The Use of Fresh Whole Blood Transfusions by the SOF Medic for Hemostatic Resuscitation in the Austere Environment

SGM F Bowling, 18Z; COL Andre Pennardt, MD

The recommendations in this manuscript are only guidelines and are not a substitute for good clinical judgment.

The views and opinions expressed in this manuscript are those of the authors and do not reflect the official policy or position of the Army Medical Department, Department of the Army, the Department of Defense, or the U.S. government.

The leading cause of death on the battlefield is uncontrolled hemorrhage.[1,2] Non-compressible (truncal) hemorrhage is the cause over two thirds of these deaths.[3] This makes truncal hemorrhage the leading cause of potentially survivable death on the battlefield.[4] Over one third of the casualties who arrive at the Emergency Department (ED) or Combat Surgical Hospital (CSH) in need of a blood transfusion are already suffering from acute traumatic coagulopathy which is associated with an 80% mortality.[5-11] Early aggressive treatment and prevention of this coagulopathy through hemostatic resuscitation has been shown to increase survival.[5,6,8,12] Hemostatic resuscitation involves the very early use of blood and blood products as primary resuscitation fluids to both treat intrinsic acute traumatic coagulopathy and prevent the development of dilutional coagulopathy. Few, if any, of the products used in hemostatic resuscitation are currently available to the Special Operations Forces (SOF) medic. Warm Fresh Whole Blood (WFWB) transfusions could be a powerful tool for the SOF medic to use in order to begin hemostatic resuscitation in the field.

Part of the current standard of care for hemostatic resuscitation is the use of component therapy (CT).[13] CT involves targeted use of the various parts of blood, including red blood cells (RBCs), plasma, and platelets, that have been separated from a donated unit. A donated unit of blood is considered "whole blood" before it is separated into its components. The components are combined with anticoagulants and stored frozen or refrigerated prior to use in order to prolong their storage life. CT products need to be thawed and warmed in order to avoid causing or worsening hypothermia, which in turn inhibits clotting and has been shown to increase mortality.[14-26] The storage and administration considerations associated with the use of CT make it too logistically burdensome for the SOF medic and therefore not practical for the SOF operational environment.

Massive transfusion (MT) is generally defined as 10 or more units of blood in the first 24 hours after admission.[27] The most critically injured patients are the most likely to need a MT of blood.[28] The use of CT in MT has been shown to cause a myriad of complications that worsen the lethal triad of coagulopathy, acidosis, and hypothermia.[29-36] The increased use of blood products is associated with increased mortality.[37,38] This increase in mortality has been shown to be higher with blood products that have been stored longer.[38] The current clinical practice guideline (CPG) from the Joint Theater Trauma Registry (JTTR) and other authors recommend that CT products be used in a ratio identical to whole blood.[39-42] Several studies show improved outcomes using an equal or higher ratio of Fresh Frozen Plasma (FFP):Packed Red Blood Cells (PRBC).[3,9,40,43-55] One retrospective study found a 1:1.4 ratio of FFP to PRBCs to be independently associated with improved patient survival ($p<0.001$) and also recommended a 1:1 ratio of FFP:PRBCs.[6] WFWB has more clotting factors than CT and none of the associated storage problems.

The use of WFWB or "buddy transfusions" by the SOF medic is an appealing prospect. In contrast to civilian or military medical treatment facilities (MTFs) WFWB may be the only efficacious

resuscitation method available to combat coagulation disorders associated with hemorrhage.[56-58] The amount of equipment needed for WFWB transfusion is relatively small (Figures 1-4), thus making it logistically feasible for the SOF medic. The only additional equipment not normally carried by the SOF medic is a blood collection bag, blood administration set, and blood typing cards. The advantages of WFWB over CT are many (Table 1).[5,6,59]

Table 1 Side-by-Side Comparison of WFWB vs. Component Therapy.[5,6,59]

	Constituents	Temperature	Hematocrit (% of RBCs)	Platelets	Coag factor %	Amount of fibrinogen	Amount of anticoagulant & additives
WFWB	500ml WFWB	37° C	38-50%	150,000-400,000	100%	1500mg	63ml
Component Therapy	680ml Total 1U PRBC + 1U PLT + 1U FFP + 1 U cry	-30° to 0°C	29%	80,000	65% (of initial)	750mg	205ml

(Adapted from Kauvar, Holcomb, Borgman, et.al.)

