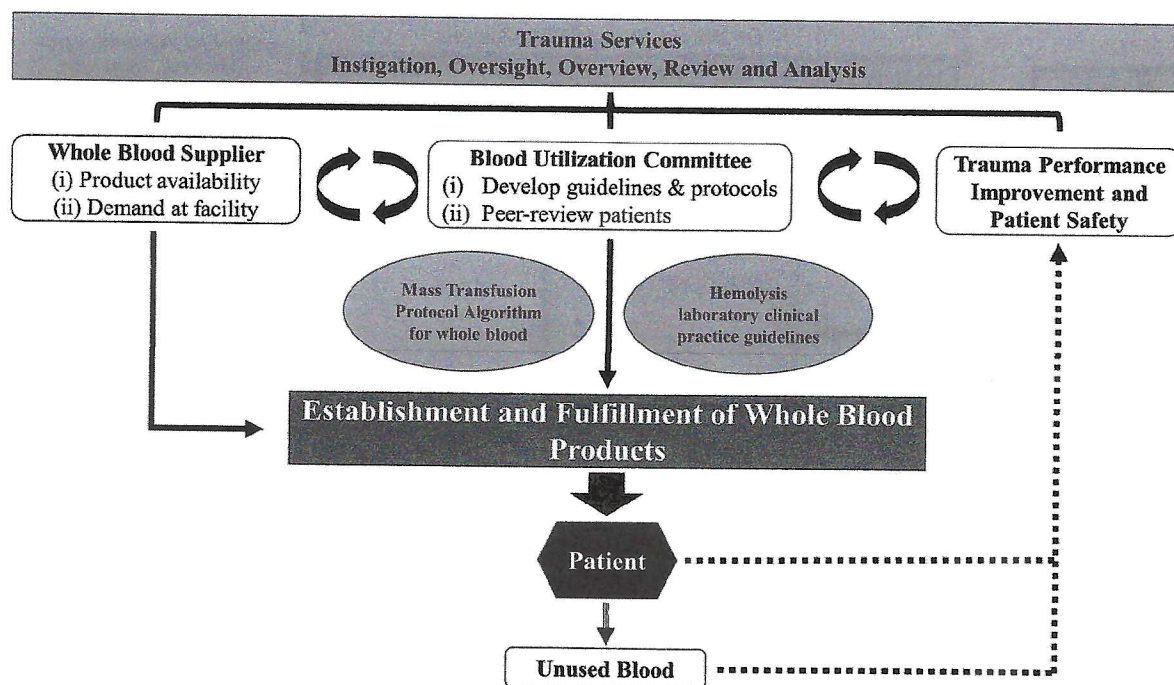
a**b**

Figure 1. Graphical representation of the temporal and organizational implementation of the whole blood program. *Note.* Panel A: Project timeline. Panel B: Key stakeholders and steps to implement cold-stored whole blood for trauma patients.

a blood bank supervisor, a trauma surgeon, a trauma program manager, a trauma outreach clinician, and the blood supplier, began developing clinical practice guidelines including proper parameters and administration. These included hemolysis laboratory testing for

incompatible ABO blood group system antibodies with monitoring at 12, 24, and 48 hr post-transfusion, as suggested by AABB (2022).

In addition, education was developed and provided for the new clinical practice guidelines with

