



Capt. Kyle Nielsen, an emergency medicine physician from 173rd Infantry Airborne Brigade, explains the importance of using a Thermal Angel (equipment used to warm blood) during a class on walking blood banks in their Role 2 prolonged field care training 13 September 2019 during Exercise Saber Junction 2019 at the Grafenwoehr Training Area, Germany. (Photo by Pfc. Ashunteia' Smith, U.S. Army)

Blood Types and Titters

Saving Lives on the Battlefield with Blood Far Forward

Lt. Col. D. Max Ferguson, U.S. Army

Second only to wartime tactics aimed at avoiding unnecessary injuries, a robust and timely whole blood transfusion capability is the most effective and most important lifesaving intervention

on the battlefield. Severe blood loss causes 90 percent of battlefield deaths.¹ Administering whole blood to critically wounded soldiers within thirty-six minutes is crucial for casualty survival; therefore,

timely access to whole blood is especially important in large-scale combat operations (LSCO) where it is difficult to get medical help within the “golden hour.”² Consequently, walking blood banks (WBBs) and access to stored whole blood will be an essential part of casualty care, making lifesaving blood available to remote aid stations and even platoons treating casualties at the point of injury.

Donors of Low-Titer Group O Blood Are Essential

A recipient’s blood type has little relevance in most prehospital and emergency whole blood transfusion programs. The donor blood is what matters, and the universal donor (an individual whose blood can be transfused into anybody) is one with *low-titer, Group O blood*.³ *Titer* refers to the concentration of specific antibodies in blood; the level of those antibodies correlates to the strength of a possible immune reaction. Low titer means that the likelihood of an adverse reaction to an O blood transfusion is low. In contrast, more substantial reactions related to high-titer Group O blood or non-Group O blood can endanger the life of the recipient. Consequently, the key to establishing WBBs is identifying those soldiers with O blood type (either Rh positive or negative) and screening that group to see if their blood is low or high titer.⁴ Soldiers with O blood and *low* titers are the acceptable WBB donor candidates for all combat casualties.

The screening process to identify suitable donor candidates occurs ahead of deployments. The first step is to establish an accurate roster of prescreened low-titer O volunteer donors. The next step is simulating blood transfusions and WBBs in unit training events to foster unit awareness and, ultimately, to save lives on the battlefield with whole blood.

Military Applications of Whole Blood

The benefits of administering fresh whole blood on the battlefield were first identified in World War I.⁵ Whole blood provides red blood cells for anemia, plasma, and platelets for clotting. Such transfusions on the battlefield remained a staple practice through World War II.

Advances in storing, screening, and freeze-drying individual blood components (like plasma and red blood

cells) after the Korean War, along with the ability to rapidly evacuate casualties to Role II and Role III hospitals, reduced the emphasis on whole blood in tactical care.⁶ Notwithstanding, analysis of combat care in Iraq and Afghanistan, where over ten thousand units of whole blood were transfused since 2002, revealed that whole blood transfusions produced consistently superior results to treating casualties with blood components.⁷

Today, prehospital care, battlefield medical evacuation, and surgical teams all use transfusion to save lives. Of note, special operations units like the 75th Ranger Regiment routinely practice whole blood transfusion programs within their formations.

Predeployment Blood Screening

Recognizing the importance of rapid, whole blood transfusions, the Department of Defense (DOD) issued DOD Instruction 6480.04, *Armed Services Blood Program*, in January 2022 (and updated in June 2023), directing the implementation of predeployment whole blood donor screening for all active and reserve units deploying overseas for more than thirty days. But this DOD policy is still pending implementation.⁸

Irrespective, services and combatant commands do not need to wait for authority to implement their predeployment requirements. The operational Army can initiate its own screening requirements now and begin establishing WBBs for training and combat.

The 2nd Brigade, 10th Mountain Division (2/10th MTN), understood the value in building a WBB program ahead of its deployment to Operation Inherent Resolve. In the spring of 2023, the unit spent

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\$30,000 of its own operations and maintenance funds to screen 3,184 soldiers, resulting in 1,072 soldiers with low-titer O blood who volunteered as donors. The initiative enabled 2/10th MTN to maintain eleven active WBBs at their outstations across Iraq, Eastern Syria, and Kuwait. No other DOD personnel

match method (e.g., A with A, B with B, etc.) is not feasible or safe for prehospital combat applications and mass casualty situations. Each distinct blood type has unique compatibility matches with some similar blood types, but they are not as intuitive as A matches with A and B with B, etc.¹⁰ Therefore, if not using



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in the combined joint task force (CJTF) underwent whole blood screening prior to deploying to the Central Command area of operation, so 2/10th MTN soldiers were the only soldiers capable of donating to a WBB across the CJTF.