While the use of a single unit of warm fresh whole blood may only be roughly equivalent in volume to a single unit of CT, there are additional factors to consider. As shown in Table 1, WFWB does not need to be warmed, has a higher concentration of RBCs, more platelets, 100% of its original clotting factors, and double the fibrinogen. All of these aid in the effectiveness of clotting and the transport of oxygen. A unit of WFWB also has fewer anticoagulants, which only worsen the coagulopathic condition you are trying to correct. The use of fresh whole blood (FWB) has been shown clinically to improve the ability of the blood to clot, and even reverse dilutional coagulopathy and provide a hemostatic effect comparable to ten units of platelets.[60, 61]

The Office of Medical History for the US Army Medical Department (AMEDD) has an extensive history of the U. S. blood program entitled, *The Blood Program in WWII*. It contains over 100 statements, citations from studies, meeting minutes, memorandums, and the like that unequivocally endorse the use of whole blood as part of the comprehensive treatment for patients requiring life saving transfusions.[62] These observations come from the years just prior to World War I through World War II and up to and including the Korean War. The fact that the use of FWB to treat hemorrhage in trauma patients is a controversial practice can only be attributed to a failure to study history or a significant misunderstanding of that history.[63-65] At the beginning of WWII a system was in place to provide both FFP and the more stable freeze dried plasma (FDP). Whole blood was thought to be highly desirable and efficacious, but logistically impractical. Despite the considerable logistical problems involved, the armed services of the United States decided to implement an unparalleled program of collection, and distribution in all theaters of operation in order to bring whole blood as far forward as possible because it was considered so beneficial. Consider this passage from *The Blood Program in WWII: Supplemented by Experiences in the Korean War*, by Douglas B. Kendrick, Brigadier General, MC, USA (1963).

> *"The rather general belief at the outbreak of the war that plasma alone could compensate for the loss of whole blood in shock simply reflected the prevailing point of view that blood loss was not necessarily the primary cause of shock. It is not easy, in looking back, to understand how these concepts were ever accepted, yet some of the most competent physicians in the country believed that plasma alone could compensate for the massive blood losses which occurred in trauma. It was a belief which did a disservice to the true and important role of plasma in the therapy of shock. Also, as pointed out*

elsewhere, many observers who believed that only whole blood was effective in shock did not believe that it would ever be practical to provide it for forward areas.

Attempts to transfer controlled laboratory studies to combat conditions led to confusion, as might have been expected, for they were based upon faulty premises. As Beecher[66] pointed out, the belief that plasma would be as effective as whole blood in the management of hemorrhagic shock seems to have been derived from laboratory experiments so set up that the number of variables could be strictly limited. There was, of course, no real resemblance between a combat Soldier who had suffered a serious wound or wounds and a rabbit lying quietly in its cage after experimental deprivation of 75 percent of its blood volume. The very management of the wounded Soldier, including his successive removal rearward from the battlefield through the chain of evacuation, produced additional trauma, which was further increased by physical and roentgenologic examinations, anesthesia, and operation. Transfer of laboratory conclusions to a combat situation with its additional and widely different variables was simply unsound reasoning, which led to therapeutic confusion."[62]

The use of FWB and WFWB have been recommended by several authors in various civilian and military circumstances and has been shown to be superior in animal studies and of potential clinical benefit.[13,59,61,65,68-78] During WWII, hundreds of thousands of units of whole blood were transfused in both battlefield and hospital environments and the rate of complications was comparable to those found in stateside civilian hospitals at the time.[62]

