

From battlefield to homefront: creation of a civilian walking blood bank

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Hemorrhagic shock remains the leading cause of preventable death on the battlefield, despite major advances in trauma care. Early initiation of balanced resuscitation has been shown to decrease mortality in the hemorrhaging patient. To address transfusion limitations in austere environments or in the event of multiple casualties, walking blood banks have been used in the combat setting with great success. Leveraging the success of the region-wide whole blood program in San Antonio, Texas, we report a novel plan that represents a model response to mass casualty incidents.

Despite major advances in modern trauma care, hemorrhagic shock remains the leading cause of preventable death for trauma patients.^{1,2} Rapid transfusion of blood products and hemorrhage control are critical to improving patient mortality.³⁻⁶

Mass casualty incidents (MCIs), defined as events that overwhelm emergency medical response systems, challenge these tactics and result in a rapid depletion of available blood products. Platelets, due to short shelf life and hours-long donation process, are difficult to replenish and are usually depleted first in a massive transfusion setting.⁷ As a result, the lack of available blood products likely contributes to preventable deaths during MCIs. The rise of whole blood (WB) transfusion for resuscitation from hemorrhagic shock in combat has been well described.⁸⁻¹¹ In particular, WB holds the potential to be more widely available than component therapy (CT) during an MCI due to the concept of the walking blood bank (WBB). A WBB is defined as a cache of healthy donors who can be mobilized to donate blood in real time for immediate transfusion needs.

ABBREVIATIONS: CT = component therapy; EMS = emergency medical service; LTOWB = low-titer O-positive whole blood; MCIs = mass casualty incidents; STBTC = South Texas Blood & Tissue Center; STRAC = Southwest Texas Regional Advisory Committee; TX EMTF = Texas Emergency Medical Task Force; WB = whole blood; WBB = walking blood bank.

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HISTORY OF THE WBB IN THE UNITED STATES

The idea of a WBB was initially reported during World War I when transfusion medicine was in its early stages.^{12,13} While blood transfusions were first performed in the early 20th century, the practice of blood banking and blood product storage was not implemented until World War II. During the Cold War in the United States, citizens in Indiana and Utah ranging in ages from elementary school students to adults were tattooed with their blood type to serve as potential blood donors in the event of an MCI.¹⁴ The idea of a civilian WBB was also described in the mid-20th century to address limited blood product availability.^{15,16} However, a shift in blood bank practice from WB to CT and the HIV epidemic decreased enthusiasm for WBBs.¹² Military conflicts in Afghanistan and Iraq renewed interest in the WBB.¹⁷⁻²² In the austere environment, the availability of plasma and platelets severely limits massive transfusion in patients with hemorrhagic shock.¹⁸ WB bypasses the existing storage-related limitations of CT. The US military uses “field blood banks” in which WB is obtained from immediately available donors, and blood is either used on site or transferred to the front line.²³ In the combat setting, WB can be transfused within 18 minutes from patient arrival with this system.²⁴ In the civilian sector, the cruise line industry has used WBBs through fresh WB donation for over a decade. One US-based cruise line has used a volunteer-based transfusion system since 2008, relying on a tiered donation system and rapid screening of donors for patients in need of emergency release transfusion.²⁵ With hemorrhagic shock and a known source of bleeding as a trigger for transfusion, 73 patients were transfused between 2008 and 2009. In a retrospective analysis, 67 of these patients survived to reach a hospital, and 64 survived to hospital discharge. A review of these 64 survivors revealed that 56 of the passengers who survived would have died without receiving a fresh WB transfusion at the onset of bleeding while onboard the ship.²⁵

WBBs outside the United States

WBBs have been described by numerous countries, and these established models could help to serve as a framework as WBBs develop in the United States. In resource-poor countries, WBBs composed of patient family members and friends, serve a critical role in providing blood as needed.²⁶⁻²⁹ These donors are often the safest resource to obtain blood in emergency situations. However, despite donations from family and friends, most countries face frequent critical shortages of blood products.³⁰ The use of volunteer WBBs during major international events such as the Olympics and natural disasters has also been described to help meet the increased needs for blood transfusions.^{31,32}

Military forces from countries such as the United States, Canada, Norway, the Netherlands, France, Poland,

and Sweden have previously described the implementation of WBBs on the frontlines.³³⁻³⁹ Norway and Sweden have described a “transfusion buddy” system and training of medics to draw blood in the field.³⁵ Other strategies for implementation and safety included a rotating system and iron supplementation for donors. Frequent donation did not result in a negative impact on soldier performance.⁴⁰ A larger-scale collaborative multinational WBB model was previously described during the military conflict in Afghanistan, which included participants from 10 nations (Belgium, Czech Republic, United Kingdom, France, Italy, Mongolia, Romania, Spain, Turkey, and the United States).³⁶ This model provided all blood types due to a diverse pool of donors.

