Use of Walking Blood Bank at Point of Injury During Combat Operations

A Case Report

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ABSTRACT

The US Military Tactical Combat Casualty Care guidelines recommend blood products as the preferred means of fluid resuscitation in trauma patients;, however, most combat units do not receive blood products prior to executing combat operations. This is largely due to logistical limitations in both blood supply and transfusion equipment. Further, the vast majority of medics are not trained in transfusion protocol. For many medics, the logistical constraints for cold-stored blood products favor the use of Walking Blood Bank (WBB), however few cases have been reported of WBB implementation at the point of injury during real world combat operations. This case report reviews one case of successful transfusion using WBB procedures at point of injury during combat. It highlights not only the feasibility, but also the necessity, for implementation of this practice on a larger scale.

KEYWORDS: *prehospital transfusion; fresh whole blood; walking blood bank*

Introduction

Fresh whole blood (FWB) transfusion has been a practice of Special Operations Forces (SOF) medicine since World War I, however most accounts of its use are anecdotal or historical.[1–4] Whole blood was actually the mainstay of resuscitation of trauma patients up until the Vietnam conflict, when crystalloid and component therapy became more common despite a lack of evidence to support this transition.[5–7] In recent years, the benefits of FWB transfusion over blood component, crystalloid, or colloid fluid therapy have been demonstrated in deployed surgical settings for hypovolemic trauma patients.[8–10] Additionally, blood transfusion has been shown to be associated with improved survival only when initiated within about 30 minutes of injury.[11]

Published cases of military prehospital FWB transfusion demonstrate the Walking Blood Bank (WBB) capability not at point of injury, but rather at the initial aid station.[12,13] The sparse documentation of successful prehospital FWB transfusion has created concern over the procedure's risks.

Recent US military combat experience as well as anticipated future scenarios highlight the need for early blood transfusion in austere and hostile settings prior to surgical team handoff.[14–20]

Case Presentation

A Special Forces Operational Detachment Alpha (SFODA) executed a night raid in the southwestern region of Afghanistan in 2018. The medics on the ground consisted of a US Army Special Operations Medical sergeant (18D), a combat medic (68W), and a US Air Force pararescueman (PJ).

At 2315L, one of the ground maneuver elements moved to breach a compound of interest when a barricaded shooter engaged the ground forces. This initial volley of fire resulted in two partner force Afghan commando casualties. The casualties were dragged away from the breach location and into a makeshift casualty collection point (CCP). At the same time, an enemy fighter threw a grenade inside the compound resulting in an additional casualty. The assault force and medics consolidated the three patients into a hasty CCP near the compound of interest and began initial assessments. Initial triage revealed two critically wounded patients, including the patient of interest (patient A) and one walking wounded.

Patient A's initial assessment revealed two penetrating gunshot wounds (GSWs): one to the superior right thigh with a presumed exit wound on the left lower back, and the second to the anterior left chest with a presumed exit on the superior aspect of the left posterior thorax at approximately the angle of the scapula. Patient A initially presented with Glasgow Coma Scale (GCS) scale of 14 with spontaneous eye opening, spontaneous verbal response, and localized pain. Radial pulses were strong and equal. External hemorrhage control was addressed first. The initial hemorrhage control attempt for the thigh wound consisted of a combat application tourniquet (C-A-T); however, the wound was too proximal for effective tourniquet application and hemostasis. The decision was then made to use a size 12 XStat (RevMed, https://www.revmedx.com/xstat/) syringe to inject hemostatic impregnated pellets into the wound cavity, and this intervention proved effective for achieving hemostasis. Afterward, the tourniquet was unfurled and left in place. A pressure dressing was then applied to the thigh wound and the 68W arrived and began applying occlusive dressings to the thoracic wounds.

After initial treatment, the ground force moved patient A to a safer CCP 400 meters away. Movement was complicated by danger close air strikes along with stream crossings while

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carrying the litter. At 2330, Patient A arrived at the second CCP and was reassessed. Vital signs revealed a decreased GCS score of 12, as the patient began sounding confused and eye opening was to speech only, radial pulses were weak and oxygen saturation was 89% on ambient air. Given the hypoxemia and known thoracic wound, a left needle thoracostomy was performed and hemorrhage control reassessed, which revealed a slow oozing at the superior right thigh wound. The team leader called for medical evacuation (MEDEVAC) while humeral and sternal intraosseous (IO) lines and an 18-gauge intravascular line were placed. The team leader initially informed the medics that there were 8 minutes until exfiltration, therefore vascular access was secured and the patient was packaged for transport.