FWB administered at far forward aid stations was credited with increasing the survival rate of wounded troops in Vietnam.[79] FWB was collected and used successfully in Mogadishu, Somalia, during the Battle of the Black Sea.[56] Over 6,000 units of FWB were transfused from March 2003 to July 2007 in Iraq and Afghanistan.[65] One retrospective study that looked at 500 patients receiving massive transfusions found that the 24-hour and 30-day survival were higher ($p=0.018$ and $p=0.002$ respectively) in a group receiving FWB versus a group receiving CT.[77] The risk of transfusion reactions did not appear to increase with the use of FWB in Iraq and Afghanistan.[77]

The ability of the SOF medic to safely carry out the collection and administration of WFWB in an austere setting has been validated.[80] SOF personnel have used a training methodology at the Special Operations Combat Medic Skills Sustainment Course (SOCMSSC) since 2004 accounting for well over 105 practice sessions. The most common complications were an inability to use the collected blood because the bag was not full enough (approximately 15% incidence). A single case of suspected mild citrate toxicity was reported, presumably from an area of high citrate concentration within the blood that had not been fully mixed with the blood. It is thought that this area of high citrate concentration was infused into the patient when the bag was rolled in order to reinfuse the entire contents of the blood collection bag back into the patient. All of these errors can be eliminated with proper instruction and training in technique. WFWB transfusions were recently used by SOF personnel in North Africa to treat a seriously injured Soldier whose evacuation was delayed for several days.[57]

The challenge is to outfit SOF medics with the proper equipment and training in order to allow them to use this hemostatic resuscitation tool safely and effectively. The two major issues that must be addressed are the prevention of transfusion reactions and the transmission of bloodborne pathogens. The prevention of transfusion reactions is already addressed by the use of blood cards that can consistently provide an accurate blood type in less than ten minutes. The recently FDA approved ABORhCard® (Micronics, Inc., Redmond, WA) (Figure 7) can provide a low cost test the size of a credit card to accurately type blood in less than one minute.[81] The risk of transfusion reactions can also be lessened by using the whole blood crossmatch test as described in The Emergency War Surgery Manual.[82] Two separate efforts are currently underway to allow for rapid crossmatch testing in a small, lightweight test.[81, 83] While neither the Eldon® nor the Micronics® blood typing cards are intended for prescreening prior to transfusion, current DoD guidelines and a NATO agreement provide for the use of ID cards and ID tags in order transfuse whole blood during contingency operations.[84,85] The use of the blood typing cards is a safeguard to reduce the risk of a hemolytic reaction resulting from incorrect information from ID cards

and ID tags (estimated to be incorrect 1.2-11% of the time).[86-88] Several authors have recommended that stricter controls should be implemented during the production of ID cards and tags. It is also not entirely clear if the errors are attributable to self reporting or clerical errors, so cards and tags should only be produced using a laboratory test for reference. Another important aspect in reducing the risk of a crossmatch reaction is to educate medical providers about the erroneous notion of a "universal donor" for FWB.[82,89] The universal donor concept arose from the practice of calling PRBCs blood, when they are technically a blood component. While there is a universal donor for PRBCs, there is no universal donor for FWB.[58,90] Only type specific FWB must be given to avoid a hemolytic transfusion reaction (Figures 5 and 6).