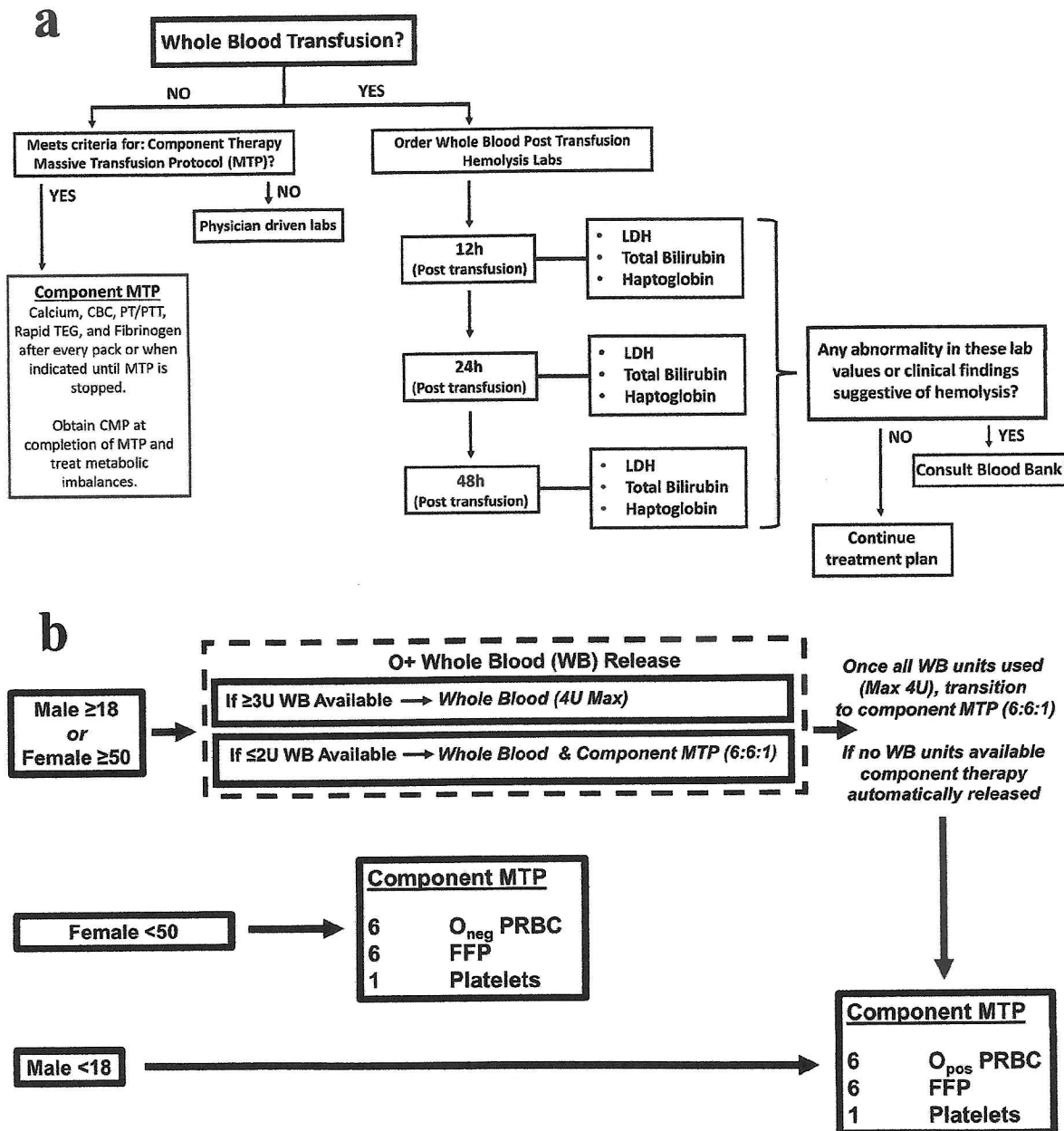


Figure 2. Developed cold-stored whole blood laboratory guidelines and usage algorithm. *Note.* Panel A: Whole blood clinical practice guideline for post-transfusion hemolysis laboratory tests. Panel B: Modified massive transfusion protocol (MTP) algorithm. All recipients of whole blood must be ≥18. One platelet pack consists of six units, single donor pack (component MTP arrival at bedside 1:1:1). CBC = complete blood count; CMP = comprehensive metabolic panel; LDH = lactate dehydrogenase; PT = prothrombin time; PTT = partial thromboplastin time; TEG = thromboelastography.

addenda to the massive transfusion protocol during onboarding and continuing education for nurses, providers, and blood bank personnel.