After the patient was packaged for evacuation, the team leader discovered that the joint operations center had not received the nine-line MEDEVAC request. This meant there was at least 20 more minutes until exfiltration. At this point, patient A had a GCS of 11 and intermittent spontaneous respirations despite repeat bilateral needle decompression and was being supported with intermittent assisted ventilations. Radial pulses continued to be weak and thready. Due to the patient's deterioration, which was assessed to be most likely due to hemorrhage, the decision was made to initiate FWB transfusion.

Transfusion Procedure

At approximately 0010, one medic was assigned to confirm patient A's blood type and recruit suitable donors while another medic administered tranexamic acid (TXA) via humeral IO. Once a suitable donor was identified, the blood types of both donor and recipient were confirmed using their respective blood identification cards. Due to tactical constraints, including restricted illumination and ongoing enemy presence, an Eldon Card (Eldon Biological A/S, https://www.eldoncard.com/) test was not performed. However, it should be emphasized that premission donor screening and issuance of blood donor cards to both US military and Afghan partner forces, were enforced and the donor procedure rehearsed. The standard procedure was to use a type-specific donor and confirm blood type of both donor and recipient using the issued blood donor cards. The medic responsible to draw blood utilized a Fenwal Single Collection Blood-Pack Unit (McKesson, https://mms.mckesson.com/product/581929/Fenwal-4R3611) for the donor, as described in the Advanced Tactical Paramedic Protocols Handbook.[2] At 0016, FWB transfusion to patient A was flowing via sternal IO. Eight minutes later, half of the unit had been administered and MEDEVAC assets were on the ground. After administration of the half unit, vital signs had improved, respirations were back to 10–12 per minute with an improved pulse of 90 beats per minute (bpm). The team loaded patient A into the helicopter, conducted hasty handover, and continued with the mission.

Follow-on Care

The patient underwent a 12-minute MEDEVAC flight from point of injury to role 2 with attached forward surgical team (FST). During the flight, he was hypotensive with blood pressure estimated to be 60mmHg by palpation with a heart rate of 90 bpm and an oxygen saturation of 72% on ambient air. The blood transfusion was completed, and he underwent an additional needle decompression prior to arriving at the FST location. On FST arrival, his blood pressure was 124/80 and heart rate 115 bpm. He was noted to have penetrating wounds of the left upper quadrant of the abdomen, left flank and two wounds to the right upper thigh; a focused assessment with sonography for trauma (FAST) was positive for abdominal fluid. He immediately underwent exploratory laparotomy where he was found to have injuries to the spleen (grade 5), colon, and left hemidiaphragm necessitating splenectomy, partial colonic resection, washout of the left thorax, diaphragmatic repair, and temporary abdominal closure. He received 6 units red blood cells (RBCs) and 4 units fresh frozen plasma (FFP). After initial damage control surgery, he remained intubated and sedated and underwent an uneventful 1.5-hour transfer flight to the role 3 hospital.

On role 3 arrival, his blood pressure had improved to 135/71 with heart rate of 95 bpm. He was taken to the operating room where he underwent re-exploration of the abdomen, washout of the left chest, colon anastomosis, diaphragm repair, abdominal closure as well as right groin exploration and removal of X-stat sponges. He received an additional 1 unit pRBCs, 2 units fresh frozen plasma (FFP), and 1 unit apheresis platelets. He required ongoing wound and respiratory care, drainage of pleural and left upper quadrant fluid collections, and gradually improved. He was discharged from the role 3 after 18 days.