The Challenge of Titer Testing

The main difficulty in screening for ideal blood donors lies in the complexity of the testing process. While medics can easily determine a person's blood group using the Eldon Blood Typing Kits, which take just five minutes and a simple finger prick, testing for titer levels is more challenging. Currently, there is no quick test for titer levels; this requires a lab technician to analyze the blood in a laboratory setting. Each titer test can take anywhere from thirty to ninety minutes to complete. For perspective, a single lab technician might spend up to 150 hours testing just one hundred blood samples, indicating the time-intensive nature of this process.

Why Low Titer Matters

When testing for titers, we determine if the donor's blood has a high or low level of antibodies that could potentially harm the recipient.⁹ Low titers in O blood means it is safe for A, B, or AB blood types because it will not cause harmful reactions. High titers, indicated by an antibody ratio above 1:256, mean there may be too many antibodies for the blood to be safely used as a universal donor.

Though this can remain a contingency option when low-titer O donors are not available, the exact

the "universal donor" (Group O) blood, the risk of a mismatch between donor and recipient is too high. Receiving even one unit (500 ml) of mismatched blood can trigger a lethal transfusion reaction.

The Need for Both Stored and Walking Blood

The U.S. military must have a nimble, capable, and redundant blood program to prevent death from survivable injuries on the battlefield. The most effective blood treatment option on the battlefield is whole blood.¹¹ And whole blood comes from the Armed Services Blood Program (ASBP) or WBBs.¹² Stored blood from the ASBP provides a crucial battlefield support capability, as does fresh whole blood from WBBs.

The difference between ASBP and WBB can be framed as a distinction between quality and quantity. Stored whole blood from ASBP will be carefully screened and managed so quality of the blood is very high (from a safety perspective). Medics can and should carry stored whole blood in the field, but these few units of blood are best suited for initial acute injury response during prehospital or Role 1 care.

There are challenges with getting whole blood rapidly into a bleeding casualty and having a refined system using both stored whole blood (from the ASBP) and fresh whole blood (from a WBB) are needed. Stored whole blood requires refrigeration, portable specialized coolers, temperature monitoring, and a logistical cold chain transport. This is difficult, especially for maneuver units that might have competing priorities for transport;



Low-titer O whole blood is stored at the Fort Leonard Wood Blood Donor Center 22 June 2023 for the Armed Services Blood Program. This lifesaving blood product can be transfused into patients of any blood type, making it a valuable tool for the military, which often needs to transfuse blood in austere environments. (Photo by Carl Norman, Defense Health Agency)

the size, weight, and storage capacity of blood coolers marginalize their value in the tactical environment.¹³ However, if there is a low-titer Group O donor in the formation, they are the “blood bank”—hence, the term “walking blood bank.”

In contrast, WBB programs reduce the need to rely solely on stored whole blood systems. Field blood transfusion kits are lightweight, compact, and make whole blood continuously accessible. For example, the Ranger O Low Titer (ROLO) Whole Blood Program has become a staple for rangers, with each assaulter carrying a blood transfusion kit in the back of their body armor (see figure 1). The key to effectively employing whole blood transfusion to casualties on the battlefield is having whole blood available with a multidimensional approach using both ASBP provided WB and the WBB.

Ultimately, the two blood programs complement one another, and both are necessary. The WBB is an essential capability that *augments* ASBP’s solid blood system.¹⁴ It is crucial that the DOD maintains

both capabilities. The stored whole blood program from ASBP is not postured to support the breadth of demands that LSCO will generate. Fresh whole blood from WBBs fills that gap, helping surge access to blood on the battlefield to small maneuver units and remote locations. But drawing fresh whole blood should be reserved for medical emergencies at the direction of on-scene commanders based on their assessment of the tactical situation. Ongoing DOD-funded research is examining at the clinical differences between fresh whole blood and stored whole blood.¹⁵

Recommendations

A new Golden Rule for LSCO. If the golden hour was the standard in previous conflicts to get a casualty to a surgical capability, *the new benchmark for tactical combat casualty care should be thirty-six minutes to the first blood transfusion* because blood transfusions within thirty-six minutes of a potentially lethal injury improves survival fourfold.¹⁶ There is no other battlefield medical capability that



