Where Do We Stand on "Buddy Transfusion" During Military Operations?

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ABSTRACT

Warm fresh whole-blood transfusion between comrades on the battlefield, also known as "buddy transfusion," has been thrust back into the limelight for several years now. It means drawing blood on the battlefield, once a bleeding soldier needs a transfusion, from one of their uninjured companions and immediately infusing it. It is a lifesaving procedure, effective and hardy. This work aims to answer the main questions that military caregivers might have about it: interest of this procedure, donor and recipient safety, and hemostatic capacity of the blood collected this way.

KEYWORDS: *blood transfusion; war-related injuries; hemostasis; physical exertion; military deployment; thrombin; transfusions; buddy transfusions; whole blood*

Introduction

With the last several years, warm fresh whole-blood transfusion between comrades on the battlefield has been thrust back into the limelight. Fresh whole blood refers to whole blood collected on an emergency basis from a "walking blood bank."[1] When a bleeding soldier needs a transfusion, and fresh whole blood is drawn on the battlefield from one of his uninjured companions and immediately infused to him, it is termed "warm fresh whole blood." Since the blood is donated by a combat buddy, it is also known as "buddy transfusion."[2] This lifesaving procedure – both effective and hardy – still requires caution to ensure complete safety for both the donor and recipient. This work aims to answer the main questions that military caregivers might have about performing such a procedure on the field.

Why Consider a "Buddy Transfusion" Procedure?

Blood products are the cornerstone of the management of bleeding trauma patients. Plasma infusions have been widely used on the battlefield since the reemergence of freeze-dried plasma, although their availability is still limited. Plasma provides coagulation factors, allows for volume expansion, and has other beneficial effects, to include targeting endotheliopathy.[3] Plasma infusion increases the survival of major trauma patients among both war casualties and injured civilians.[4] Nevertheless, plasma has only a low or zero effect on oxygenation and primary hemostasis. In addition, platelets play a major role in coagulation propagation beyond primary hemostasis.[5] Likewise, it is now well documented that systemic blood failure sets in after a severe hemorrhagic trauma, combining trauma-induced coagulopathy, trauma endotheliopathy, and the decrease in oxygen transportation capacity. All of these combined lead to overall tissue ischemia.[6] Red blood cell (RBC) intake is the only way to address this oxygen debt.[7] As such, it is currently recommended to provide a bleeding trauma patient with blood products in a 1:1:1 ratio for plasma, platelets, and RBCs. Whole blood (WB) thus appears as a perfect all-in-one product, providing all the necessary components.

Another essential point to understand is that blood product administration must be made early in hemorrhagic trauma management.[8,9] It must be started at the presurgical phase when blood bank products are not available yet. The transport of blood products to the field is also possible. This allows laboratory tests and screening for transfusion transmissible diseases to be carried out in the blood bags before the mission. Despite being associated with logistical issues (cold chain, cube and weight, and resupply constraints related to the shelf life of blood products), this strategy is widespread in Western armed forces.[10] Despite this, there are still unexpected situations in which a blood collection in the field may be required, even though the combatants did not take blood products with them (often due to evacuation difficulties, logistical remoteness, unanticipated situations, etc.).

An obvious benefit of a warm fresh whole-blood strategy is thus logistical. Warm fresh whole blood is always available, even behind enemy lines, during operations requiring high mobility and a light footprint, from the moment the personnel is trained to the procedure and equipped with collection bag. Warm fresh whole blood is maintained indefinitely at 37°C without storage constraints or the need for equipment (coolers, batteries, etc.). However, its additional advantage is qualitative. Because it is not infused with additive solutions and anticoagulant, whole blood consists of – for an equal amount – more platelets, more RBCs, and more coagulation factors than reconstituted blood from components.

Another advantage could be that warm fresh whole blood is not stored but immediately used. Storage of blood products

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results in multiple biochemical, structural, and metabolic changes, referred to as to the storage lesion. Whole blood is also exposed to such lesions when cold stored. In particular, the relative rate of hemolysis observed in whole blood is equivalent to the one in packed red blood cells.[11] A link between the length of storage of transfused red blood cells and important clinical outcomes has never been pointed out.[12] Nevertheless, one might consider a potential beneficial effect of fresh whole blood in the context of the hemorrhagic shock, notably for the repayment of the oxygen debt.

In many studies, it seems that WB could be more effective for a bleeding patient, especially for war-injured personnel.[13,14] Moreover, during such a procedure, the blood transfused to the injured will be warm. This will also help fight hypothermia, which is one of the components of the lethal triad. It is for this reason that the Tactical Combat Casualty Care (TCCC) guidelines, as in the French Armed Forces transfusion policy, whole blood is the most recommended resuscitation fluid for casualties in hemorrhagic shock.[15,16]

Are "Buddy Transfusions" Safe for the Donor?

The first question to ask is whether the donor has the capability to carry on with the mission and even resume fighting after a blood donation. Two studies led by the Norwegian Naval Special Operations Commandos explored this issue. The first study showed, under experimental conditions, that well-trained Soldiers, after a blood donation of 450mL, did not show a decrease in endurance capacity or shooting skills.[2] Another study, which was randomized and double-blinded, was conducted after a prolonged escape field exercise as a way to simulate the severe fatigue of deployed conditions (6 days, with a mean weight loss of 3 kg for each participant). Although relative and absolute maximal oxygen uptake (VO_2 max) decreased after a 450mL blood donation, there was no significant difference in physical performance between Soldiers who had donated blood compared to those who did not.[17] These results were from Special Operations Forces Soldiers, who were well trained and probably very motivated and cannot be generalized to the general population or even to all Soldiers. Nevertheless, it still shows the feasibility of a blood donation in the field. It is recommended that the donor drink a volume of at least 500mL during the blood donation to limit the risk of syncope.[18,19]

Are "Buddy Transfusions" Safe for the Recipient?