In order to lessen the risk of viral transmission associated with FWB, rapid infectious disease screening tests are available that would not significantly increase the overall weight and cube space of the SOF medic's load. Retrospective testing of FWB unit screened with these tests revealed no false negatives, although the manufacturer only guarantees ranges between 98.2% and 99.4% among the various tests.[91] Donors should all be retrospectively screened IAW the JTTR Clinical Practice Guideline for FWB transfusion which states:

> *"Retrospective testing for infectious disease markers will be performed on all donor specimens. This testing will be completed at an FDA-approved, DoD-sanctioned laboratory in accordance with FDA/AABB standards of medical care.* ***Four EDTA and one red top tube will be collected for retrospective testing."***

There are currently efforts underway to develop a single, credit card sized test to rapidly rule out the presence of multiple bloodborne pathogens, which should make donor testing quicker and easier.[83]

There are several tactical and logistical factors that should be taken into account prior to deciding whether to perform a fresh whole blood transfusion in an austere environment. The decision making process that should be undertaken before undertaking this procedure is well beyond the scope of this article. The need of the patient, availability of supplies and trained personnel, and the evacuation time must be weighed along with the tactical situation before considering this procedure. It is suffice to say that the decision to perform a fresh whole blood transfusion should be made only after considering all of the possible consequences and weighing them against the benefit of the patient. Chief among these considerations should be the possible catastrophic results to the patient should a hemolytic reaction occur and the degradation to the performance of the donor. At no time should more than one unit if blood be collected from a single donor and the donor should be given 500ml of Hextend or similar fluid following donation.[65] The donor should also be in a position to perform light duty for at least 72 hours following donation. Current Army regulations mandate that aircrew personnel are restricted from performing flying duties for this same period of time following whole blood donation.[92] At no time should evacuation to a higher level of medical care, especially surgical care be delayed in order to perform a buddy transfusion, but the procedure could conceivable be carried out during TACEVAC in under 30 minutes depending on the medic's level of proficiency and experience with the procedure.

The strategy of hemostatic resuscitation has addressed a critical need for patients presenting to EDs and CSHs. However, there are few, if any, tools for the SOF medic to begin any form of hemostatic resuscitation prior to arrival at an MTF. Under the right circumstances, and with the implementation of proper training and safety measures, WFWB transfusions can be that tool.

References

1. Bellamy, R. F. (1984). The causes of death in conventional land warfare: implications for combat casualty care research. *Military Medicine*; 149:55-62.

2. Champion, H. R., Bellamy, R. F., et al. (2003). A profile of combat injury. *The Journal of Trauma*; 54:S13-19.

3. Holcomb, J. B., McMullin, N. R., et al. (2007). Causes of death in U.S. Special Operation Forces in the global war on terrorism: 2001-2004. *Annals of Surgery*; 245:986-991.

4. Kelly, J. F., Ritenour, A. E., et al. (2008). Injury severity and causes of death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003-2004 versus 2006. *The Journal of Trauma*; 64:S21-26; discussion S26-27.

