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Transfusion chain during Barkhane operation: organization and lessons learned

Chaine transfusionnelle pendant l'opération Barkhane : organisation et retour d'expérience

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Abstract

From the perspective of a major combat operation, or counter-terrorism operations with a small footprint on the ground, modern conflicts put a strain on the logistics chain. One of the most sensitive and critical is the supply of blood products. Various solutions are possible to provide our casualties with the right blood products at the right time, from fractionated bank products to "buddy transfusion". The recent experience of the French army in the Sahara-Sahelian strip shows that none of them should be ruled out beforehand and all of them require anticipation and training.

Keywords: Blood Transfusion, Blood Product, Military Medicine

Résumé

Les conflits modernes mettent à rude épreuve la chaîne logistique, qu'il s'agisse d'une opération majeure de combat ou d'opérations de lutte contre le terrorisme avec peu d'implications sur le terrain. L'approvisionnement en produits sanguins représente l'un des aspects les plus sensibles et primordiaux de cette chaine logistique. Différentes solutions sont envisageables pour fournir aux victimes les bons produits sanguins au bon moment, depuis les produits fractionnés issus de banques de sang jusqu'à la "transfusion entre camarades" sur le terrain. L'expérience récente de l'Armée française dans la bande saharo-sahélienne montre qu'aucune de ces solutions n'est à exclure a priori et que toutes nécessitent une certaine anticipation et formation.

Mots clés : Transfusion Sanguine, Produits Sanguins, Médecine Militaire.

Introduction

For years and especially since the first international conflicts, it has been evident that survival of the hemorrhagic injured soldiers is inevitably compromised without transfusion. Since the WWI, fresh whole blood transfusions have been used to treat the military trauma patients.

Two factors of the transfusion therapy are essential to improve the survival of the trauma patient: the timing and the quality of this transfusion.

First, to restore blood pressure and subsequent complications as well as the clotting capacity, the time to first transfusion must be as short as possible. During the conflict in Afghanistan, the 24h mortality of the US military trauma patients who received a first transfusion within the first 15 min after the injury was lower (HR 0.17 [95% CI, 0.04-0.73], p=0.02) than those who could not be transfused or could be transfused only within more than 15 minutes.(1)

Second, the blood loss and the traumatic coagulopathy require a transfusion, which composition is close to that of whole blood. Indeed, in a study of Roquet et al, the 30-day survival rate of the trauma patients was higher (HR, 0.74; 95% CI, 0.58- 0.94; p=0.01) when the transfusion ratio was greater than 1 plasma for 1.5 RBCs transfused.(2,3)

Blood products in Barkhane operation_

The French Military Medical Service (FMMS) provides four categories of blood products in the field. (4)

The different products available during Operation Barkhane were Red Blood Cell units (RBCs), French Lyophilized Plasma (FLYP), cold-stored low-titer group O WB (CS-LTOWB) and warm fresh whole blood (wFWB).

The RBCs that are obtained from blood collections in France, are 280 mL bags composed of approximately 60% erythrocytes. It can be stored 42 days at a temperature between 2 and 6°C and are supplied from France every 30 days. Transfusion must be performed according to ABO compatibility. The FLYP, prepared by plasmapheresis of about ten human blood by the French Military Blood Institute (FMBI) packaged in a 210 mL glass vial with a shelf life of 2 or 3 years at room temperature.(5) The FLYP provides only coagulation factors. There are significant logistical advantages to using FLYP: storage at room temperature and no requirement for thawing time permits usage at pre-hospital stages and in austere conditions, with only 3 to 5 minutes to be reconstituted. Moreover, FLYP is compatible with all blood type, make it easy to use. Finally, two types of whole blood are available: the warm Fresh Whole Blood (wFWB) and the cold-stored low titer group O whole blood (CS-LTOWB). The main advantage of the whole blood transfusion is to provide to the military trauma patient all

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the constituent of the blood: red blood cells, plasma and platelet. The whole blood transfusion is the only source of platelet transfusion before the repatriation to the France.

The wFWB is fresh blood collected by the medical team directly in the field from pre-screened donors, in a 500mL bag. The main limitations of the wFWB are a collection time of around one hour for a trained medical team, a theorical infectious risk (HIV, HCV, malaria). It can be stored at room temperature for 6 hours before used then at 2-6°C for 48 hours.