Discussion

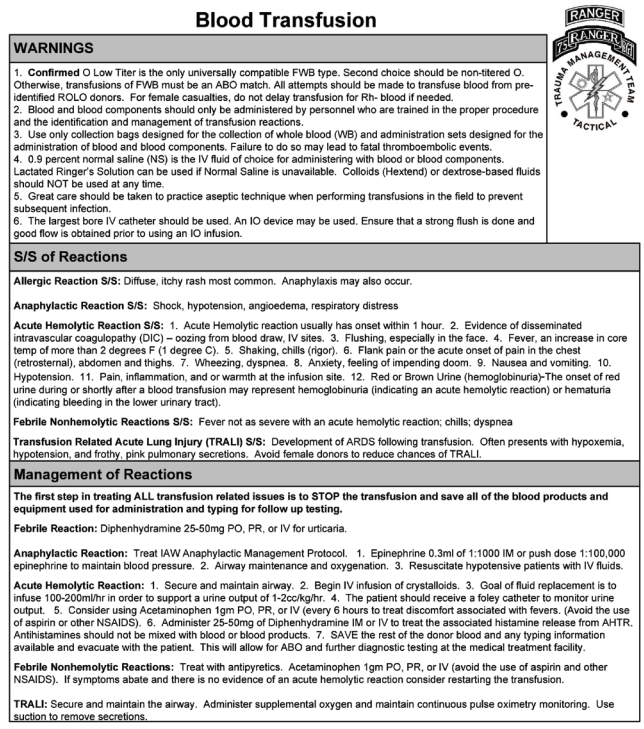
Hemorrhage is the leading cause of mortality from potentially survivable injuries on the battlefield, and most of these injuries are truncal (67.3%) followed by junctional (19.2%) and peripheral extremity (13.5%).[21] Even with advances in junctional hemorrhage control techniques, truncal hemorrhage control cannot be accomplished on the battlefield. Improving survivability on the battlefield requires managing the critically wounded using alternative techniques until they can reach a surgical capability.

United States military data support that prehospital blood product transfusion within about 30 minutes of injury improves survival from combat trauma.[11] This capability was initially implemented on MEDEVAC platforms in 2012, and then expanded to Special Operations medics for use at the point of injury beginning in 2014.[3,22]

The Ranger Regiment first implemented the capability for WBB procedures and FWB transfusion.[3] However, as the capability to carry cold-stored, universal donor low-titer group O whole blood (LTOWB) was successfully advanced, the implementation of WBB during real-world combat operations became a backup plan with questionable feasibility that has only rarely been executed.[18] However, a WBB FWB approach offers some advantages over cold-stored blood as it requires fewer items and less weight for the medic to carry and avoids the logistical challenges and extensive blood product wastage inherent to the use of cold-stored products (Figure 1). Additionally, FWB is associated with a survival advantage compared to blood component therapy.[8–10]

Currently there is a disparity between US military Special Operations and conventional forces for prehospital transfusion capability. Conventional units seeking to implement prehospital transfusion are faced with a limited supply of LTOWB as well as a formidable cost to purchase ruck-portable blood storage solutions and hand-held blood warmers for all medics. Due to such barriers, many units are investigating the feasibility of

FIGURE 1 *Blood transfusion.*



Blood Transfusion

WARNINGS

1. **Confirmed** O Low Titer is the only universally compatible FWB type. Second choice should be non-titered O. Otherwise, transfusions of FWB must be an ABO match. All attempts should be made to transfuse blood from pre-identified ROLO donors. For female casualties, do not delay transfusion for Rh- blood if needed.
2. Blood and blood components should only be administered by personnel who are trained in the proper procedure and the identification and management of transfusion reactions.
3. Use only collection bags designed for the collection of whole blood (WB) and administration sets designed for the administration of blood and blood components. Failure to do so may lead to fatal thromboembolic events.
4. 0.9 percent normal saline (NS) is the IV fluid of choice for administering with blood or blood components. Lactated Ringer's Solution can be used if Normal Saline is unavailable. Colloids (Hextend) or dextrose-based fluids should NOT be used at any time.
5. Great care should be taken to practice aseptic technique when performing transfusions in the field to prevent subsequent infection.
6. The largest bore IV catheter should be used. An IO device may be used. Ensure that a strong flush is done and good flow is obtained prior to using an IO infusion.

S/S of Reactions

Allergic Reaction S/S: Diffuse, itchy rash most common. Anaphylaxis may also occur.