(3) Studied the benefits within the trauma patient population. Whole blood utilization was reviewed and evaluated through monthly data reporting at trauma

performance improvement and patient safety and BUC meetings. Whole blood administration was also comprehensively evaluated by trauma services with any issues or opportunities for improvement sent for additional peer or systems review. Laboratory compliance was evaluated and reported at trauma performance

improvement and patient safety and BUC meetings where opportunities for improvement were identified and addressed as appropriate.

(4) Minimized waste by identifying suitable applications for whole blood approaching its expiration date. The mean shelf life of whole blood is one-third less when compared to red blood cell components (Cohn et al., 2023). Therefore, to limit end of shelf-life wastage, additional whole blood uses were explored outside of trauma. Literature has indicated cardiothoracic surgery (Manno et al., 1991; Pitkin & Rice, 2012) to be the most appropriate service line for surplus use; therefore, a process was developed for whole blood utilization during open heart surgery.

The study involved only adult patients (aged 18 or older) who met the criteria for the hospital's massive transfusion protocol. This protocol is triggered when a patient receives more than four units of blood products within 4 hr of arriving at the facility. Regular nursing staff, who had undergone training on the new protocol, administered the transfusions.

Statistical Analysis

A descriptive statistical analysis was performed using the statistical package R (R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were summarized using mean $\pm$ 95% confidence intervals. A two-tailed Student's *t*-test, or Fisher's exact test for binomials, was used and accepted as significant when the $p < .05$.

RESULTS

During the 2 years prior to initiation and commencement of the whole blood program (2018–2019), there were 81 massive transfusion activations, defined at this facility as more than four units of blood products administered in the first 4 hr. This indicated that every 9 days, the facility initiated a component therapy massive transfusion. Through this data evaluation, the blood supplier suggested four units of low-titer, O-positive whole blood could be delivered every 2 weeks to provide adequate coverage to benefit trauma patients and minimize wastage.

Guidelines were developed in coordination with the multidisciplinary BUC. Clinical practice guidelines were established to include proper parameters, administration, and subsequent hemolysis laboratory testing (Figure 2a). Addenda were applied to the current massive transfusion protocol (Figure 2b). Then, education was developed and disseminated to nurses, providers, and blood bank personnel.

From the inception of the whole blood program in 2020 through 2022, the program population included 68 trauma patients who were deemed hemodynamically unstable and subsequently received a blood transfusion

Table 1. Combined Patient Overview During Cold-Stored Whole Blood Program Implementation (2020–2022)

Overview Characteristic	Mean	95% Confidence Interval
Injury Severity Score	26.9	24.1, 29.7
Shock Index	1.1	1.0, 1.2
Distance, injury site to tertiary facility, miles	96.4	67.5, 125.4
Injury to arrival time, hours:minutes	3:09	2:16, 4:02

Note. Only includes massive transfusion protocol-activated patients (greater than four units of blood products administered in the first 4 hr upon arrival). The exclusion criteria were (1) emergency department to morgue patients and (2) patients with the maximum Injury Severity Score (≥ 75).

(Table 1). These patients traveled a mean of 96.4 miles from the injury site with a mean transport time of more than 3 hr from injury to tertiary facility arrival. The mean Injury Severity Score was 26.9 with a mean Shock Index of 1.1.

In Table 2, a comparison of those patients receiving whole blood ($n = 37$) vs those receiving component therapy only ($n = 31$) shows similar demographics in heart rate and systolic blood pressure upon arrival. Shock Index, Injury Severity Score, total blood products used, and hospital and intensive care unit length of stay between the groups also demonstrated no significant differences. However, patient mortality was significantly lower ($p = .030$) in the whole blood group (8.1%) compared to the component therapy-only group (29.0%).

Whole blood compliance was demonstrated in hemolysis laboratory tests ordered and subsequently performed at each of the appropriate time points (Table 3). Further, no post-whole blood transfusion reactions were observed.

The utilization of whole blood in the facility was routinely assessed and reviewed. In 2021, wastage rates were 43.4%; the following year 2022, this was reduced to 38.7%.