The CS-LTOWB is prepared by the FMBI from whole blood collected from group O donors who have low titer of anti-A and anti-B antibodies. The group O whole blood is then filtered for leukoreduction without altering the number of platelets or their hemostatic quality. [5] The low titer of anti A and B antibodies allow its universal transfusion compatibility. It can be stored in a cooler between 2 and 6°C for 21 days which requires a supply from France more frequently than RBC, every 14 days. The CS-LTOWB was made available for the first time in the field in 2021.(6)

Transfusion chain organization

The FMMS's policy concerning the management of the hemorrhagic war wounded is based on the Damage control resuscitation strategy (DCR).

The DCR starts from the point of injury by controlling massive bleeding, applying hemostatic strategies of the Tactical Combat Casualty Care with pressure dressing, tourniquet, pelvic binder or hemostatic gauze, as close to combat as possible. The DCR continues with the fastest possible transport to ROLE 1.

At ROLE 1, the medical care begins by injection of tranexamic acid, an antifibrinolytic drug, and by starting the transfusion strategy for the military trauma patient who required it, with FLYP or Cs-LTOWB transfusion in a first time and wFWB if necessary. When the patient is properly conditioned and a carrier is available, the military trauma patient is transported by forward MEDEVAC to ROLE 2, usually by air. During the forward MEDEVAC, the transfusion may be continued with RBC, CS-LTOWB or FLYP.
At ROLE 2, the damage control strategy includes a damage control surgery (DCS). The DCS consists of rapid surgery (ideally less than 60 minutes) aiming at stopping bleeding by strategies of suturing culprit arteries, arterial shunts, packing, or compression devices. This shortened surgery avoids the development of the lethal triad. At this stage, the transfusion is continued with RBC, FLYP, CS-LTOWB and wFWB is necessary.

The main goal is to stabilize the military trauma patient to allow the transport to France early. During the strategical evacuation (STRATEVAC) to France, the transfusion may be continued, if necessary, with RBC, FLYP and platelet concentrate (PC).
Finally, the ROLE 4 is the French military training hospital in France where the military trauma patient receives the definitive care.

The organization of the transfusion chain must therefore be modelled on this chain of survival while taking into consideration the logistical constraints to provide the patient and the medical team with the right products at the right time.
Thus, the transfusion chain must meet the following 4 rules:

- transfuse as quickly as possible ;
- transfuse blood first instead of crystalloids ;
- provide platelets during the transfusion protocol ;
- and, respect a ratio of products close to the composition of whole blood (ratio of 1:1:1 of RBCs, plasma and platelets or whole blood unit).

FLYP is therefore available to all medical teams from forward medical team to strategical evacuation medical team.

RBCs or CS-LTOWB are available where they can be stored according to their storage rules so at ROLE 2. But in some case, RBC and CS-LTOWB could be used at ROLE 1 and forward MEDEVAC thanks to the golden hour box, which is a cooler allowing 48 hours storage for 3 RBCs or 2 CS-LTOWB. In some special circumstances, these products are available in armored vehicles directly at the beginning of patient care.

During STRATEVAC, the possibility of bringing back blood products directly from the FMBI allows a "multi-component" transfusion notably with platelet concentrate and to continue the transfusion strategy as long as necessary. The CS-LTOWB, currently not much produced, is not used at this stage of the transfusion chain.

Since it requires an hour to be done, wFWB is mainly performed on stable phases without transport (ROLE 1 and ROLE 2).

Finally, for logistical reasons, platelet concentrates are not available on the field.

Feedback on transfusion consumption in Barkhane between 2013 and 2021

The FMMS's doctrine is based on using the transfusion in the following order of priority :

Priority 1= CS-LTOWB ;
Priority 2 = RBCs and FLYP in a 1:1 ratio ;
Priority 3 = RBCs or FLyP if only one is available ;
Priority 4 = crystalloids while waiting for FLYP.

