Prehospital Whole Blood in SOF

Current Use and Future Directions

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ABSTRACT

The US Joint Trauma System (JTS) recommends stored whole blood (SWB) as the preferred product for prehospital resuscitation of battlefield casualties in both their Tactical Combat Casualty Care (TCCC) guidelines and their clinical practice guidelines (CPGs). Clinical data from nearly 2 decades of war during Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) suggest that whole blood (WB) is safe, effective, and far superior to crystalloid and colloid resuscitation fluids. The JTS CPG for whole blood transfusion reflects the most recent clinical evidence but poses unique challenges for execution by Special Operations Forces (SOF) operating in austere environments. Given the limited shelf-life of 35 days, WB requires a constant steady pool of donors. Additionally, the cold-chain requirement for storage poses challenges for SOF on long missions without access to blood refrigerators. SOF operating in less-developed theaters face additional logistical challenges. To mitigate the challenges of WB delivery, US SOF have implemented various protocols to ensure optimal donor pool, awareness/education among medics and specialized equipment for tactical methods of blood-carry and delivery. In general, steps taken include the following: (1) Prior to deployment, soldiers are screened for blood type and titers in order to establish a large donor pool. Support soldiers have been found to be particularly beneficial donors as they typically are in closer proximity to the blood support detachment. (2) In units that operate in smaller teams, such as ODAs, medics are outfitted with "blood kits" to carry blood on missions for point of injury transfusion. In units with larger teams, LTOWB donors are identified on missions and deliver fresh WB in the event of casualties. (3) Medics receive a WB transfusion refresher tabletop exercise and review after action reviews from previous rotations. Additionally, prehospital WB delivery is a required component of scenario-based premission training. The expectation is that medics will administer WB on missions when tactically feasible. Using the prolonged field care framework (ruck, truck, house) as a template, medics now use different methods to store and transport the SWB depending on phase. Medic "truck" and "house" kits include the Dometic CFX™ powered coolers that run on AC, DC, or solar power and allow for constant temperature monitoring. When on foot, medics have been outfitted with tactical blood coolers including the Pelican Biomedical Medic 4™ or Combat Medical Blood Box™ along with a Belmont Buddy-Lite™ intravenous (IV) infusion warmer and IV administration kit with standard micron filter. Presently, SOF medics have the donor support, logistical framework, training, and equipment to deliver WB at the point of injury. However, widespread implementation will require expanded distribution and standardization of "blood kits." Additionally, SOF medical planners must put greater emphasis on education and the importance of WB over crystalloids or colloids—as many medics continue to carry only these products out of convenience. As SOF strive to establish tactics, techniques, and procedures (TTPs) and streamline prehospital WB delivery, we must constantly reassess and refine our procedures, incorporate the latest evidence and technology, and adapt to an evolving battlefield.

Keywords: prehospital; whole blood; executive summary

Introduction: WB as a Standard of Care

The JTS recommends SWB as the preferred product for prehospital resuscitation of battlefield casualties both in their TCCC guidelines and their CPGs.[1] The JTS CPG for whole blood transfusion reflects the most recent clinical evidence but also stems from extensive historical wartime use and tactical advantages. However, the CPG poses unique challenges for execution by SOF operating in austere environments. To address these challenges, current US SOF have implemented various TTPs, although widespread implementation will require standardization, resourcing, and education for homogeneity. Additionally, units should constantly reassess these TTPs based on outcome to optimize their processes and adapt to an evolving battlefield.

Background

SWB is drawn from a human donor and stored in an anticoagulant solution: citrate-phosphate-dextrose (CPD) for 21 days or **CPD-adenine (CPDA-1)** for up to 35 days when cooled to **1°C to** 6°C. After collection, the Armed Services Blood Program (ASBP) tests these units for transfusion transmitted diseases.[1] Because SWB is collected, stored, and tested by a licensed center, it is US Food and Drug Administration (FDA) approved for use in battlefield casualties.[1] FWB is typically drawn in emergency situations (aka "walking blood bank") when there is not an adequate supply of SWB or other resuscitative products.[1,2] FWB is drawn and administered at room temperature within 24 hours and therefore is not tested for TTD and is not FDA approved.

Low-titer O WB (LTOWB) refers to type O blood that has <1:256 saline dilution of anti-A and anti-B antibody titers. Specifically, IgM is more closely associated with hemolysis than

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IgG.[2] There is no universally dedicated "safe" titer of anti-A and anti-B antibodies, so the 1:256 dilution was implemented as policy by the Ranger-O-low titer (ROLO) protocol.[2] Use of LTOWB minimizes the risk of hemolytic transfusion reactions, and it can be therefore considered "universal WB." The ASBP only supplies LTOWB to OCONUS units for use as it decreases the risk of severe transfusion reactions.[1,3] The US Army has relied on LTOWB to treat casualties in World War II, Korea, and Vietnam, and it has resurged in OEF, OIF, and Operation Inherent Resolve.[1–4]

WB contains red blood cells (RBCs), plasma, and platelets. CONUS medical centers split donor blood into these components in order to preserve storage longevity (e.g., plasma can be frozen and stored for up to a year, but freezing platelets would destroy them[1,5]), target therapy (some medical patients may need only platelets rather than WB), and minimize transfusion reactions. While component therapy is practical for most CONUS medical center use, it creates several disadvantages when relied on in an operational setting.