Battlefield Transfusion System Package Product List

Field Blood Transfusion Kit
(Donor & recipient)



NSN 6515-01-618-3730
\$110
Recommend: LFX + deployed
*1x kit issued to pre-screened
Low Titer O Whole Blood (LTOWB)
volunteer donor*

Portable Cold Storage Blood Systems

1. Solid State Refrigerator-freezer "HemaCool" 40 units blood
NSN 4110-01-629-9593 **\$9000**
Req batt/electricity: Role I/Role II
2. Golden Hour Cooler
NSN 6530-01-505-5306 **\$2300**
4 units, passive cold 48 h
MEDEVAC/designated CASEVAC
3. Golden Hr Series S Medic
NSN 6530-01-654-0062 **\$600**
2 units, passive cold 24 h





MOLLE to Aid Bag

(Figure by Maj. Justin Stewart, 2/10 BDE surgeon)

Figure 1. Comparison of Field Transfusion Kits and Various Portable Blood Storage Systems

has evidence to support the ability to save lives like blood.¹⁷

Screen soldiers before deployment. Whole blood donor screening must occur during predeployment soldier readiness processing. This is a critical step in establishing a WBB program. Soldiers with O blood must be identified, and their blood samples must be sent to a lab for screening to determine the candidates' titer levels. Field expedient kits like the Eldon Kit (see figure 2) allow medics to quickly determine blood groups and rapid tests exist to screen for transfusion transmissible diseases (like HIV and hepatitis). But O group blood must be screened for Anti-A and Anti-B antibody titer levels using special chemicals that require a laboratory setting.

Units assuming a response force status should also prescreen their soldiers for whole blood donor

candidates. Waiting until a deployment is too late. There is merit to screening all soldiers for whole blood donor compatibility.

Walking blood bank training. The WBB has been used for over a century; however, the joint requirement for training with WBBs does not exist. Aid stations and maneuver units need to practice activating WBBs and performing blood transfusions in both combat and emergency scenarios using fresh and stored whole blood. Training is necessary to increase proficiency and to educate the force on important considerations like major mismatch and transfusion reactions.¹⁸ Services should explore how to expand on training initiatives like the U.S. Marine Corps' four-day Valkyrie Battlefield Transfusion Program course at Camp Pendleton, California, or adapt the 75th

Ranger Regiment's ROLO program for soldiers in conventional units.¹⁹

Additional Research Opportunities

Developing a rapid titer test. A valuable effort that medical researchers can pursue is developing a rapid Anti-A/Anti-B antibody titer test that medics can use in the field. The only available screening method is time intensive, resource demanding, and costly. Developing a rapid field test to check if a person's blood titers are high or low would be a major advancement. Such a test would have worldwide applications, and it would expand the Army's ability to establish WBBs, ultimately saving lives in future LSCO.

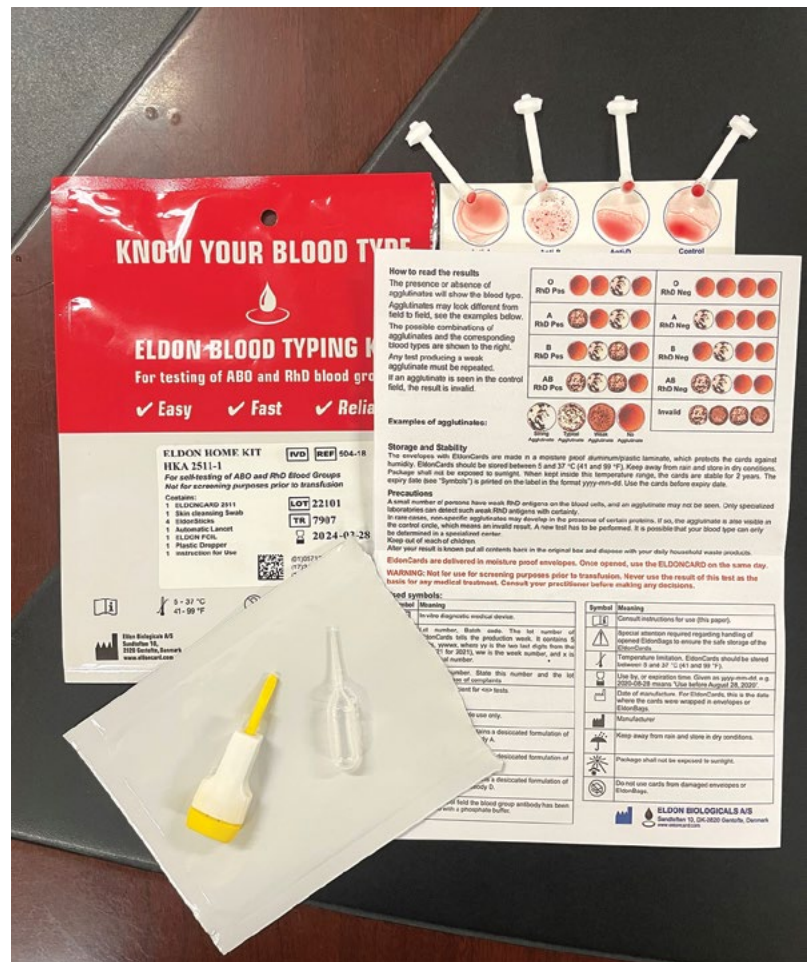
FDA-approved test for transfusion-transmissible diseases. Being able to rapidly assess the safety of blood includes rapid testing for hepatitis, HIV, and other blood-borne pathogens. While rapid tests for HIV and hepatitis exist, they are not FDA approved. (However, they are > 90 percent sensitive and specific.)²⁰ Having FDA-approved rapid tests for transfusion-transmissible diseases would allow the expansion of WBBs.