DISCUSSION

Whole blood transfusions began during the US Civil War and were more widely adopted during later major international conflicts (Black et al., 2020). More recently in the civilian realm, utilizing whole blood as an adjunct to component therapy has been associated with improved outcomes in severely injured trauma patients (Hanna et al., 2020). Furthermore, the use of cold-stored whole blood makes whole blood resuscitation in the civilian arena more accessible (Hanna et al., 2022).

Without coordinated collaboration with an institutional blood supplier, a whole blood initiative cannot ultimately succeed (Pivalizza et al., 2018). Before the

Table 2. Patient Demographics and Clinical Comparison (2020–2022) Between Cold-Stored Whole Blood (N = 37) and Component Therapy-Treated Patients (N = 31)

Variable	Whole Blood		Blood Component Therapy		p Value
	Mean	95% Confidence Interval	Mean	95% Confidence Interval	
Age, years	46.3	39.9, 52.8	41.8	35.1, 48.6	.336
Penetrating MOI, n (%)	16 (43.2%)		9 (29.0%)		.313
Arrival heart rate, per minute	100.9	92.4, 109.5	109.6	100.3, 118.9	.180
Arrival systolic blood pressure, mmHg	103.4	93.4, 113.3	102.1	93.5, 110.7	.854
Shock Index	1.0	0.9, 1.2	1.1	1.0, 1.3	.351
Injury Severity Score	25.3	21.6, 28.9	28.9	24.6, 33.1	.203
Total blood product, ml per patient	4149.6	2775.7, 5523.5	5255.5	3310.0, 7201.1	.348
Hospital LOS, days	13.5	10.5, 16.5	11.9	8.1, 15.7	.522
ICU LOS, days	9.0	7.0, 11.0	7.4	4.7, 10.2	.371
Mortality, n (%)	3 (8.1%)		9 (29.0%)		.030*

Note. MOI = mechanism of injury; LOS = length of stay. Only includes massive transfusion protocol-activated patients (greater than four units of blood products administered in the first 4 hr upon arrival). Whole blood patients are defined as those who received greater than or equal to two units of whole blood. The exclusion criteria are (1) emergency department to morgue patients and (2) patients with the maximum Injury Severity Score (=75). A two-tailed Student's *t*-test, or Fisher's exact test for binomials, was used and accepted as significant when the *p* < .05 (denoted bold*).

inception of the whole blood program at this facility, one component therapy massive transfusion was initiated approximately every 9 days (2018–2019). These data provided proof to the blood supplier that initiating a whole blood program at this rural facility was a viable and sustainable endeavor. Therefore, the supplier suggested four units low-titer, O-positive whole blood could be delivered every 2 weeks to provide adequate coverage to benefit trauma patients and minimize wastage.

From inception, the goal of this program was to utilize whole blood in trauma patients. Although our data cannot prove whole blood administration exclusively decreases mortality, as treatment is multifactorial and recipient numbers (*n* = 37) are relatively small, mortality rates are significantly lower in the whole blood population (*n* = 3, 8%; *p* = .030) compared to those patients who received solely component therapy (*n* = 9, 29%). These results are not in agreement with the literature from single-center urban academic trauma systems (Williams et al., 2020; Yazer, Freeman, et al., 2021) where no mortality distinction is observed between whole blood and blood

component therapy (1:1:1); however, generally these urban academic trauma systems have short transport times (Walsh et al., 2021). In contrast, these results presented are congruent with the current multicenter study literature, which demonstrates enhanced survival with whole blood resuscitation (Hazelton et al., 2022). In comparison to each of the literature discussed (Hazelton et al., 2022; Williams et al., 2020; Yazer, Freeman, et al., 2021), this study has a lower percentage of penetrating injuries, with higher mean age, mean Injury Severity Score, and mean Shock Index. Furthermore, this rural trauma center holds a unique position with a substantial mean distance from the injury site to the facility, as well as a prolonged time from injury to arrival. As a result, this study site is a distinctive and original representation within the whole blood literature.

