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Logistical Concerns for Prehospital Blood Product Use by Air Medical Services

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A B S T R A C T

Over the past few decades, reports have described favorable results from transfusion of blood products in helicopter EMS (HEMS). Nevertheless, the initiation of a HEMS transfusion program requires consideration of many factors, some unique to each clinical site. This paper describes our experience developing a HEMS transfusion program in an urban non-hospital based HEMS program with a history of long transport times. When considering blood use away from the hospital, major consideration must be given to safe storage and monitoring of blood products both on the ground and while in flight. PRBCs have been shown to generally be resilient to helicopter transit and have a prolonged storage duration. Transfusion of other blood products, such as plasma, involves additional challenges but has been achieved by some HEMS sites. Flight protocols should be developed addressing when and how many blood products should be transported, potentially considering patient factors, scene factors, and the regional availability of blood products during interfacility transport. Quality assurance and documentation protocols must also be developed for blood product use in flight. In our center's experience, we have so far transfused a limited number of patients with generally good results. Patient outcomes are described as below.

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Helicopter emergency medical services (HEMS) and other forms of air medical evacuation are now the preferred method for moving critically ill or injured patients from the scene of injury to the hospital or from lower to higher levels of hospital care when distances are long or travel is otherwise difficult or time-consuming.¹⁻³ HEMS programs have provided advanced resuscitation and airway support for many years, but only recently have more programs begun to integrate blood transfusion as an additional resource for hemorrhaging patients.⁴ According to a recent survey of all air medical programs in the United States, 25.3% of programs currently carry blood products, with an additional 5.8% having previously carried blood on their flights before stopping for various reasons.⁵ Rurally based programs were more likely to carry blood products in that survey as well.

Early evidence has suggested that blood provision during air transport may improve outcomes. A retrospective cohort study from the University of Pittsburgh suggested improved survival,

decreased risk of shock, and lower 24-hour transfusion requirements.⁶ However, the provision of blood to a remotely based air ambulance service involves various logistical challenges.

The value of HEMS is particularly true for services in locations such as the Pacific Northwest, where tertiary hospitals supporting 4 states are located in a confined and congested urban corridor.⁷ Airlift Northwest (ALNW) is a local service run under the auspices of University of Washington Medicine. The medical crew for rotary missions includes 2 registered nurses with prior experience in adult and pediatric critical care units. These flight nurses undergo additional training in HEMS care before beginning full duty with ALNW. Unlike hospital HEMS systems with landing and service facilities on the hospital roof or surrounding grounds, our supporting air medical evacuation services in Seattle are based at an airport 5 miles south of the county hospital, which also serves as the main blood product provider and the regional trauma center. The distance between these 2 facilities means that the time required to prepare and send blood components for emergency use would be longer than desirable for the deployment of air medical services.

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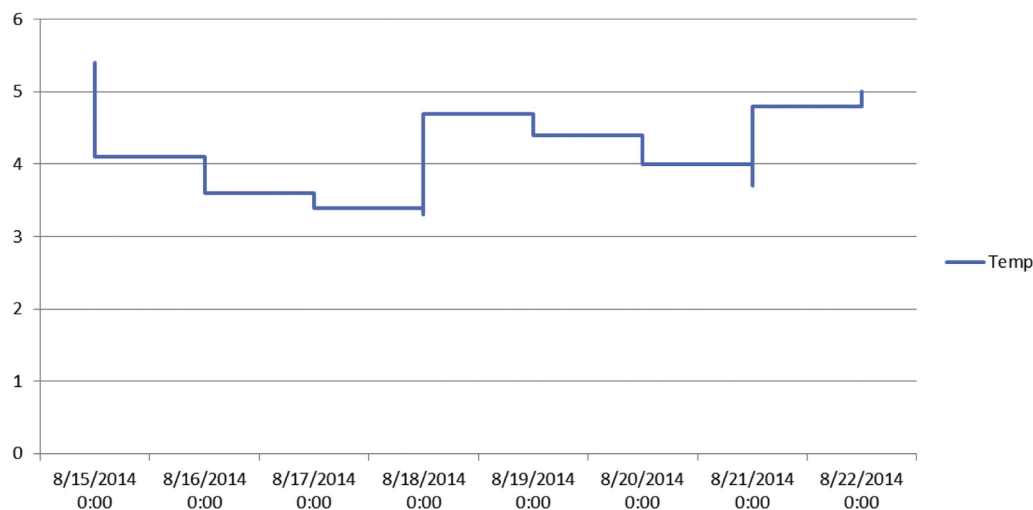


Figure 1. An example of temperature measurement of a blood refrigerator on multiple journeys (temperature in Celsius).