Anaphylactic Reaction S/S: Shock, hypotension, angioedema, respiratory distress

Acute Hemolytic Reaction S/S: 1. Acute Hemolytic reaction usually has onset within 1 hour. 2. Evidence of disseminated intravascular coagulopathy (DIC) – oozing from blood draw, IV sites. 3. Flushing, especially in the face. 4. Fever, an increase in core temp of more than 2 degrees F (1 degree C). 5. Shaking, chills (rigor). 6. Flank pain or the acute onset of pain in the chest (retrosternal), abdomen and thighs. 7. Wheezing, dyspnea. 8. Anxiety, feeling of impending doom. 9. Nausea and vomiting. 10. Hypotension. 11. Pain, inflammation, and or warmth at the infusion site. 12. Red or Brown Urine (hemoglobinuria)-The onset of red urine during or shortly after a blood transfusion may represent hemoglobinuria (indicating an acute hemolytic reaction) or hematuria (indicating bleeding in the lower urinary tract).

Febrile Nonhemolytic Reactions S/S: Fever not as severe with an acute hemolytic reaction; chills; dyspnea

Transfusion Related Acute Lung Injury (TRALI) S/S: Development of ARDS following transfusion. Often presents with hypoxemia, hypotension, and frothy, pink pulmonary secretions. Avoid female donors to reduce chances of TRALI.

Management of Reactions

The first step in treating ALL transfusion related issues is to STOP the transfusion and save all of the blood products and equipment used for administration and typing for follow up testing.

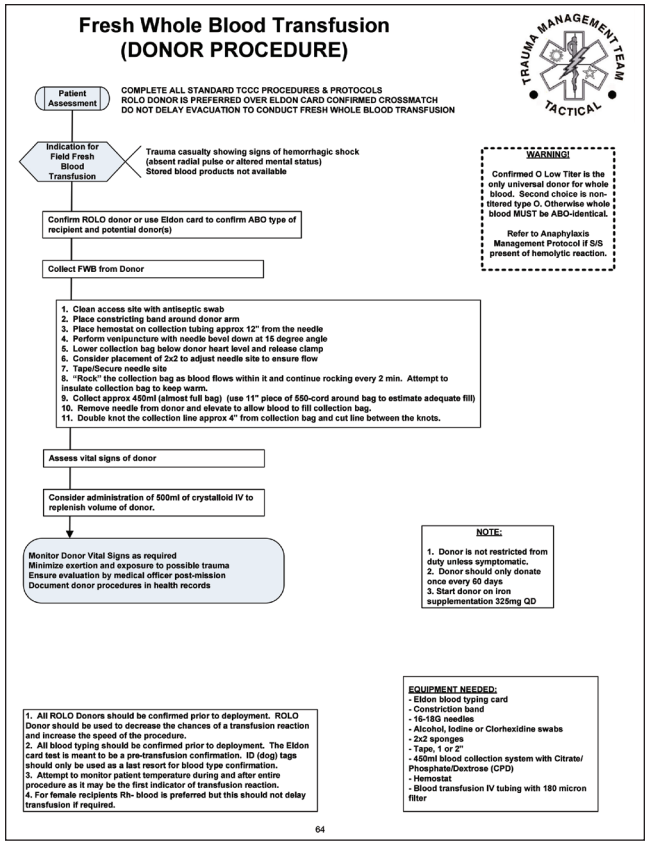
Febrile Reaction: Diphenhydramine 25-50mg PO, PR, or IV for urticaria.

Anaphylactic Reaction: Treat IAW Anaphylactic Management Protocol. 1. Epinephrine 0.3ml of 1:1000 IM or push dose 1:100,000 epinephrine to maintain blood pressure. 2. Airway maintenance and oxygenation. 3. Resuscitate hypotensive patients with IV fluids.

Acute Hemolytic Reaction: 1. Secure and maintain airway. 2. Begin IV infusion of crystalloids. 3. Goal of fluid replacement is to infuse 100-200ml/hr in order to support a urine output of 1-2cc/kg/hr. 4. The patient should receive a foley catheter to monitor urine output. 5. Consider using Acetaminophen 1gm PO, PR, or IV (every 6 hours to treat discomfort associated with fevers. (Avoid the use of aspirin or other NSAIDS). 6. Administer 25-50mg of Diphenhydramine IM or IV to treat the associated histamine release from AHTR. Antihistamines should not be mixed with blood or blood products. 7. SAVE the rest of the donor blood and any typing information available and evacuate with the patient. This will allow for ABO and further diagnostic testing at the medical treatment facility.