Anecdotally, nurses at the facility appreciated the ease of administration and documentation of transfusing whole blood, as it negated the need to switch between component products for ratio compliance. This ease of administration is suggested elsewhere in the literature regarding whole blood usage and its impact on nursing (Jones et al., 2021). Two specific benefits are theorized: (1) reduced nurse workload and (2) ease in whole blood resuscitation logistics compared to component therapy resuscitation.

LIMITATIONS

This study was a nonrandomized, retrospective, observational, single-center study, so there may have been a selection and/or surveillance bias. Nonetheless, no statistical method can truly substitute for a randomized control trial.

Table 3. Whole Blood Compliance (2020–2022; N = 35)

Compliance	Whole Blood Patients	
	n	%
Applicable laboratory test order placed	33	94.3
12-hr labs performed	30	90.9
24-hr labs performed	30	90.9
48-hr labs performed	30	90.9
Post-whole blood transfusion reactions	0	0.0

Note. Compliance, *n* includes only patients who survived greater than 48 hr after whole blood transfusion.

Whole Blood Compliance

Initially, laboratory testing orders were manually placed for each timepoint (i.e., 12, 24, and 48 hr) resulting in compliance issues. To address these inefficiencies, a shortcut/abbreviation was developed to initiate an automated response (smart phrase) and utilized to improve order compliance within the electronic health record. Furthermore, additional review by trauma services ensures the ordered labs were performed. In the future, we aim to automate the ordering of these laboratory tests whenever whole blood administration is documented in the electronic health record.

Wastage Rates

Other options for whole blood use are constantly being explored, such as utilization for obstetrical hemorrhage. Additionally, the hospital-based air ambulance service now carries whole blood for trauma transport, benefiting both wastage rates and enabling earlier hemostatic resuscitation en route.

CONCLUSIONS

This cold-stored whole blood program has proven sustainability through consistent administration of whole blood with no lapse in product availability since its establishment in 2020.

The successes of the whole blood program include: (1) providing onboarding and continuing education for nurses, providers, and blood bank personnel; (2) ensuring compliance with national AABB standards, including monitoring for hemolysis; (3) thoroughly reviewing patient outcomes after whole blood administration; and (4) monitoring and maintaining minimal product waste.

This whole blood program demonstrates its critical role in delivering up-to-date, evidence-based care to severely injured patients in a vast, rural region. Our study further strengthens the existing body of research by highlighting the feasibility and positive outcomes of whole blood resuscitation for severely injured trauma patients facing extended transport times and distances.

Orcid iDs

Lanny C. Orr  <https://orcid.org/0009-0003-7118-4337>
 Alexa L. Peterson  <https://orcid.org/0009-0003-9665-9204>
 Tessa C. Savell  <https://orcid.org/0009-0003-8131-4940>
 Elizabeth L. McCotter  <https://orcid.org/0009-0000-7878-6638>
 Craig E. Palm  <https://orcid.org/0009-0002-3724-9945>
 Sadie L. Arnold  <https://orcid.org/0009-0008-7057-5594>
 Gordon M. Riha  <https://orcid.org/0009-0001-7279-4183>
 Simon J. Thompson  <https://orcid.org/0000-0003-0769-8555>

