Prolonged Field Care and Fresh Whole Blood

A required capability in the future operating environment

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20XX: Islands off the coast of the fictional country of Sembatu. You are the battalion commander tasked with seizing and retaining islands in support of Operation LITTORAL RESOLVE II. These islands are critical to setting conditions for follow-on actions in the naval campaign. Seizing the islands has been rough; however, the Navy's ability to create seams in the enemy's anti-access/area denial system facilitated multiple vertical and small boat assaults, which allowed the battalion to accomplish its mission.

What was not foreseen was the fog of war. The enemy launched a massive counterattack on amphibious shipping using advanced anti-ship cruise missiles after creating gaps in the electromagnetic spectrum. The Navy took damages, including the loss of two destroyers, forcing it to egress the amphibious objective area.

As your operations officer issues orders, your early-warning radar detects incoming missiles. Forty seconds later, they impact, and Echo Company reports five killed in action (and eight wounded in action, four of which are urgent.) You send medevac nine-lines to the landing force operations center. The commander landing force calls and explains that the Navy believes it will take 48 hours to set conditions for an electronic attack corridor for casualty evacuation (casevac).

Your medical officer informs you that with the amount of hemorrhaging these Marines have sustained, they have little chance of survival with only the saline solution that is presently available. Whole blood replenishment is required; unfortunately, the nearest blood is located at the blood bank at the hospital ward aboard the USS Essex.

You know these wounded Marines are likely to die. You instruct your medical officer to do all he can. You order Marines to dig in and prepare for the next attack, knowing that you have one heck of a fight ahead of you.

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Prolonged Field Care in the Future Operating Environment

What the above scenario described is but one example of the type of battlefield in which the Marine Corps may find itself in the future operating environment and is one where the so called "golden hour" just does not exist. The fictional battalion commander has little recourse at this point and must accept the casualties. It is simply not worth the risk to the air crews to attempt a tactical evacuation, and any unmanned aerial vehicles designated for casevac (yet to be developed) are also likely to be destroyed if they operate in the weapons engagement zone.

Prolonged field care is a contingency model of tactical medical care for extending survival timelines of critically injured patients in austere environments when tactical evacuation is delayed beyond doctrinal timelines. Plainly stated, it is how you keep a wounded Marine alive when you need to get him to a higher level of care as quickly as possible but cannot do so.

Prolonged field care is not just a nice-to-have; in the future operating environment, it will become a requirement. Expeditionary advanced basing operations (EABO) are predicted to pose complex challenges to casevac timelines that contrast starkly with the wars in Iraq and Afghanistan, including disputed air superiority, advanced enemy threat systems complicating air and ground mobility, the encumbrances of cyberwarfare, and the scale of operations throughout isolated or arduous terrain. The MAGTF or the naval task force commander will to have balance operational priorities with casevac and

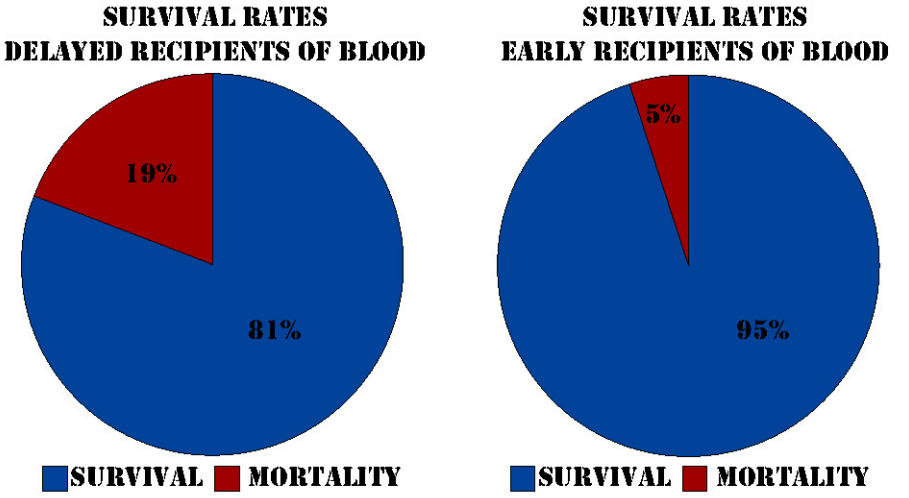

Figure 1. Difference in survival of delayed versus early recipients of FWB. *(Figure provided by author.)*

may be unable to reduce the risk of evacuation to an acceptable level in many situations.