ALNW helicopter flights began carrying blood products in April 2015. This article describes the considerations for protocol creation, the staff development and training undertaken, and the effects of implementation on the care for our first “transfused in transit” patients, focusing on concerns for systems based outside of a major hospital setting.

Storage and Transport

A major concern when storing and transporting blood away from a central processing facility is the maintenance of blood product temperature between 1°C and 6°C. Although studies have shown that brief temperature deviations may be safe,⁸ US Food and Drug Administration regulations require this strict temperature range on units transfused within the United States.⁹ For HEMS purposes, storage containers must also be lightweight and small enough to fit comfortably in the helicopter resuscitation area. Given weight and volume restrictions for HEMS, we chose a eutectic box for blood product storage (Crédo Medic Pack Series 4 248 EMT; Pelican Biothermal, Plymouth, MN) with external dimensions of 10 × 9 × 8 inches and weighing 7.2 lb unloaded. This unit has an internal capacity of 2 L, and it weighs 10 lb when fully loaded with 2 units of red blood cells and 2 units of plasma. The insulation for these units uses heavy water in a sealed container, which melts slowly at 3.8°C.

We have validated our containers for holding payload temperatures between 1°C and 6°C for up to 1 week when held in refrigeration most of the time (Fig. 1). When storage was punctuated by periods outside the refrigerator up to 24 hours at ambient temperatures up to 37°C to simulate the removal of blood products during a scene pickup or extended hospital transfer, the measured temperature rise in our prevalidation phase was limited to roughly 1.2°C. Therefore, these containers were approved for use up to 24 hours outside of controlled storage if unopened.

Between HEMS missions, transport packs are returned to refrigeration at a goal temperature of 3.5°C (in the middle of the allowed range of 1°C–6°C) consistent with Food and Drug Administration temperature standards. Temperature monitors for data logging (microDL Red; Marathon Products, Inc, San Leandro, CA) were added to all blood storage units for quality assurance. These data loggers provide temperature resolution to 0.2°C, are water-resistant, weigh less than 1 oz, and have a diameter of only 2.8 cm. Blood storage coolers are sealed at the blood bank before delivery to the HEMS base.

Although there were early reports of hemolysis with inadequately packaged red blood cell units during helicopter transport,¹⁰ more recent reports with purpose-built blood storage containers have shown no clinically significant differences in blood up to 42 days after 4 hours of helicopter transport.¹¹ The duration of red cell storage, including for unused units returned to the central blood bank, has been shown not to affect mortality if stored for less than 42 days under the recommended conditions.¹²

Types of Products

We worked with a regional blood supplier to provide 2 U of either type AB or type A, low-titer B, liquid plasma (estimated weight = 275 g/U), as well as 2 U type O Rh-negative red blood cells (estimated at 325 g/U) for each storage container. Blood product types were chosen to be universal donors, given the impossibility of providing type-specific or crossmatched blood in this setting.

Red blood cells were the first products described in HEMS transfusion⁴; other products have since been added to HEMS transfusion supplies to provide balanced transfusions with some promising results. The early use of plasma in prehospital settings has been shown to increase compliance with recommended balanced resuscitation ratios, as suggested by trials such as the Pragmatic, Randomized Optimal Platelet and Plasma Ratios (PROPPR) trial.^{13,14} Transfusion of plasma may treat or prevent the development of traumatic coagulopathy and partially correct coagulopathies from vitamin K antagonist use.

Although there has been mounting interest in whole blood resuscitation in the prehospital setting for military use,¹⁵ this has not yet become standard in civilian trauma. Likewise, given the shorter shelf life of platelets for transfusion, no civilian services appear to include platelets in their prehospital transfusion supply.

When to Bring Blood Products in Flight

A majority of HEMS programs providing transfusion support carry blood on all missions, with a median of 2 U.¹⁴ On average, blood products are given on 4.9% of scene transports compared with 6.2% of interfacility transports.¹⁴ Given the prolonged transport times in some patients as well as the limited blood availability at smaller regional hospitals, more units may be needed to support massively bleeding patients in some circumstances.^{16,17} Consideration must also be given to the burden placed on hospitals without blood banking centers if their supply must be used to continue transfusion of patients during transport.

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