REFERENCES

- Association for the Advancement of Blood & Biotherapies. (2022). *Standards for blood banks and transfusion services* (A. f. t. A. o. B. Biotherapies, Ed. 33rd ed.).
- Black, J. A., Pierce, V. S., Kerby, J. D., & Holcomb, J. B. (2020). The evolution of blood transfusion in the trauma patient: whole blood has come full circle. *Seminars in Thrombosis and Hemostasis*, 46(2), 215–220. <https://doi.org/10.1055/s-0039-3402426>
- Cap, A. P., Beckett, A., Benov, A., Borgman, M., Chen, J., Corley, J. B., Doughty, H., Fisher, A., Glassberg, E., Gonzales, R., Kane, S. F., Malloy, W. W., Nessen, S., Perkins, J. G., Prat, N., Quesada, J., Reade, M., Sailliol, A., Spinella, P. C., & Gurney, J. (2018). Whole blood transfusion. *Military Medicine*, 183(Suppl 2), 44–51. <https://doi.org/10.1093/milmed/usy120>
- Cohn, C., Delaney, M., Johnson, S. T., Katz, L. M., & Schwartz, J. (2023). *Technical Manual* (21st ed.). Association for the Advancement of Blood & Biotherapies.
- Cuschieri, S. (2019). The STROBE guidelines. *Saudi Journal of Anesthesia*, 13(Suppl 1), S31–S34. https://doi.org/10.4103/sja.sja_543_18
- Hanna, K., Bible, L., Chehab, M., Asmar, S., Douglas, M., Ditillo, M., Castanon, L., Tang, A., & Joseph, B. (2020). Nationwide analysis of whole blood hemostatic resuscitation in civilian trauma. *Journal of Trauma and Acute Care Surgery*, 89(2), 329–335. <https://doi.org/10.1097/ta.0000000000002753>
- Hanna, M., Knittel, J., & Gillihan, J. (2022). The use of whole blood transfusion in trauma. *Current Anesthesiology*, 12(2), 234–239. <https://doi.org/10.1007/s40140-021-00514-w>
- Hazelton, J. P., Ssentongo, A. E., Oh, J. S., Ssentongo, P., Seamon, M. J., Byrne, J. P., Armento, I. G., Jenkins, D. H., Braverman, M. A., Mentzer, C., Leonard, G. C., Perea, L. L., Docherty, C. K., Dunn, J. A., Smoot, B., Martin, M. J., Badiie, J., Luis, A. J., Murray, J. L., & Porter, J. M. (2022). Use of cold-stored whole blood is associated with improved mortality in hemostatic resuscitation of major bleeding: A multicenter study. *Annals of Surgery*, 276(4), 579–588. <https://doi.org/10.1097/sla.0000000000005603>
- Holcomb, J. B., Tilley, B. C., Baraniuk, S., Fox, E. E., Wade, C. E., Podbielski, J. M., Del Junco, D. J., Brasel, K. J., Bulger, E. M., Callcut, R. A., Cohen, M. J., Cotton, B. A., Fabian, T. C., Inaba, K., Kerby, J. D., Muskat, P., O'Keeffe, T., Rizoli, S., Robinson, B. R., & van Belle, G. (2015). Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs a 1:1:2 ratio and mortality in patients with severe trauma: The PROPPR randomized clinical trial. *JAMA*, 313(5), 471–482. <https://doi.org/10.1001/jama.2015.12>
- Jones, A. R., Miller, J. L., Jansen, J. O., & Wang, H. E. (2021). Whole blood for resuscitation of traumatic hemorrhagic shock in adults. *Advanced Emergency Nursing Journal*, 43(4), 344–354. <https://doi.org/10.1097/tme.0000000000000376>
- Koch, E., Lovett, S., Nghiem, T., Riggs, R. A., & Rech, M. A. (2019). Shock index in the emergency department: Utility and limitations. *Open Access Emergency Medicine*, 11, 179–199. <https://doi.org/10.2147/oaem.S178358>
- Manno, C. S., Hedberg, K. W., Kim, H. C., Bunin, G. R., Nicolson, S., Jobes, D., Schwartz, E., & Norwood, W. I. (1991). Comparison of the hemostatic effects of fresh whole blood, stored whole blood, and components after open heart surgery in children. *Blood*, 77(5), 930–936. <https://doi.org/10.1182/blood.V77.5.930.930>
- McCoy, C. C., Brenner, M., Duchesne, J., Roberts, D., Ferrada, P., Horer, T., Kauvar, D., Khan, M., Kirkpatrick, A., Ordóñez, C., Ferreira, B., Priouzm, A., & Cotton, B. A. (2021). Back to the future: Whole blood resuscitation of the severely injured trauma