5. Brohi, K., Singh, J., et al. (2003). Acute traumatic coagulopathy. *The Journal of Trauma*; 54:1127-1130.

6. Borgman, M. A., Spinella, P. C., et al. (2007). The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a combat support hospital. *Journal of Trauma*; 63(4):805-13.
7. Kaufmann, C. R., Dwyer, K. M., et al. (1997). Usefulness of thrombelastography in assessment of trauma patient coagulation. *The Journal of Trauma*; 42:716 –720: discussion 720–722.
8. Niles, S. E., McLaughlin, D. F., et al. (2008). Increased mortality associated with the early coagulopathy of trauma in combat casualties. *Journal of Trauma*; 64:1459–1463: discussion 1463–1455.
9. Hess, J., Holcomb, J., et al. (2006). Damage control resuscitation: the need for specific blood products to treat the coagulopathy of trauma. *Transfusion*; 46:685-686.
10. Brooks, J., Marshall, J. (1995). Early awareness of post-traumatic coagulopathy. *Injury*; 26:283-284.
11. Hirshberg, A., Mattox, K. (1995). Planned reoperation for severe trauma. *Annals of Surgery*; 222:3-8.
12. Cotton, B., Oliver, M., et al. (2008). Damage control hematology: The impact of a trauma exsanguination protocol on survival and blood product utilization. *Journal of Trauma*; 64:1177-1183.
13. Repine, T. B., Perkins, J. G., et al. (2006). The use of fresh whole blood in massive transfusion. *Journal of Trauma*; 60(Suppl):S59 –S69.
14. Jurkovich, G. J., Greiser, W. B., et al. (1987). Hypothermia in trauma victims: an ominous predictor of survival. *Journal of Trauma*; 27:1019–1024.
15. Johnston, T.D., Chen, Y., and Reed, R. L. (1994). Functional equivalence of hypothermia to specific clotting factor deficiencies. *Journal of Trauma*; 37:413–417.
16. Patt, A., McCroskey, B. L., and Moore, E. E. (1988). Hypothermia-induced coagulopathies in trauma. *Surgical Clinics of North America*; 68:775–785.
17. Hess, J. R., Lawson, J. H. (2006). The coagulopathy of trauma versus disseminated intravascular coagulation. *Journal of Trauma*; 60(Suppl):S12–S19.
18. Kettner, S.C., Kozek, S.A., Groetzner, J.P., et al. (1998). Effects of hypothermia on thrombelastography in patients undergoing cardiopulmonary bypass. *British Journal of Anaesthesia*; 80:313–317.
19. Kettner, S.C., Sitzwohl, et al. (2003). The effect of graded hypothermia (36 degrees C–32 degrees C) on hemostasis in anesthetized patients without surgical trauma. *Anesthesia Analgesia*; 96:1772–1776.
20. Arthurs, Z., Cuadrado, D., Beekley, A., et al. (2006). The impact of hypothermia on trauma care at the 31st combat support hospital. *The American Journal of Surgery;* 191:610-614.
21. Gentilello, L. M., Jurkovich, G. J., et al. (1997). Is hypothermia in the victim of major trauma protective or harmful? A randomized, prospective study. *Annals of Surgery*; 226:439–447.
22. Martin, R. S., Kilgo, P. D., et al. (2004). Injury-associated hypothermia: An analysis of the 2004 National Trauma Data Bank. *Shock*; 24:114–118.