A Marine infantry battalion must have the capability to conduct prolonged field care in the future operating environment, as the golden hour is not a safe assumption. What follows is an explanation of why the Marine Corps needs this capability and why it is not present already, as well as a description of a proof of concept that has demonstrated the feasibility of attaining it.

The Need for an Emergency Fresh Whole Blood Transfusion Capability

Prolonged field care requires multiple skill sets; however, the most critical to the company corpsman is the ability to resuscitate a patient with fresh whole blood (FWB). FWB is drawn from a prescreened donor and transfused immediately to the patient. This is in contrast to "stored whole blood" and components of blood (i.e., red blood cells, platelets, or plasma), which require a larger logistical footprint such as refrigeration, laboratory equipment for processing, and storage under tightly regulated conditions. An emergency FWB transfusion program prescreens suitable donors ahead of time for safe characteristics of their blood (i.e., Group O with low levels of reactive antibodies and screening for absence of transmittable infections). These donors are clearly identified and then called upon in an emergency to give blood in the pre-hospital environment, which may be safely transfused regardless of the patient's blood type.

The #1 Cause of Preventable Death

From the wars in Iraq and Afghanistan (2001–2011), 91 percent of preventable deaths were caused by hemorrhages.[1] This equates to 888 lives lost to potentially survivable wounds, or approximately one infantry battalion. When treating for hemorrhage, the most important first step is to stop the bleeding, and then the patient must receive replacement for the lost blood as soon as possible.

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A Time-Critical Intervention

An important retrospective study that compared mortality rates between hemorrhagic shock patients in Afghanistan was recently published. The study compared the outcomes of those patients who received blood while en route to hospital care to those who received blood upon arriving at the hospital or not at all. Those who received blood within the *first 36 minutes of injury* had dramatically reduced mortality rates. Within 24 hours, 19 percent of those unable to receive immediate blood replenishment succumbed to their injuries. Conversely, those who did receive blood within that 36-minute window experienced a mortality rate of only 5 percent.[2] Stated differently, the odds of death from hemorrhagic shock were nearly 1 in 5 without timely FWB replenishment, yet when the patient received FWB in the first 36 minutes, the odds of death dropped to 1 in 20. The speed with which hemorrhaging patients receive FWB unquestionably correlates directly to their survival rate.

The golden hour was the guiding milestone throughout the wars in Iraq and Afghanistan. However, this study illuminates another important milestone: a 36-minute window in which a critical life-saving intervention must be made, without which the patient is nearly four times more likely to succumb to his injuries. Given the complexities of EABO and the future operating environment, casevac to a higher-level facility within this 36-minute window is not an assumption that future commanders should make. Further demonstrating the unforgiving imperative of time, a different study shows that the *mortality rate rises five percent for each minute that transfusion is delayed.*[3]

Historical Context

Field blood transfusions were common in World War II and to a lesser extent in the Korean War. Based on blood type identification by dog tags, blood could be transfused to wounded personnel near the front lines. However, the process was imperfect, and concerns about lethal transfusion reactions and transfusion-transmittable infections led to a decline of this process in the field. Blood transfusions gravitated to Role Two facilities, where more extensive laboratory testing and controlled environments mitigated those risks. By the Vietnam conflict, corpsmen and medics were primarily carrying crystalloid fluids (e.g., normal saline), which were helpful in treating the vast number of heat casualties experienced in that

theater. However, the efficacy of these crystalloid fluids in the treatment of hemorrhagic shock patients would not be widely challenged for decades.

The medical community has since become increasingly aware that crystalloid fluids are actually harmful to the hemorrhaging patient. These fluids contribute to hypothermia, coagulopathy, and acidosis—three components of the "lethal triad," a self-reinforcing condition that worsens shock and often leads to death. The lethal triad is best countered by whole blood, which is now recommended by the Committee on Tactical Combat Casualty Care as the best fluid for the hemorrhagic patient.[4] Unfortunately for the conventional Marine infantryman, crystalloid fluids remain the mainstay of battalion aid stations and company corpsmen who are not trained in emergency blood transfusion.