Advantages

Clinical data from nearly 2 decades of war during OIF and OEF suggest that WB is both safe and effective compared with component therapy and far superior to crystalloid and colloid resuscitation fluids.[1,6–8] WB has been shown to be as effective as component therapy in resuscitating trauma patients and may actually improve survival.[1,6,7] CONUS medical centers resuscitate trauma patients using component therapy in a 1:1:1 ratio of RBCs, plasma, and platelets. On the battlefield, thawing plasma and managing multiple infusion bags with potentially limited vascular access are impractical. WB allows prehospital medical providers to infuse a single resuscitative product that provides all of the critical components to address both oxygen debt and coagulopathy and requires minimal preparation before the casualty reaches a surgeon. Additionally, in emergency situations, Soldiers themselves can act as the transport vessel for the product via WBB.

Many Operators now incorporate freeze-dried plasma (FDP) into their trauma care algorithms, and it has become a valuable tool for battlefield resuscitation. However, current protocols still recommend FDP be used only if WB is not available.[2,9]

Limitations

Given the limited shelf-life of 21 to 35 days, WB requires a constant steady pool of donors. Additionally, identifying and tracking LTOWB donors limit the number of Soldiers eligible to donate and may require repeated testing. Soldiers should not donate more often than every 56 days and may need to be on limited duty in the days following a donation. Additionally, blood titers can change over time and donors should intermittently be retested for titer level, which can prove difficult when Soldiers are in austere environments (although in the absence of receiving blood products, most individuals trend to remain low titer). The cold-chain requirement for storage also poses challenges for SOF on long missions without access to blood refrigerators. SOF operating in less-developed theaters face additional logistical challenges.

It is important to note that WB will never substitute for definitive surgical hemorrhage control. The role of WB transfusion is to optimally resuscitate casualties prior to their arrival at a Role 2 and therefore improve outcome. DCR should not delay transport of casualty to definitive surgical care.

Current Use in US SOF

To mitigate the challenges of WB delivery, US SOF have implemented various measures to ensure optimal donor pool, awareness/education among medics and specialized equipment for tactical methods of blood-carry and delivery. In general, steps taken include:

1. Prior to deployment, unit soldiers are screened for blood type and titers to establish a large donor pool. Support Soldiers have been found to be particularly beneficial donors as they typically are in closer proximity to the blood support detachment.[4,10]

   This list is kept on hand by the unit surgeon so donors may be called upon to donate at the blood support detachment when supply is running low. Additionally, in larger units or in emergent situations, it can be used to initiate a WBB.

   Units of SWB are then ordered and pushed to SOF outstations, which are often colocated with either a Role 2 or Role 3 facility. Colocation with a Role 2 allows for utilization of existing medical supply routes and product storage in a dedicated blood refrigerator. Once SWB units are allocated for the mission, team medics retrieve the SWB units from the Role 2.
2. In units that operate in smaller teams, medics are outfitted with "blood kits" to carry blood on missions for point of injury transfusion. Using the prolonged field care framework (ruck, truck, house) as a template, medics now use different methods to store and transport the SWB depending on phase. Medic "truck" and "house" kits include the Dometic CFX™ powered coolers that run on AC, DC, or solar power and allow for constant temperature monitoring. When on foot, medics carry tactical blood coolers including the Pelican Biomedical Medic 4™ or Combat Medical Blood Box™ along with a Belmont Buddy-Lite™ IV infusion warmer and IV administration kit with standard micron filter. In units with larger teams, donors are identified on missions and deliver FWB in the event of casualties.[2]
3. Medics receive a WB transfusion refresher tabletop exercise and review after-action reviews from previous rotations. Additionally, prehospital WB delivery is a required component of scenario-based premission training. The expectation is that medics will administer WB on missions when tactically feasible.

Way Forward and Conclusion

Utilization of LTOWB as a universal blood product shattered preexisting medical practice, and much of its implementation in SOF can be attributed to the ROLO program.[2] Presently, SOF medics have the donor support, logistical framework, training, and equipment to deliver WB at the point of injury. However, widespread implementation has yet to occur. Adoption of WB at the point of injury as a standard expectation will require expanded distribution and standardization of "blood kits." Additionally, SOF medical planners must put greater emphasis on education and the importance of WB over crystalloids or colloids—as many medics continue to carry only these products out of convenience.

Along with education and resourcing, technological advancements will also shape the future of WB resuscitation. The Norwegian THOR program is developing methods of far forward blood delivery via unmanned aerial systems, and US developers are researching methods to modify blood to make any blood type a universal donor (R. Knight, email communication, 12 March 2019; S. Patrick, email communication, 11 March 2019).[11] Additionally, ruggedizing and miniaturizing of blood coolers, or the development of an additive to extend shelf life will likely promote WB practice due to ease of transport.

Taken together, the next stages of expanded WB use must be:

1. Making prehospital WB delivery to casualties on mission a standard expectation at the lowest unit levels. The infrastructure to carry and deliver WB at the point of injury exists—medics and providers must now follow through on executing the practice.
2. As the practice expands, developments in technology and techniques of delivery will further shape and optimize far forward blood delivery.

As SOF strive to establish TTPs and streamline prehospital WB delivery, we must constantly reassess and refine our procedures, incorporate the latest evidence and technology, and adapt to an evolving battlefield.

Disclosure

Products mentioned in this manuscript were purchased by 1SFG(A). The authors have no financial conflicts to disclose.

Author Contributions

TJ created initial blood kits. VM implemented kits throughout 1SFG(A) and presented to 1SFC(A) during innovations briefing. AS wrote the first draft, and all authors read and approved the final manuscript.

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