23. Cosgriff, N., Moore, E. E., et al. (1997). Predicting life-threatening coagulopathy in the massively transfused patient: Hypothermia and acidosis revisited. *Journal of Trauma*; 42:857– 862.
24. Blackbourne, L., Gratwohl, K., et al. (2007). Optimizing transport of postoperative damage control patients in the combat zone. *U.S. Army Medical Department Journal*; January-March:11-16.
25. Krishna, G., Sleigh, J., Rahman, H. (1998). Physiological predictors of death in exsanguinating trauma patients undergoing conventional trauma surgery. *Australia New Zealand Journal of Surgery;* 68:826-829.
26. Pend, R., Bongard, F. (1999). Hypothermia in trauma patients. *Journal of the American College of Surgeons;* 188:685-96.
27. Erber, W. N. (2002). Massive blood transfusion in the elective surgical setting. *Transfusion Apheresis Science*; 27:83–92.
28. Croce, M., Tolley, E. (2005). Transfusions result in pulmonary morbidity and death after a moderate degree of injury. *Journal of Trauma;* 59:19-23.
29. Hakala, P., Hiippala, S., et al. (1999). Massive blood transfusion exceeding 50 units of plasma poor red cells or whole blood: the survival rate and the occurrence of leucopenia and acidosis. *Injury*; 30:619–622.
30. Miller, R. D., Robbins, T. O., et al. (1971). Coagulation defects associated with massive blood transfusions. *Annals of Surgery*; 174:794–801.
31. Loong, E. D., Law, P. R., Healey, J. N. (1981). Fresh blood by direct transfusion for hemostatic failure in massive hemorrhage. *Anaesthesia and Intensive Care*; 9:371–375.
32. Counts, R. B., Haisch, C., et al. (1979). Hemostasis in massively transfused trauma patients. *Annals of Surgery*; 190:91–99.
33. Lim, R. C., Olcott, C., et al. (1973). Platelet response and coagulation changes following massive blood replacement. *Journal of Trauma.*; 13:577–582.
34. Alam, H. B., Stanton, K., et al. (2004). Effect of different resuscitation strategies on neutrophil activation in a swine model of hemorrhagic shock. *Resuscitation*; 60:91–99.
35. Holcomb, J. B. (2004). Methods for improved hemorrhage control. *Critical Care*; 8(Suppl):S57–S60.
36. American Society of Anesthesiologists Task Force on Perioperative Blood Transfusion and Adjuvant Therapies. (2006). Practice guidelines for perioperative blood transfusion and adjuvant therapies: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Blood Transfusion and Adjuvant Therapies. *Anedthsiology*;105(1):198-208.
37. Malone, D., Dunne, J. (2003). Blood transfusion, independent of shock severity, is associated with worse outcome in trauma. *Journal of Trauma;* 54:898-907.
38. Spinella, P., Carroll, C. (2009). Duration of red blood cell storage is associated with increased incidence of deep vein thrombosis and in hospital mortality in patients with traumatic injuries. *Critical Care;* 13: R151.