Febrile Nonhemolytic Reactions: Treat with antipyretics. Acetaminophen 1gm PO, PR, or IV (avoid the use of aspirin and other NSAIDS). If symptoms abate and there is no evidence of an acute hemolytic reaction consider restarting the transfusion.

TRALI: Secure and maintain the airway. Administer supplemental oxygen and maintain continuous pulse oximetry monitoring. Use suction to remove secretions.



Fresh Whole Blood Transfusion (DONOR PROCEDURE)

Patient Assessment

COMPLETE ALL STANDARD TCCC PROCEDURES & PROTOCOLS
ROLO DONOR IS PREFERRED OVER ELDON CARD CONFIRMED CROSSMATCH
DO NOT DELAY EVACUATION TO CONDUCT FRESH WHOLE BLOOD TRANSFUSION

Indication for Field Fresh Blood Transfusion

Trauma casualty showing signs of hemorrhagic shock (absent radial pulse or altered mental status)
Stored blood products not available

WARNING!

Confirmed O Low Titer is the only universal donor for whole blood. Second choice is non-titered type O. Otherwise whole blood MUST be ABO-identical.

Refer to Anaphylaxis Management Protocol if S/S present of hemolytic reaction.

Confirm ROLO donor or use Eldon card to confirm ABO type of recipient and potential donor(s)

Collect FWB from Donor

1. Clean access site with antiseptic swab
2. Place constricting band around donor arm
3. Place hemostat on collection tubing approx 12" from the needle
4. Perform venipuncture with needle bevel down at 15 degree angle
5. Lower collection bag below donor heart level and release clamp
6. Consider placement of 2x2 to adjust needle site to ensure flow
7. Tape/Secure needle site
8. "Rock" the collection bag as blood flows within it and continue rocking every 2 min. Attempt to insulate collection bag to keep warm.
9. Collect approx 450ml (almost full bag) (use 11" piece of 550-cord around bag to estimate adequate fill)
10. Remove needle from donor and elevate to allow blood to fill collection bag.
11. Double knot the collection line approx 4" from collection bag and cut line between the knots.

Assess vital signs of donor

Consider administration of 500ml of crystalloid IV to replenish volume of donor.

Monitor Donor Vital Signs as required
Minimize exertion and exposure to possible trauma
Ensure evaluation by medical officer post-mission
Document donor procedures in health records

NOTE:

1. Donor is not restricted from duty unless symptomatic.
2. Donor should only donate once every 60 days
3. Start donor on iron supplementation 325mg QD

EQUIPMENT NEEDED:
- Eldon blood typing card
- Constriction band
- 16-18G needles
- Alcohol, Iodine or Clorhexidine swabs
- 2x2 sponges
- Tape, 1 or 2"
- 450ml blood collection system with Citrate/Phosphate/Dextrose (CPD)
- Hemostat
- Blood transfusion IV tubing with 180 micron filter

1. All ROLO Donors should be confirmed prior to deployment. ROLO Donor should be used to decrease the chances of a transfusion reaction and increase the speed of the procedure.
2. All blood typing should be confirmed prior to deployment. The Eldon card test is meant to be a pre-transfusion confirmation. ID (dog) tags should only be used as a last resort for blood type confirmation.
3. Attempt to monitor patient temperature during and after entire procedure as it may be the first indicator of transfusion reaction.
4. For female recipients Rh- blood is preferred but this should not delay transfusion if required.