Testing frequency for titer levels. Titer levels can change over time, so it is not clear how often they need to be tested. Early studies suggest testing twice, three months apart, may be enough to confirm a person's titer level.²¹ However, we need more research to find the best testing schedule for Army units before they deploy.

Research on soldiers donating blood. We should study how donating blood affects soldiers in combat. An initial study suggests little impact on soldiers' ability to do physical tasks or shoot accurately after giving 450 ml of blood (one unit). But, we need to know more about the effects of donating 1000 ml of blood, which the usual amount taken in WBB draws.²²

Conclusion

Blood and war are inextricably linked. The military has learned and relearned this lesson in every war



(Photo by 1st Lt. Caleb Homol, 2nd Battalion, 14th Infantry Regiment)

Figure 2. Eldon Blood Typing Kits

over the past century. Combat casualty survival on the battlefield depends on a well-resourced and well-trained blood capability. Not equipping and training for stored and fresh whole blood transfusions will come at a cost of lives lost on the battlefield.

Leaders need to maintain a reliable WBB plan for each deploying unit and those performing advanced combat training. Screening formations for low-titer O group blood donor candidates and incorporating whole blood transfusions into training events will save lives at home and overseas.

Whole blood in thirty-six minutes needs to be the new benchmark for casualty care in LSCO. Ready access to stored whole blood and WBB programs along with individual soldier proficiency in blood transfusion techniques will make that standard possible. ■

This article was written as a catalyst paper to help advance the conversation about how to transform prolonged casualty care on the battlefield for future LSCO fights. The concepts and ideas in this paper originate from across the community of tactical combat casualty care providers, including the unit-driven initiative by 2nd Brigade, 10th Mountain Division, to establish a brigade combat team walking blood bank program for their 2023-2024 deployment to Combined Joint Task Force–Operation Inherent Resolve. Col. Jennifer Gurney, chief of the Joint Trauma System, was instrumental

in developing this article and contributing a medical perspective. The mission of the Joint Trauma System is to ensure every service member injured has the best chance of survival and optimal recover. Gurney focused her career on improving combat casualty care and leads the Army's research on whole blood on the battlefield. She has championed the need for expanding access to whole blood on the battlefield for years. It is time for maneuver leaders and close combat units to embrace what medical research has conclusively shown: whole blood far forward on the battlefield saves lives.