39. Ho, A., Karmakar, M. K., and Dion, P. W. (2005). Are we giving enough coagulation factors during major trauma resuscitation? *American Journal of Surgery*; 190:479-484.
40. Ho, A., Dion, P., et. al. (2005). A mathematical model for fresh frozen plasma transfusion strategies during major trauma resuscitation with ongoing hemorrhage. *Canadian Journal of Surgery*; 48(6): 470-478.
41. Joint Theater Trauma Registry. (2009). Clinical practice guidelines for damage control resuscitation at level IIb/III treatment facilities. 13 February 2009.
42. Malone, D., Hess, J., Fingerhut, A. (2006). Massive transfusion practices around the globe and a suggestion for a common massive transfusion protocol. *Journal of Trauma*; 60(6 suppl):S91-S96.
43. Sperry, J., Ochoa, J., et al. (2008). An FFP:PRBC transfusion ratio >=1:1.5 is associated with a lower risk of mortality following massive transfusion. *Journal of Trauma*; 65(5):986-993.
44. Gonzalez, E., Jastrow, J., et al. (2008). Early achievement of a 1:1 ratio of FFP:PRBC reduces mortality in patients receiving massive transfusion. *Journal of Trauma*; 64:247.
45. Roche, A. M. and James, M. (2003). Watering down the clots, or are we? *Trauma*; 5:235-244.
46. Holcomb, J. B., Jenkins, D., et al. (2007). Damage Control Resuscitation: Directly Addressing the Early Coagulopathy of Trauma. *Journal of Trauma*; 62(2):307-10.
47. Ketchum, L., Hess, J. R., Hiippala, S. (2006). Indications for early fresh frozen plasma, cryoprecipitate, and platelet transfusion in trauma. *Journal of Trauma*; 60(6)(suppl):S51-
S58.
48. Hirshberg, A., Dugas, M., et al. (2003). Minimizing dilutional coagulopathy in exsanguinating hemorrhage: a computer simulation. *Journal of Trauma*; 54(3):454-463.
49. McPherson, W. G., Boeley, A. A., Wallace, C. (1922). Blood transfusion; Chapter 5 in *History of the Great War; Medical Services; Surgery of the War*. McPherson, W. G., Boeley, A. A., Wallace, C. (eds) London, His Majesty's Stationery Office 1922, p. 108–132.
50. McLean, J. A., Luke, H. A. (1969). Direct exchange blood transfusion; technique and results of treatment in liver disease, severe infection, thrombocytopenia, and leukemia. *Medical Journal of Australia*; 1:43– 47.
51. Milam, J. D., Fairchild, V. D. (1983). Disaster response planning for Texas blood banks and transfusion services. *Texas Medicine*; 79:31–35.
52. Sheldon, G. F., Lim, R. C., Blaisdell, F. W. (1975). The use of fresh blood in the treatment of critically injured patients. *Journal of Trauma*; 15:670–677.
53. Spinella, P. C., Perkins. J. G., et al. (2008). Effect of plasma and red blood cell transfusions on survival in patients with combat related traumatic injuries. *Journal of Trauma*; 64(2 Suppl):S69-77; discussion S77-8.
54. Bochicchio, G., V., et al. (2008). Outcome analysis of blood product transfusion in trauma patients: a prospective, risk-adjusted study. *World Journal of Surgery*; 32: 2185-2189.
55. Armand, R., Hess, J. R. (2003). Treating coagulopathy in trauma patients. *Transfusion Medicine Review*; 17:223–231.
56. Mabry, R. L., Holcomb, et al. (2000). United States Army rangers in Somalia: an analysis of combat casualties on an urban battlefield. *Journal of Trauma*; 49:515–528; discussion 528–529.
57. Case presentation by CPT Robert Bradley (2009) at the Special Operation Medical Association conference, December 2009.
58. Joint Theater Trauma Registry. (2009). Clinical Practice Guidelines for the administration of Fresh Whole Blood. 12 January 2009.
59. McMullin, N. R., Holcomb, J. B., et al. (2006). Hemostatic resuscitation. In Vincent, J. L. (Ed). *Yearbook of Intensive Care and Emergency Medicine*. New York, NY, Springer, 2006, p. 265-278.
60. Lozano, M., Rivera, J. (1997). Loss of high-affinity thrombin receptors during platelet concentrate storage impairs the reactivity of platelets to thrombin. *Transfusion*; 37:368-75.
61. Manno, C. S., Hedberg, K. W., et al. (1991). Comparison of the hemostatic effects of fresh whole blood, stored whole blood, and components after open heart surgery in children. *Blood*; 77:930–936.
62. Kendrick, D. B. (1963). *The Blood program in WWII Supplemented by Experiences in the Korean War*. U. S. Army Medical Department, Office of Medical History. Retrieved June 10, 2010. Website: http://history.amedd.army.mil/booksdocs/wwii/blood/default.htm
63. Little, R. (2009, March 29). Army medicine: Untested in battle. *The Baltimore Sun. Retrieved June 3, 2010. Website:* http://www.baltimoresun.com/news/nation-world/bal-te.militarymed29mar29,0,6680487.story
64. Berenson, A. (2007, November 6). Army's aggressive surgeon is too aggressive for some. *New York Times*. Retrieved June 10, 2010. Website: http://www.nytimes.com/2007/11/06/health/06prof.html
65. Kauvar, D. S., Holcomb, J. B., et al. (2006). Fresh whole blood transfusion: A controversial military practice. *Journal of Trauma*; 61: 181–184.
66. Beecher, H. K. (1960). The Physiologic Effects of Wounds. *Archives of Surgery;* 80: 366-373.
67. Hrezo, R., Clark, J. (2003). The walking blood bank: An alternative blood supply in military mass casualties. *Disaster Management & Response*; 1(1):19-22.
68. Sondeen, J. L., Wade, C. E., et al. (2006). Fresh whole blood is the best 24-hour hypotensive resuscitative fluid in severe hemorrhage in swine. *Shock*; 25(6):21.
69. Barbee, R. W., et al. (1999). A Comparison of Resuscitation with PRBCs and whole blood following hemorrhagic shock in canines. *Shock*; 12(6):449-53.