During Barkhane operation, 45 french military trauma patients were transfused with at least one blood products. Twenty three

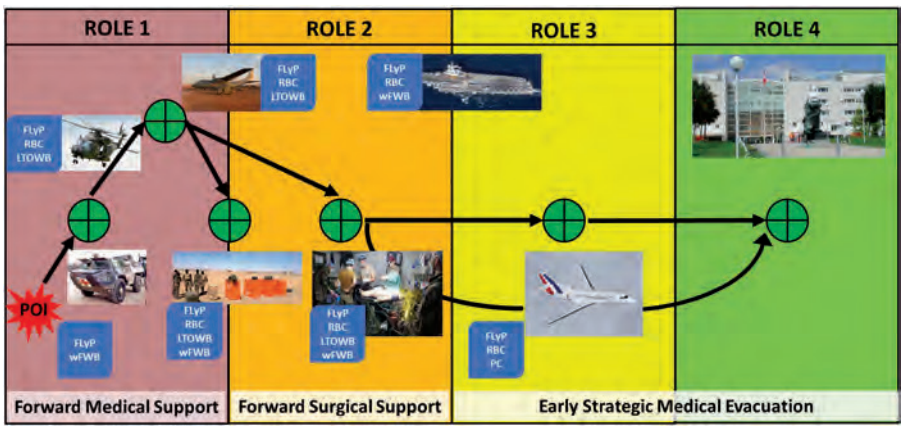

Figure 1: Medical blood supply in the French military medical service, organized according to the chain of survival of the war wounded, from point of injury to role 4 facility.
FLyP : French Lyophilized Plasma ; LTOWB : Low Titer group O Whole Blood ; PC : Platelet Concentrate ; POI : Point Of Injury ; RBC : Red Blood Cell units ; wFWB : warm Fresh Whole Blood.

patients (51%) received at least four RBC during the first day, defining a severe hemorrhage (SH).

At ROLE 1, 12 (27%) of the 45 injured patients who required a transfusion during Barkhane operation were transfused. Among these, four were defined retrospectively as severe hemorrhaged, whereas five were not transfused again after this stage. Totally, 17 blood products were transfused, mostly FLYP, while two patients with SH were transfused with FLYP and RBC.

During the forward MEDEVAC, fourteen patients (31%) were transfused. Of these patients, eight subsequently presented with non-SH and six with SH. Twenty-four blood products were transfused at this stage, divided into 15 to patient with SH and nine to patient without SH. The FLYP was the most blood products transfused with thirteen FLYP transfused, equally divided between patients with and without SH. Six RBCs and three wFWB were transfused to patients with SH. Only one CS-LTOWB transfusion, was transfused to a patient without SH.

Overall, 41 blood products were transfused before ROLE 2 arrivals with a significantly increase from 0.45 blood products per patients before 2017, to 1.28 since this year.

At ROLE 2, 38 patients (84%) were transfused with 310 blood products. A roughly equal proportion of RBCs, FLYP or wFWB were transfused to patients with SH. Patients with SH received a median of 10 blood products at ROLE 2, divided into 4 RBCs, 4 FLYP and 3 wFWB. In contrast, the patients without SH received median of 2 blood products mostly FLYP or RBC.

Therefore, the patient with SH, received from the ROLE 1 to the end of the ROLE 2 management a median Plasma:RBC ratio of 1.2 and Platelets:RBC 0.4.

During STRATEVAC, nine (24%) patients received a transfusion. Eight were patient with a SH and were transfused with 36 blood products whereas one patient without SH was transfused with one blood products. A similar proportion of RBCs and FLYP were transfused (16 RBCs and 14 FLYP). Interestingly, regarding platelet products, 2 wFWB and 2 PC were transfused.

In France at ROLE 4, 16 (42%) patients were transfused with 131 blood products until the 48th hours after the injury, 13 with SH and 3 without SH. In detail, patient with SH received a median of 6 blood products, with a median of 2 RBC and 2 plasma. At this stage, the plasma transfused is mostly fresh frozen plasma rather than FLYP.

Finally, between the 48th hours and the day 7, 400 blood products, mainly RBCs, then plasma and some mixed platelets were transfused, almost exclusively to patients with SH at baseline.

To summarize, 55% of blood products were used on the field, and 45% were needed throughout the first week, mainly by the patient with a severe hemorrhage.

Conclusion

The FMMS's doctrine is based on the damage control strategy. As soon as possible, the military trauma patient should receive medical support, starting from the POI with tactical combat casualty care, then from ROLE 1 and 2 with advanced medical and surgical support and throughout the different medical evacuation.

During all these steps, the FMMS provides a transfusion chain with different blood products adapted to the logistic and tactical constraints: RBC, FLYP, and two types of whole blood unit : CS-LTOWB and wFWB.

This feedback from the transfusion chain during Operation Barkhane demonstrates the ability of the FMMS to deploy a complete transfusion chain in a low-intensity conflict despite an extensive war zone.

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