Notes

1. Brian J. Eastridge et al., "Death on the Battlefield (2001–2011): Implications for the Future of Combat Casualty Care," *Journal of Trauma and Acute Care Surgery* 73, no. 6 (Supp. 5) (December 2012): S431–37, <https://doi.org/10.1097/TA.0b013e3182755dcc>.
2. "The traditional (pre-2015) concept of the golden hour is based on movement of the injured person to a fixed location or echelon of care within 60 minutes. The evolved concept for 2015 and beyond involves delivering advanced resuscitative capability to the injured person within one hour, regardless of location or echelon of care." Todd E. Rasmussen et al., "In the 'Golden Hour': Combat Casualty Care Research Drives Innovation to Improve Survivability and Reimagine Future Combat Care," *Army AL&T Magazine* (January–March 2015): 82, <https://cccrp.health.mil/ScientificPapers/In%20the%20Golden%20Hour.pdf>. The thirty-six-minute limit is from Stacy A. Shackelford et al., "Association of Prehospital Blood Product Transfusion during Medical Evacuation of Combat Casualties in Afghanistan with Acute and 30-Day Survival," *Journal of the American Medical Association* 318, no. 16 (October 2017): 1581–91, <https://doi.org/10.1001/jama.2017.15097>.
3. There are eight blood groups across the ABO and Rh blood group system. The four types are A, B, AB, or O with each group either Rh positive or Rh negative, for eight total variations.
4. Group O-negative is commonly considered the universal donor but for Army walking blood bank purposes, either variant of the O group is suitable. Healthy adult males and females of any blood group can receive O-positive blood, though females who are Rh negative may experience a condition called alloimmunization complications during future pregnancies, even years after the transfusion. There are medications available to take during pregnancies to counter this issue, so the overall risk is low but still important to acknowledge.
5. Fresh whole blood refers to drawing warm blood from a donor and making it immediately available to a trauma patient. Fresh whole blood can be administered to a patient within twenty-four hours without cold storage or can be preserved for storage if refrigerated within eight hours of the draw. Stored whole blood needs to be kept cold in a fridge or specialized cooler and has a shelf life of about two weeks. It cannot be administered cold to a patient, so heating elements are needed to bring stored whole blood to the right temperature during transfusions.
6. Jennifer M. Gurney and John B. Holcomb, "Blood Transfusion from the Military's Standpoint: Making Last Century's Standard Possible Today," *Current Trauma Reports* 3 (2017): 144–55, <https://doi.org/10.1007/s40719-017-0083-1>; J. R. Hess and M. J. Thomas, "Blood Use in War and Disaster: Lessons from the Past Century," *Transfusion* 43, no. 11 (November 2003): 1622–33, <https://doi.org/10.1046/j.1537-2995.2003.00576.x>.
7. Jennifer M. Gurney and Philip C. Spinella, "Blood Transfusion Management in the Severely Bleeding Military Patient," *Current Opinion in Anaesthesiology* 31, no. 2 (April 2018): 207–14, <https://doi.org/10.1097/aco.0000000000000574>; Cecily K. Vanderspurt et al., "The Use of Whole Blood in US Military Operations in Iraq, Syria, and Afghanistan since the Introduction of Low-Titer Type O Whole Blood: Feasibility, Acceptability, Challenges," *Transfusion* 59, no. 3 (March 2019): 965–70, <https://doi.org/10.1111/trf.15086>; Jennifer M. Gurney et al., "Whole Blood at the Tip of the Spear: A Retrospective Cohort Analysis of Warm Fresh Whole Blood Resuscitation Versus Component Therapy in Severely Injured Combat Casualties," *Surgery* 171, no. 2 (February 2022): 518–25, <https://doi.org/10.1016/j.surg.2021.05.051>.
8. Department of Defense Instruction (DODI) 6480.04, *Armed Services Blood Program* (Washington, DC: Department of Defense, 29 June 2023, incorporating change 1), <https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/648004p.pdf?ver=09Gn5i-K7UP7ucvoCjrVzyQ%3D%3D>. The official DOD requirement will be initiated not later than eighteen months after the Defense Health Agency issues standardized procedural guidance pursuant to the DODI.
9. Antibodies are measured as a special blood protein in a given volume of blood that directly correlates to the strength of an immune reaction. A titer test determines a person's immunity to a particular blood agent.
10. To review the unique combinations of patient to donor matches, see "Blood Type Compatibility Chart," Stanford Blood Center, accessed 8 January 2024, <https://stanfordbloodcenter.org/donate-blood/blood-donation-facts/blood-types/0318-south-bay-center-infographics-compatibility-web/>.
11. In addition to whole blood, medical providers can maintain stores of individual packaged blood components such as packed red blood cells, frozen fresh plasma, cold-stored platelets, and liquid plasma.
12. The Armed Services Blood Program (ASBP) was established in 1952 by President Harry Truman because the United States entered the Korean War without a blood capability, and thousands

of U.S. service members died as a result. The ASBP now falls under the Defense Health Agency. The ASBP has not been resourced to support the full range of military operations for large-scale combat operations (LSCO) or to even surge for increased tempo during a contingency. The Walking Blood Bank can bridge this gap for a very short period but has substantial challenges in a highly kinetic environment. Additionally, ASBP functions have a lag time to get to full operational capability; for example, the ASBP took nearly a decade to become a fully functional program in 1962 after it was mandated by Truman in 1951. Continued diminishment of the ASBP will result in an unacceptable lag time during LSCO and force attrition from preventable deaths.