The creation of a structured military-civilian WBB in Norway was established in 2010 between the Norwegian Naval Special Operation Commando and the Department of Immunology and Transfusion Medicine at Haukeland University Hospital in Bergen, Norway.^{12,41} The Bergen model was adapted from the military WBB.⁴⁰ The goal of the collaboration was to establish a WBB for civilians in the event of an MCI and also to have WB and freeze-dried plasma available for military conflicts.¹² WB can be obtained from established or pretested blood group O donors with a low titer of anti-A and anti-B. Donors were recruited from civilians and also from military personnel at a nearby naval base. As blood resources become depleted, donors are notified and advised to report to the blood bank to donate. Coordination between the blood bank director and clinicians is imperative to obtain a sufficient supply of blood without generating waste.¹² WB is available within 1 to 4 hours. Up to 50 units of WB can be available for five massive transfusion events, but this can also be increased as needed to meet the demand for MCIs.⁴¹

Proposal for civilian WBBs

With the resurgence of WB transfusion in civilian trauma systems, the concept of the WBB is gaining momentum in nonmilitary environments.^{12,23} A WBB, or “floating blood bank,” has even been proposed in the setting of space missions.⁴² The creation of a civilian WBB could be lifesaving for patients in the event of an MCI. Currently, US hospitals and blood banks institute campaigns to collect blood on demand to meet the need for blood products during shortages by often appealing to repeat donors.⁴³⁻⁴⁵ This current system could be formalized into the development of WBBs available to respond during times of increased need for blood.

CURRENT PREHOSPITAL WB PROGRAM IN SOUTH TEXAS

The Southwest Texas Regional Advisory Committee (STRAC) provides regional trauma management services for

Trauma Service Area P, which is a 22-county, 26,000-square-mile area and includes 70 emergency medical service (EMS) agencies, two Level 1 trauma centers, three Level 3 trauma centers, and 25 Level 4 trauma centers. In 2018, STRAC, The University of Texas Health Science Center at San Antonio, and South Texas Blood & Tissue Center (STBTC) partnered to create a comprehensive pre-hospital WB program that includes availability for selected ground and helicopter EMS units and trauma centers of all levels.⁴⁶ In the prehospital setting, WB is transported in carefully chosen and validated storage containers that meet current standard blood bank parameters. The WB units are monitored so that they never exceed safe storage temperatures, and the blood is rapidly warmed during transfusion.

Using the STRAC infrastructure, a product rotation system for optimal use of WB units to minimize waste has been established. Freshly packaged units of WB are distributed to participating EMS units and outlying lower-tiered trauma centers that do not use the product as frequently. Once a unit of WB at a low-use site has reached an age of 14 days, it is reallocated to a high-use trauma center, where it is more likely to be used and not wasted. Newly packaged units are then redistributed to the low-use sites to maintain appropriate levels. This system has minimized the WB waste in the STRAC region to as low as 2%.⁴⁶

Initially, only helicopter EMS units were supplied with prehospital WB. Following the success of the STRAC prehospital program, ground EMS units were then incorporated into the WB distribution process. As the local system gained experience with the logistics of prehospital WB administration, selected rural trauma centers were also then included in the program. Transfusion criteria were developed by all parties involved in the STRAC prehospital WB program. The criteria consist of a set of injury and physiologic parameters that have been chosen to maximize identification of patients who will benefit from transfusion while minimizing the number of unnecessary transfusions.⁴⁶

The STRAC infrastructure has facilitated the ability to track outcomes for patients who are transfused with WB in the prehospital setting. Tracking clinical outcomes allows for continuous refinement of the transfusion practices associated with the prehospital WB program. As civilian prehospital WB programs evolve, these program elements will be essential to optimize care and resource utilization.

TOWARD A CIVILIAN WBB: PLANNING FOR DONATION AND DELIVERY DURING AN MCI

The Southwest Texas Whole Blood Consortium, a component of the STRAC, has developed the largest network of both prehospital and in-hospital use of cold-stored low-titer O-positive whole blood (LTOWB) in the United States. Currently, LTOWB is supplied by STBTC via a program known as “Brothers in Arms.” The Brothers in Arms program

consists of 4000 preidentified, low-titer (<1:256 anti-A anti-B) O-positive male donors who regularly donate to maintain a readily available stock of LTOWB across the 22 counties of Trauma Service Area P. These donors routinely present to one of seven STBTC donation centers when they are notified of a need for LTOWB. Of the 4000 available donors, 400 donors give blood frequently. Thanks to this reliable donor pool, STBTC is able to maintain 30 units of cold-stored LTOWB on its shelves at all times as well as provide LTOWB to trauma centers, first responders that use rotary wing, and ground EMS units, totaling approximately 80 units available at all times within the STRAC region. Across our trauma system, clinical variables are tracked for all trauma patients who receive prehospital transfusion including demographic data, hemodynamic data in the prehospital and inpatient setting, and incidence of transfusion reaction (captured at each of the two Level 1 trauma centers, which are enabled to provide retrospective crossmatching), as well as outcomes data to include mortality.