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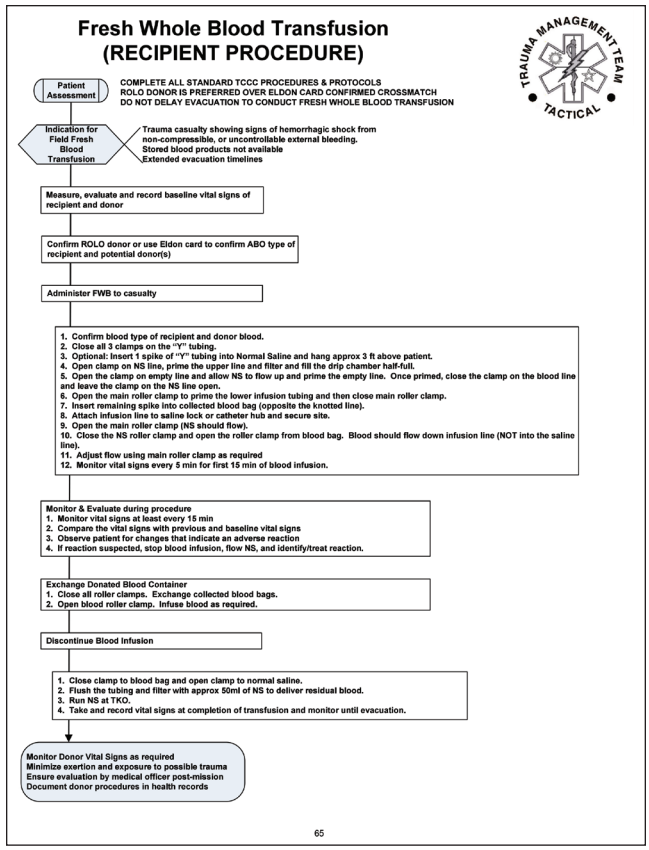

Fresh Whole Blood Transfusion (RECIPIENT PROCEDURE)

Patient Assessment

COMPLETE ALL STANDARD TCCC PROCEDURES & PROTOCOLS
ROLO DONOR IS PREFERRED OVER ELDON CARD CONFIRMED CROSSMATCH
DO NOT DELAY EVACUATION TO CONDUCT FRESH WHOLE BLOOD TRANSFUSION

Indication for Field Fresh Blood Transfusion

Trauma casualty showing signs of hemorrhagic shock from non-compressible, or uncontrollable external bleeding.
Stored blood products not available
Extended evacuation timelines

Measure, evaluate and record baseline vital signs of recipient and donor

Confirm ROLO donor or use Eldon card to confirm ABO type of recipient and potential donor(s)

Administer FWB to casualty

1. Confirm blood type of recipient and donor blood.
2. Close all 3 clamps on the "Y" tubing.
3. Optional: Insert 1 spike of "Y" tubing into Normal Saline and hang approx 3 ft above patient.
4. Open clamp on NS line, prime the upper line and filter and fill the drip chamber half-full.
5. Open the clamp on empty line and allow NS to flow up and prime the empty line. Once primed, close the clamp on the blood line and leave the clamp on the NS line open.
6. Open the main roller clamp to prime the lower infusion tubing and then close main roller clamp.
7. Insert remaining spike into collected blood bag (opposite the knotted line).
8. Attach infusion line to saline lock or catheter hub and secure site.
9. Open the main roller clamp (NS should flow).
10. Close the NS roller clamp and open the roller clamp from blood bag. Blood should flow down infusion line (NOT into the saline line).
11. Adjust flow using main roller clamp as required
12. Monitor vital signs every 5 min for first 15 min of blood infusion.

Monitor & Evaluate during procedure
1. Monitor vital signs at least every 15 min
2. Compare the vital signs with previous and baseline vital signs
3. Observe patient for changes that indicate an adverse reaction
4. If reaction suspected, stop blood infusion, flow NS, and identify/treat reaction.

Exchange Donated Blood Container
1. Close all roller clamps. Exchange collected blood bags.
2. Open blood roller clamp. Infuse blood as required.

Discontinue Blood Infusion

1. Close clamp to blood bag and open clamp to normal saline.
2. Flush the tubing and filter with approx 50ml of NS to deliver residual blood.
3. Run NS at TKO.
4. Take and record vital signs at completion of transfusion and monitor until evacuation.

Monitor Donor Vital Signs as required
Minimize exertion and exposure to possible trauma
Ensure evaluation by medical officer post-mission
Document donor procedures in health records

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implementing a WBB capability for combat medics.[23] Such a capability is labor intensive in terms of prescreening donors as well as training and skill sustainment of medics; however, the WBB solution may be more achievable than cold-stored products for widespread implementation across the Force.