70. Spinella, P. C., Perkins, J. G., et al. (2008). Warm fresh whole blood transfusion for severe hemorrhage: U.S. military and potential civilian applications. *Critical Care Medicine*; 36(7 Suppl):S340-5.
71. Grosso, S. M., Keenan, J. O. (2000). Whole blood transfusion for exsanguinating coagulopathy in a US field surgical hospital in postwar Kosovo. *Journal of Trauma*; 49:145–148.
72. Hess, J. R., Thomas, M. J. (2003). Blood use in war and disaster: Lessons from the past century. *Transfusion*; 43:1622–1633.
73. Lavee, J., Martinowitz, U., et al. (1989). The effect of transfusion of fresh whole blood versus platelet concentrates after cardiac operations. A scanning electron microscope study of platelet aggregation on extracellular matrix. *Journal of Thoracic Cardiovascular Surgery*; 97: 204–212.
74. Mohr, R., Goor, D. A., et al. (1992). Fresh blood units contain large potent platelets that improve hemostasis after open heart operations. *Annals of Thoracic Surgery*; 53:650–654.
75. Traverso, L. W., Hollenbach, S. J., et al. (1986). Fluid resuscitation after an otherwise fatal hemorrhage: II. Colloid solutions. *Journal of Trauma*; 26:176–182.
76. Arslan, E., Sierko, E., et al. (2005). Microcirculatory hemodynamics after acute blood loss followed by fresh and banked blood transfusion. *American Journal of Surgery*; 190:456–462.
77. Spinella, P. C., Perkins, J. G., et al. (2009). Warm fresh whole blood is independently associated with improved survival for patients with combat-related traumatic injuries. Journal of Trauma; 66(4 Suppl):S69-76.
78. Kilduffe, R. A., and DeBakey, M. (1942). *The Blood Bank and the Technique and Therapeutics of Transfusions*. St. Louis: C. V. Mosby Co., 1942.
79. Neel, S. (1991). *Vietnam Studies: Medical Support of the U.S. Army in Vietnam 1965-1970*. Department of the Army, Washington, D.C., 1991. Retrieved July 13,2010. Website: http://www.history.army.mil/books/Vietnam/MedSpt/MedSpt-FM.htm
80. Personal correspondence with Mr. Rick Strayer. (2009). former Noncommissioned Officer in Charge (NCOIC) of the Special Operations Combat Medic Skills Sustainment Course (SOCMSSC).
81. Website: http://www.micronics.net/products/diagnostic-products/immunohematology
82. Andy, C. S. (ed.), et al. (2004). *Emergency War Surgery*, Third US Revision, Chapter 7: Shock and Resuscitation. p. 7.11.
83. U. S. Special Operations Command (USSOCOM) Biomedical Initiatives Steering Committee (BISC) meeting 29 April 2010.
84. Assistant Secretary of Defense for Health Affairs: Health Affairs Policy 95-005, March 1995.
85. North American Treaty Alliance (NATO) Standardization Agreement (STANAG) 2939.
86. Gaydos, J., Polk, A., et al. (1988). Blood typing errors on U.S. Army Identification cards and tags. *Military Medicine*; 153: 618-620.
87. Ensign, B., Dougherty, T., et al. (1995). ABO and Rh Blood Type Errors on Air Force Identification Cards. *Military Medicine*; 160:288-290.
88. Rentas, F., Clark, P. (1999). Blood Type Discrepancies on Military Identification Cards and Tags: A Readiness Concern. *Military Medicine*; 164: 785-787.
89. Tenglin, R., et al. (2008). Special Operations Forces Medical Manual. Second Edition, Chapter 8: Procedures. p. 8-14.
90. Ruben, M. (2008). Is there a universal blood donor type? MayoClinic.com. Retrieved June 10, 2010. Website: http://www.mayoclinic.com/health/universal-blood-donor-type/hq00949
91. Spinella, P. C., Perkins, J. G., et al. (2007). Risks associated with fresh whole blood and red blood cell transfusions in a combat support hospital. *Critical Care Medicine*; 35:2576–2581.
92. Army Regulation 40–8 Medical Services Temporary Flying Restrictions Due to Exogenous Factors Affecting Aircrew Efficiency, Headquarters Department of the Army, Washington, DC, 16 May 2007.

F. Bowling has served as a Special Forces medic for 16 years in both the 7th Special Forces Group and USASOC and has numerous deployments in support of overseas contingency operations.