- patient. *Shock*, 56(1S), 9–15. <https://doi.org/10.1097/shk.0000000000001685>
- Pitkin, A. D., & Rice, M. J. (2012). Whole blood: More than the sum of the parts. *Anesthesiology*, 117(4), 915–916. <https://doi.org/10.1097/ALN.0b013e318268ffa0>
- Pivalizza, E. G., Stephens, C. T., Sridhar, S., Gumbert, S. D., Rossmann, S., Bertholf, M. F., Bai, Y., & Cotton, B. A. (2018). Whole blood for resuscitation in adult civilian trauma in 2017: A narrative review. *Anesthesia & Analgesia*, 127(1), 157–162. <https://doi.org/10.1213/ane.00000000000003427>
- Walsh, M., Moore, E. E., Moore, H. B., Thomas, S., Kwaan, H. C., Speybroeck, J., Marsee, M., Bunch, C. M., Stillson, J., Thomas, A. V., Grisoli, A., Aversa, J., Fulkerson, D., Vande Lune, S., Sjeklocha, L., & Tran, Q. K. (2021). Whole blood, fixed ratio, or goal-directed blood component therapy for the initial resuscitation of severely hemorrhaging trauma patients: A narrative review. *Journal of Clinical Medical*, 10(2), 320. <https://doi.org/10.3390/jcm10020320>
- Williams, J., Merutka, N., Meyer, D., Bai, Y., Prater, S., Cabrera, R., Holcomb, J. B., Wade, C. E., Love, J. D., & Cotton, B. A. (2020). Safety profile and impact of low-titer group O whole blood for emergency use in trauma. *Journal of Trauma and Acute Care Surgery*, 88(1), 87–93. <https://doi.org/10.1097/ta.00000000000002498>
- Yazer, M. H., Freeman, A., Harrold, I. M., Anto, V., Neal, M. D., Triulzi, D. J., Sperry, J. L., & Seheult, J. N. (2021). Injured recipients of low-titer group O whole blood have similar clinical outcomes compared to recipients of conventional component therapy: A single-center, retrospective study. *Transfusion*, 61(6), 1710–1720. <https://doi.org/10.1111/trf.16390>
- Yazer, M. H., Spinella, P. C., Anto, V., & Dunbar, N. M. (2021). Survey of group A plasma and low-titer group O whole blood use in trauma resuscitation at adult civilian level 1 trauma centers in the US. *Transfusion*, 61(6), 1757–1763. <https://doi.org/10.1111/trf.16394>

For more than 90 additional nursing continuing professional development activities related to trauma topics, go to [NursingCenter.com/ce](https://www.NursingCenter.com/ce).

Lippincott®
NursingCenter®

NCPD Nursing Continuing
Professional Development

INSTRUCTIONS

Whole Blood Program: Implementation in a Rural Trauma Center

TEST INSTRUCTIONS

- Read the article. The test for this nursing continuing professional development (NCPD) activity is to be taken online at www.NursingCenter.com/CE/JTN. Tests can no longer be mailed or faxed.
- You'll need to create an account (it's free!) and log in to access My Planner before taking online tests. Your planner will keep track of all your Lippincott Professional Development online NCPD activities for you.
- There's only one correct answer for each question. A passing score for this test is 8 correct answers. If you pass, you can print your certificate of earned contact hours and access the answer key. If you fail, you have the option of taking the test again at no additional cost.
- For questions, contact Lippincott Professional Development: 1-800-787-8985.
- Registration deadline is September 4, 2026.

PROVIDER ACCREDITATION

Lippincott Professional Development will award 2.0 contact hours for this nursing continuing professional development activity.

Lippincott Professional Development is accredited as a provider of nursing continuing professional development by the American Nurses Credentialing Center's Commission on Accreditation.

This activity is also provider approved by the California Board of Registered Nursing, Provider Number CEP 11749 for 2.0 contact hours. Lippincott Professional Development is also an approved provider of continuing nursing education by the District of Columbia, Georgia, West Virginia, New Mexico, South Carolina, and Florida, CE Broker #50-1223. Your certificate is valid in all states.

Payment: The registration fee for this test is FREE for STN members and \$21.95 for nonmembers.

STN members can take JTN CE for free using the discount code available in the members-only section of the STN website. Use the discount code when payment is requested during the check-out process.

DOI: 10.1097/JTN.0000000000000814