An argument against WB field transfusions is the possibility of transfusion reaction and transmitted disease. The most lethal transfusion reaction is a blood type mismatch, which is potentially fatal, albeit rare. Type-specific transfusions carry the risk of type mismatch, particularly in multicasualty situations, and should be utilized only in dire circumstances when group O donors are depleted. Current military prehospital guidelines specify the use of group O donors for all, preferably confirmed low titer.[24,25] Rh match is not necessary.[3,15,26] Transfusion protocols give medics protocol-based steps for treating transfusion reactions, however transfusion reaction is difficult to differentiate from hemorrhagic shock and is rarely diagnosed. [2,27,28] In the circumstance in which a field WB transfusion is performed, the risk of death from hemorrhage far outweighs the rare possibility of transfusion reaction or disease transmission.

Tactical considerations also must come into play when discussing prehospital transfusion. The standard equipment load of a SOF medic is variable depending on the mission set. In current operations, more often than not, SOF medics execute raids in which equipment must be as light and streamlined as possible. The supplies required for safe execution of FWB transfusion, as demonstrated in this case, are minimal and include only the collection bag, one pair of hemostats, scissors, appropriate lab materials, and standard resuscitation materials universally carried by combat medics (Table 1). The additional WBB supplies add no more than 18 ounces, versus the average 60 ounces required to carry cold-stored WB in the proper container along with a warming unit.

In the case presented, the entire procedure from start of donor draw to end of recipient transfusion spanned 15 minutes. Only one unit was transfused prior to role 2 arrival, along with external hemorrhage control. Both helped stabilize the casualty's

TABLE 1 *Fresh Whole Blood Transfusion Packing List*

1. Fresh Whole Blood Transfusion Packing List[26]
2. FDA-approved blood collection bag (Fenwal [McKesson] bag used)
3. Blood administration set (either Y type or straight line with 170- to 260-µm filter)
4. 2 × clamps for bloodline (mosquito forceps used)
5. Normal saline (100mL bag used)
6. Intravenous (IV) catheter × 2 (18-G used)
7. Alcohol prep pads × 2
8. Eldon blood typing kit × 2
9. PRN adapter (needless saline lock)
10. 550 cord (9.5 in)
a. Anaphylaxis medications
b. Diphenhydramine intramuscular (IM)/IV
c. Epinephrine 1:1000 IM/IV
d. Ranitidine IM/IV
11. Decadron
12. Tape
13. Op-Site/Tegaderm
14. Constricting band
15. 18-gauge needle

vital signs. With proper training and familiarization, the ability to execute the WBB procedure rapidly and safely is practical, especially when donors' blood types are preidentified. Transfusion of relatively small volumes of a warm, fresh whole blood product provides an optimal resuscitation intervention to bleeding casualties and may bridge casualties to evacuation and damage control surgery. This is especially relevant in cases where hemorrhage control can be achieved with prehospital interventions.

Conclusion

Uncontrolled hemorrhage prior to reaching damage control surgical care contributes disproportionately to battlefield mortality. Resuscitation from hemorrhagic shock requires blood products, however there are significant logistic barriers to carrying cold-stored blood products to the point of injury. The WBB capability is a lightweight and rapid method to provide medics with FWB, enable early resuscitation, and improve survival from severe traumatic injury. This capability should be expanded to all military medics, and medic training must include WBB with goal-directed tactical damage control resuscitation. These skills should be considered standard for all combat medics across the Department of Defense (DoD)

Disclosures

The authors declare that they have no competing interests.

Disclaimer

The opinions or assertions contained herein are the private views of the authors and not to be construed as official or as reflecting the views of the Defense Health Agency or the Department of Defense. Public affairs office and operational security reviews were conducted by the Defense Health Agency.

Authorship Contributions

MG and AF conducted the mission and collected the documentation. MG and VH drafted the manuscript. SS provided the role 2 and 3 follow-up, reviewed all documentation and edited the manuscript. All authors read and approved the final manuscript.

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Dedicated to the Indomitable Spirit, Lessons Learned & Sacrifices of the SOF Medic

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