Upon establishing the rotation system, STRAC, STBTC, and members of the Southwest Texas Whole Blood Consortium were able to create an MCI plan for delivery of cold-stored LTOWB in San Antonio and the surrounding area. This plan, which has been in place since 2018, involved the delivery of 30 units of cold-stored LTOWB via helicopter to any MCI scene within flight distance. Upon notification of an MCI, STBTC loads and delivers shipping containers with its current stock of LTOWB. The LTOWB is arranged in a temperature-controlled (1-6°C), 5-unit shipping container. This allows a single shipping container to be opened and the blood transfused at the MCI site while maintaining temperature control of the remaining shipping containers until the units are used or returned. The six “5-pack” shipping containers are packed in a larger single container and loaded onto a helicopter and flown to the scene or staging area designated by the MCI commander. At this time, no units have been dispatched in the context of an MCI; however, these units were made available and offered during a recent MCI in Odessa and Midland, Texas.

To serve a large-scale MCI or provide support to surrounding trauma regions across Texas, we have created a WBB that would allow large volumes of WB to be collected and transported across Texas in times of calamitous need. STRAC’s MEDCOM communication center serves as the hub for activating regional mutual aid resources, and the MCI WB protocol is included in the steps that occur after an MCI is declared. Anytime an EMS agency declares an MCI, defined as an incident that overwhelms local resources, the MCI protocol is initiated. STRAC also serves as the state coordinating office for the Texas Emergency Medical Task Force (TX EMTF), which is the state’s response system for medical disasters. The TX EMTF has field hospitals, ambulance buses that can carry 20 patients, hundreds of ambulances, and teams of emergency medicine physicians and

nurses that can respond on a moment's notice. STRAC is the activation process for these assets across the state, after the decision is made to activate them by the state of Texas. Anytime a large-scale incident occurs anywhere in Texas, the TX EMTF state coordinating office is aware and can intervene to launch the WB MCI protocol.

Upon activation of this MCI protocol, a text message will be sent to the Brothers in Arms donors requesting that they present to their local donation center. STBTC will send additional supplies via ground transportation to these designated collection centers and send a liaison to the Regional Medical Operations Center at STRAC. When these donors arrive at their local collection center, they will be evaluated for eligibility. If the prescreened donor has provided two acceptable blood donations over the preceding 6 months, their blood will be made available for transfusion before all infectious disease testing is complete via the emergency release protocol and tested after transfusion. A safety monitoring system is already in place following existing military protocol. If the donor has not met the aforementioned criteria, the collected blood will be cooled and undergo standard infectious disease testing before delivery to hospitals. The medical and/or transfusion service directors for the receiving transfusion services are required to authorize the receipt and distribution of emergency release blood products from STBTC in accordance with standard practices. Warm WB from reliable donors who meet the 6-month acceptable donation criteria will be transported by San Antonio Fire Department response vehicles to the local Level 1 and Level 3 trauma hospitals for immediate use. Ambulance strike teams will also be deployed to transport WB to hospitals closest to the MCI. As this plan continues to undergo testing at the local level, we anticipate having the ability to transport WB to a predesignated airfield where the freshly collected WB can be transported directly to another part of Texas through existing flight contracts.

To further aid in ensuring safety with regard to transfusion reactions, WB units sent to the scene or region of an MCI will include our STRAC regional paperwork used to track prehospital transfusion. This documentation, which includes instructions on blood bag and blood tubing segment storage, instructs prehospital providers to ensure that the facility that receives the patient stores the blood bag and corresponding blood tubing segments. These supplies are crucial in the workup and management of transfusion-related incidents through retrospective crossmatching. Standard STRAC transfusion paperwork also contains details that instruct prehospital providers on the procedures to follow in the event of a suspected transfusion reaction. Just-in-time training for transfusion of prehospital blood is currently published on the STRAC.org/Blood Web site, where important clinical information and quick training videos are available. These videos and other information can be accessed on a smartphone or tablet, or from a conventional laptop/desktop. Transport time from San Antonio

to the remote destination ranges between 1 and 2.5 hours, so there is adequate time before the WB MCI package arrival to provide just-in-time training.

In rural Texas, this plan makes it possible to supply regional centers that lack the capability for emergent or large-volume blood transfusion (over 100 units in 4 hours). Simultaneously, STBTC will send their mobile blood donation units across San Antonio and Bexar County to collect blood from the community as needed. The reliability of the regional LTOWB donor pool and the success of the prehospital WB transfusion program have demonstrated the feasibility of this system. The South Texas WBB is an efficient and effective model that can be implemented in trauma systems across the nation to address transfusion needs for hemorrhaging patients during an MCI.

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