Proven Solutions from the Special Operations Force Community

The special operations force (SOF) community has actively addressed this issue through a variety of initiatives. However, perhaps the most notable and relevant to the Marine Corps GCE is the U.S. Army 75th Ranger Regiment's "ROLO," or Ranger O Low Titer program.[5] The Rangers have trained their medics to successfully and safely transfuse a patient with FWB that is donated from a fellow Ranger near the point of injury. Every Ranger is now trained to safely collect blood from prescreened Group O Ranger donors. Every Ranger medic is trained to conduct the transfusion to the patient. The Rangers have reported the ability to initiate blood transfusion near the point of injury in as little as twelve minutes. This successful program has been replicated throughout every branch within the SOF community and within many allied nation SOF units.

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The SOF medic has a baseline level of training that far exceeds that of the general duty line corpsman serving within a Marine infantry battalion. Yet, only the line corpsman bears the potential capability of initiating a blood transfusion within the tight time constraints demanded by a hemorrhaging patient in conventional Marine units.

All of this begs the question: Can this program be successfully replicated within the Marine division and executed safely by general duty corpsmen?

Marines and Sailors donate blood to the ASBP. *(Photo by Cpl Leynard Kyle Plazo.)*

The 2d Battalion, 5th Marines Proof of Concept

2/5 set out to demonstrate this capability as a proof of concept for a Marine infantry battalion in November 2017. Achieving this end state required four major milestones:

Establishing a donor pool. Through coordination with the Armed Services Blood Program (ASBP) at Navy Medical Center San Diego and Naval Hospital Okinawa, our medical team organized a series of blood drives targeting a list of potential Group O low titer blood donors within the battalion. The battalion provided blood donations to the ASBP, which in turn provided the requisite laboratory testing of our donors to ensure strict compliance with established protocols.[6] The goal was to establish no less than ten percent of each company as donors.

Over two months, three major blood drives yielded 159 satisfactory blood donors (17 percent of the battalion) who could subsequently be used for emergency collection. Among the three rifle companies, twenty percent were eligible donors.

This data translates directly into a medical asset that is gained at minimal expense and weighs next to nothing in the ruck sack. The company commander can now step off with roughly 36 units of organically available blood that can be drawn upon to save a Marine's life in an emergency.

Equipment acquisition. Equipment was open-purchased with unit funds and includes two types of medical equipment sets. A "collection kit" is issued to each successfully screened donor to be carried in his individual first aid kit. The collection kit enables the collection of one unit of whole blood (about one-half liter). Each corpsman who has been trained in emergency whole blood transfusion is issued one or more "transfusion kits." The transfusion kit contains all the items required for the corpsman to administer that collected blood to a patient.

As an initial purchase, 80 collection kits and 75 transfusion kits were pur-

A Valkyrie instructor (far right) assists the students in troubleshooting a blood line during a training scenario at Camp Pendleton, CA. *(Photo by Cory Wier.)*

chased for the purposes of initial training and demonstration of capability. The open purchase request was made for under $5,000.[7]

Program development. Our program and protocols were modeled after the well-established ROLO program with assistance from the Ranger regiment medical staff. Additionally, blood banking specialists from I MEF, II MEF, and the ASBP in San Diego and Okinawa contributed from their experiences to enrich the program.

The Valkyrie Training Program. The 2/5 medical team created a comprehensive training program designed to develop the knowledge base and refine the preexisting skill sets of our corpsmen. Furthermore, it ensured that corpsmen understood the critical elements and contingency responses associated with emergency FWB transfusion. The Valkyrie Training Program is named after the mythological Norse angels of war who soared over the ancient battlefields with the ability to determine whom among the fallen would be carried to Valhalla and who would be restored to life.

The Valkyrie Training Program is structured in a training and readiness (T&R) format and consists of the complete range of topics necessary to safely and efficiently perform field blood transfusions. In its initial form, the syllabus included eight academic modules, six practical-application scenarios, self-study assignments, oral and written examinations, and a final capstone evaluation.

Fourteen corpsmen commenced the initial training in July 2017, and over the following weeks, twelve would complete the training satisfactorily.

Testing during 31st MEU Amphibious Integration Training

Aboard the USS *Wasp*, our first prefield rehearsal was conducted, and I underwent a live autologous transfusion to demonstrate corpsman capability. Autologous transfusion, or auto-transfusion, permits whole blood collection and transfusion to be practiced safely. Collected blood from a donor is immediately transfused back to the same person who transitions to role-playing a patient. Subsequent field demonstration was conducted as part of a tiltrotor-borne raid during Amphibous Integration Training. During the 90-minute raid, a four-person foot-mobile battalion aid station forward element was inserted with Fox Company. Two cherry pickers (one of which included the battalion commander) underwent live auto-transfusion. Collection and transfusion for both casualties were completed in the field within the 36-minute window.