Two major risks for the recipient must be controlled for when considering a warm fresh whole-blood procedure: the risk of ABO mismatches and the risk of transfusion-transmitted diseases (TTDs). The former is clearly the more significant. The latter often worries Soldiers and it is important to explain that it is controlled.

Mismatch of ABO blood group is preventable with compliance to standard clinical transfusion practice. However, with stress and fatigue due to combat, human errors may occur. When the procedure is implemented in a unit, potential blood donors are prescreened before deployment; thus, blood types of each Operator are listed beforehand. This procedure allows for control of this ABO mismatch risk. Some countries, including France, add a systematic blood group check of both donor and patient before donation on the field, using rapid ABO testing (devices with predried reagents).[20]

Another way to reduce this risk is to always collect WB from group O donors, whose titers of anti-A and anti-B antibodies are low, to avoid the risk of hemolytic reactions mediated by these antibodies. This kind of donor can be considered a universal donor.[21] Such blood is called low-titer O whole blood. This approach reduces the risk of mistakes in selecting the donor in the field. It requires a selection of the electable potential donors prior to the deployment. Initially developed among Norwegian SOF and the 75th Ranger Regiment, this approach is nowadays allowed in many Western armed forces.[2,22–24] Many militaries, including the US Armed Forces, collect blood only from low-titer O donors, thus preventing the risk of ABO mismatch. Although other countries, notably France, allow this approach, they give priority to group-specific donors because the antierythrocyte titer can vary in a lifetime for the same donor.[16,25] These two approaches both seem consistent; the most important thing is to define upstream procedures adapted to the way that forward medical support works for each country.

The risk of TTD transmission must also be considered. Molecular biology or serology cannot be performed on the battlefield. Rapid tests for only the most common and serious TTDs are available under these conditions. A strict protocol for prescreening potential donors and meeting local regulatory and legal requirements must be in place to control this risk before implementing a "buddy transfusion" program in a unit. The medical selection of volunteer donors is fundamental. Preferably, it is done upstream. Volunteer donors can thus undergo a medical interview and medical examination during which they are informed about TTDs. Each reason to defer blood donation is queried, including recent risk behaviors. Laboratory testing can also be performed before deployment. The duration of validity of the tests differs from country to country, ranging from a single blood donation for Norway to 12 months for France and the United States. If this cannot be anticipated before deployment, donors must be selected in the operation theater solely on the basis of medical interview data. Medical teams must be trained to perform such a selection. Some authors have developed questionnaires operable by a nonphysician if no medical personnel are on site.[26] The most rigorous selection of donors, in addition to the use of rapid diagnostic tests on the battlefield, allows control of the risk enough to be lower than the expected benefit of a WB transfusion to a bleeding combat casualty in a remote setting.

Are "Buddy Transfusions" Medically Adequate for a Bleeding Patient?

A recent study conducted among French SOF commando candidates during their selection brings partial answers about the hemostatic capacities of such blood.[27] Considering the selection course as an experimental model by placing participants into the same physiological conditions as those faced by deployed fighters, the authors compared coagulation markers at the beginning and after six weeks of course. These data suggest that there is no obvious modification of hemostatic properties and that their blood could be well adapted for a war-injured patient for a "buddy transfusion" procedure. Such modifications are incontestably beneficial for the hemorrhaging patient (increased fibrinogen level and shortened prothrombin time and activated partial thromboplastin time at 6 weeks). A decreased thrombin generation is also pointed out, which may reflect lower levels of circulating procoagulant proteins, as

well as a better ability to shut down the thrombin generation once started.

Final Recommendations

It should be remembered at this stage that a transfusion procedure between comrades must never delay the evacuation of the injured person to the operating theater if a rapid evacuation is possible. Depending on the delay, it may also be possible to collect blood in the field and give it to the injured person during transport. Similarly, other lifesaving interventions should continue to be performed as soon as possible (stopping external bleeding, tranexamic acid, etc.).

During blood donation, a point of attention should be the filling of the blood bag. The donation should be stopped when the bag is filled with 420 to 500mL of blood. If the bag is underfilled (<300mL, approximately 15% incidence in a large US series), the blood bag should not be administered.[28] The citrate anticoagulant concentration in the bag would then be too high and thus deleterious. Operators must be therefore trained to recognize the correct filling of the bag. A technique described by Meledeo et al. can be used on the battlefield. It consists in constricting the center of the blood bag by a cord at a 6.5-inch circumference.[29] This method is efficient, and reliable for controlling the collection volume in austere environment.

Another point of attention must be hypocalcemia. This can be accelerated by the anticoagulants and preservative solutions contained in the blood-collection bags. In trauma, low calcium levels on admission are associated with both increased mortality and increased need for transfusion.[30,31] Calcium supplementation is necessary as early as the prehospital phase and should be protocolized in advance. The Joint Trauma System recommends the administration of 1g of calcium with the first unit of blood product and to re-dose 1g of calcium after every 4 units of blood products.[1]

Conclusion

WB donation between comrades on the battlefield is a truly lifesaving procedure that must be implemented and taught within units called upon to conduct military operations in remote settings. The risks inherent to this procedure can be controlled by the rigor of the medical teams, their training, and the scrupulous oversight of previously validated procedures.

Author Contributions

YD drafted the manuscript. CD, PM, ST, and CM carefully revised the manuscript.

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