13. See Micah J. Gaspary et al., "Obstacles to an Effective Low-Titer O Walking Blood Bank: A Deployed Unit's Experience," *Military Medicine* 186, no. 1-2 (January-February 2021): e137-42, <https://academic.oup.com/milmed/article/186/1-2/e137/5909708>. For reference, the average trauma patient can expect to need eight units (one unit = 500 ml) of whole blood. So, carrying two to four units in a portable cooler may be of marginal use in a restricted LSCO or mass casualty situation. Patients with severe blood loss may require fifty units or more to save their life. One blood transfusion study found, "with 50 reliable donors, we could likely massively transfuse two to four patients."

14. Anthony B. Hall et al., "Blood Utilization at Abbey Gate," *Trauma* 25, no. 2 (December 2022): 174-75, <https://doi.org/10.1177/14604086221145653>. The Abbey Gate attack on Hamid Karzai International Airport on the afternoon of 26 August 2021 demonstrated the need to augment blood component supplies with walking blood banks when nineteen patients required blood, exceeding the available stockpiles at trauma centers.

15. Jennifer M. Gurney et al., "Determining Resuscitation Outcomes in Combat Casualties: Design of the Deployed Hemostatic Emergency Resuscitation of Traumatic Exsanguinating Shock (Deployed HEROES) Study," *Journal of Trauma and Acute Care Surgery* 93, no. S2 (Supp. 1) (August 2022): S22-29, <https://doi.org/10.1097/TA.0000000000003681>.

16. Shackelford et al., "Association of Prehospital Blood Product Transfusion during Medical Evacuation."

17. Russ S. Kotwal et al., "The Effect of Prehospital Transport Time, Injury Severity, and Blood Transfusion on Survival of US Military Casualties in Iraq," *Journal of Trauma and Acute Care Surgery* 85, 1S (Supp. 2) (July 2018): S112-21, <https://doi.org/10.1097/ta.0000000000001798>; Shackelford et al., "Association of Prehospital Blood Product Transfusion during Medical Evacuation"; Jeffrey T. Howard et al., "Use of Combat Casualty Care Data to Assess the US Military Trauma System During the Afghanistan and Iraq Conflicts, 2001-2017," *Journal of the American Medical Association Surgery* 154, no. 7 (July 2019): 600-8, <https://doi.org/10.1001%2Fjamasurg.2019.0151>.

18. A blood transfusion reaction can lead to a dangerous anaphylactic situation. Giving a nonmatched unit of blood has potentially grave (and rapid) consequences where patients can go into renal failure and die. Sometimes it can be treated with steroids or EpiPen treatments to stabilize the patient. The risk of transfusion reaction from nonmatched blood creates a major complication for any trauma patient in any circumstance, but the risk of accidentally causing a blood transfusion reaction in an austere tactical scenario is especially dangerous. This is why prescreening and training are so important.

19. For more on ROLO, see Kaoru H. Song et al., "Ranger O Low Titer (ROLO): Whole Blood Transfusion for Forward Deployed Units," *Military Medicine* 188, no. 7-8 (July-August 2023): e2733-37, <https://doi.org/10.1093/milmed/usab473>. The Army also runs a five-day "Tactical Combat Medical Care" course at Fort Sam Houston, Texas, for providers and senior NCOs.

20. Andrew P. Cap et al., *Whole Blood Transfusion*, Joint Trauma System Clinical Practice Guideline 21 (Fort Sam Houston, TX: Joint Trauma System, 15 May 2018), https://jts.health.mil/assets/docs/cpgs/Whole_Blood_Transfusion_15_May_2018_ID21.pdf.

21. Bailey et al., "Changes in Donor Antibody Titer Levels Over Time."

22. Geir Strandenes et al., "Donor Performance of Combat Readiness Skills of Special Forces Soldiers Are Maintained Immediately after Whole Blood Donation: A Study to Support the Development of a Prehospital Fresh Whole Blood Transfusion Program," *Transfusion* 53, no. 3 (March 2013): 526-30, <https://doi.org/10.1111/j.1537-2995.2012.03767.x>.