Counter Points

This capability is already present at the shock trauma platoon (STP) and forward resuscitative surgical suite (FRSS). The STP and the FRSS are able to perform transfusions of FWB and component therapies. However, given the likely need for dispersion vice concentration, this capability will simply become over-

Demonstration of the 2/5 FWB proof of concept during AIT with the 31st MEU. *(Photo by LCpl Alexis Betances.)*

stretched, and there is a high probability that neither the FRSS nor the STP will be able to support all the separate nodes required in an EABO scenario. In the best of circumstances, casevac to these facilities will exceed the aforementioned 36-minute window. Providing blood closer to the point of injury will improve survival rates.

In a large-scale conventional conflict, the demand for readily available FWB will likely jeopardize existing Class VIIIB (medical) supply. A forward-capable Low Titer O Whole Blood program stands to reduce the demand experienced at the STP/FRSS (and, by extension, existing Class VIIIB supply chains) by reducing the units required by at least an equal number of units provided before arrival. The severity of the pathology of trauma worsens with time, and to reverse it requires even more blood. By providing blood closer to the time of injury, the patient is evacuated in better condition and is likely to require less total blood.

Requiring a donation from an infantryman in combat will reduce his combat effectiveness. The notion of reduced combat effectiveness by a blood donor who is an athletic individual is not supported by research. In a 2012 study, soldiers were tested by a treadmill stress test, pushups, and pull-ups; a 50-round rapid pistol–shooting test; and an uphill hiking exercise carrying a 20 kilogram backpack. After baseline testing, the soldiers performed the tests again, two to six minutes after donating 450 milliliters of blood. Researchers did not find any significant decrease in physical performance or shooting performance after donating the blood.[8] Repeating similar testing on civilians and staff officers was also demonstrated to have little to no effect on performance.

The L03A line corpsman (formerly 8404) is insufficiently skilled or trained to perform FWB transfusion. This is inconsistent with the proof of concept demonstrated by 2/5. All of the foundational skill sets required for the task lie squarely within the scope of the line corpsman's training. In my experience, corpsmen are generally eager to exercise these skill sets, which are too often underutilized.

The knowledge base required to safely conduct FWB transfusion requires additional training. The Valkyrie Training Program has been developed specifically for the general duty corpsman or medic.

Recommendations for Moving Forward

1. Medical officers must demand evidence-based solutions and make appropriate risk decisions for combat operations. Despite incontrovertible evidence supporting the use of emergency FWB, institutionally entrenched resistance and skepticism to implementation within the medical corps is common. General medical officers attached to infantry battalions must remain abreast of the current medical literature regarding remote damage control resuscitation and advise their ground commanders accordingly.[9] Informed ground commanders can create a strong demand signal, which will be noticed by senior leadership in policy-making positions.

2. Emergency FWB training should be codified and integrated into respective T&R manuals. Specifically, the Health Service Support T&R should be amended to include FWB training. An example framework is included in the Valkyrie Training Program's materials. Infantry T&R should be amended to include prolonged field care incorporated into 7000- and 8000-level codes for processing casualties.

3. Headquarters Marine Corps and the Navy Bureau of Medicine should consider adopting a formal course to ensure standardization and a quality of instruction that is vetted by the Committee on Tactical Combat Casualty Care. This course may serve as the initial training certification for medical providers attached to infantry battalions.

4. The development of a supporting structure must be established to ensure that medical providers maintain currency and proficiency in accordance with the T&R standards. The proposed model of initial training at a formal school and the subsequent enforcement of refresher training by regimental/division-level evaluators is suitable.[10]

5. The Inspector General of the Marine Corps should incorporate unit FWB program inspections into the Health Service Support functional area checklist to ensure compliance with donor safety programs. The Armed Services Blood Program should vet the checklist for compliance with governing regulations.

6. FWB transfusion is only the first of many steps that are required to adequately conduct prolonged field care appropriately. The further refinement and development of a prolonged field care syllabus is recommended.

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Conclusion

The next fight will require prolonged field care.[11] Time-critical emergency FWB transfusion in the field can stop the most common cause of preventable death on the battlefield.

If the Marine Corps is going to innovate for the future, it cannot assume that the way it fought the last war will be the same way it fights the next. Innovation does not have to come through a new, costly technological advancement. In this case, the future can be seen in the past—blood transfusing on the shores of Omaha Beach. The development of

FRSS-STP train with simulated patients to ensure personnel can perform component therapies and transfusions. *(Photo by SSgt Rebekka Heite.)*

FWB training toward the goal of developing a prolonged field care capability is a step that the Marine Corps and Navy would be foolish not to take.

Returning now to our scenario on the island off the coast of the fictional country of Sembatu:

The medical officer recommends drawing upon the list of 150-plus prescreened and approved blood donors. Two donors at a time are pulled from their tasks to contribute a unit of blood to save their fellow Marines' lives and then return to the defensive effort. The corpsmen collect the blood and immediately transfuse it to the wounded Marines. The wounded still require surgical care to save their lives, but the unit's preparation bought them some time. The Navy is working suppressing enemy air defense missions to get an MV-22 from the Essex ashore. Now, with these measures, these guys just might make it home.

Notes

1. Brian J. Eastridge, et al., "Death on the Battlefield (2001–2011): Implications for the Future of Combat Casualty Care," *The Journal of Trauma and Acute Care Surgery*, (Philadelphia, PA: December 2012).

2. 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 American Medical Association*, (Chicago, IL: October 2017).

3. David E. Meyer, et al., "Every Minute Counts: Time to Delivery of Initial Massive Transfusion Cooler and its Impact on Mortality," *The Journal of Trauma and Acute Care Surgery*, (Philadelphia, PA: July 2017).

4. Frank K. Butler, et al., "Fluid Resuscitation for Hemorrhagic Shock in Tactical Combat Casualty Care: TCCC guidelines change 14-01–2 June 2014," *Journal of Special Operations Medicine*, (St. Petersburg, FL: Fall 2014).

5. COL Andrew P. Cap, USA, et al., *Joint Trauma System Clinical Practice Guidelines: Whole Blood Transfusion (CPG ID: 21)*, (May 2018), available at jts.amedd.army.mil.

6. Russ S. Kotwal, et al., "Leadership and a Casualty Response System for Eliminating Preventable Death," *The Journal of Trauma and Acute Care Surgery*, (Philadelphia, PA: June 2017).

7. Donor/recipient kits are available through conventional supply chains (NSN 6515-01-664-0306 & 6515-01-663-9469). However, 2/5 open-purchased kits #680150 and #680151 through BoundTree Medical to be consistent with kits used by the Ranger Regiment, which are lighter weight, and donor collection kits that fit more easily into an individual first-aid kit.

8. Geir Strandenes, Hakon Skogrand, Philip C. Spinella, Tor Hervig, and Erling B. Rein, "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*, (Bethesda, MD: American Association of Blood Banks, June 2012); and Gier Strandenes, Joar Sivertsen, Hakon Skogard Eliassen, Haane Braathen, and Tor Hervig, "Staff Officers as Blood Suppliers: Effects of Repeated Donations and Autologous Reinfusions of Untransfused Units," *The Journal for Trauma and Acute Care Surgery*, (Philedelphia, PA: Lippincott, Williams & Wilkins, June 2018).

9. The Trauma Hemostasis and Oxygenation Research Group is a highly regarded network of specialists actively engaged in research of the use of FWB, and provides relevant physician information. Information available at www.rdcr.org.

10. The proposed model is similar to the current model of Joint Terminal Attack Controller training and progression, by which initial certification is completed at a formal school taught by Joint Terminal Attack Controller instructors and refresher training and advanced codes are supervised at the regimental/MEU level by Joint Terminal Attack Controller evaluators.

11. The Joint Trauma System Clinical Practice Guidelines are essentially medical doctrine for U.S. Forces. They are specifically designed for prolonged field care, emphasize this need, and illuminate a path for training our medical corps. These guidelines are viewable at https://jts.amedd.army.mil.

>Author's Note: The Valkyrie Training Program has subsequently been used to train more than 80 physicians and corpsmen operating across the MAGTF. The program materials may be downloaded at https://www.milsuite.mil/book/groups/valkyrie-emergency-blood-transfusion-training. Instruction sanctioned by the author is presently provided primarily at the Combat Trauma Management Course hosted by First Marine Division at Camp Pendleton, CA. For further inquiries, please contact the author via e-mail at russell.p.wier.mil@mail.mil or russell.wier@usmc.mil.