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REPORT NO. 958

BLOOD COMPONENT LOGISTICS

(Progress Report)

by

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30 December 1971

Military Blood Banking:
Preservation Methods--Liquid and Frozen--and Logistics
Work Unit No. 155
Combat Surgery
Task No. 00
Combat Surgery
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ABSTRACT

BLOOD COMPONENT LOGISTICS

OBJECTIVE

To study the packaging and transporting aspects of a relatively new phase of blood banking--blood components.

METHODS

Experiments were conducted to ascertain the temperature change in platelets when shipped in ambient temperatures of 31 and 5 C. The temperature was maintained in an environmental chamber to within ± 1 C. The internal temperature of the 25 ml aliquots of water, representing the platelet-rich plasma (PRP), was measured by thermistor probes inserted inside the individual plastic bags. Two units bearing the temperature monitoring probes were placed in the shipping container in opposite corners. The temperature was recorded periodically.

By prearrangement with the Director of Walter Reed Army Blood Bank, data were collected on actual shipments between Fort Knox and Washington, D. C. A temperature recorder was placed inside the shipping box containing the PRP. A permanent record of the temperature changes is included in this report.

RESULTS AND CONCLUSIONS

At the elementary level of considering blood as composed of three components, namely red cells, plasma, and platelets, the specific requirements for packaging and transporting them are vastly different. To maintain platelets at 22 C, data show that it may be necessary to include a warming or cooling agent in the shipping container.

The efficacy of blood component therapy is in a large measure dependent on proper temperature maintenance for the blood fractions, from phlebotomy to transfusion.

BLOOD COMPONENT LOGISTICS

INTRODUCTION

History reveals that, in 1939 at the outbreak of World War II, the United States found itself with no organized blood bank system. There were no plans for supplying whole blood or blood substitutes within the theaters of operation. By 1941, when this country became a belligerent in that war, a plasma program was beginning to evolve but a whole blood program was not yet planned. The high combat mortality attested to the inadequacy of the plasma program and it was soon discontinued.

Ten years later, at the outbreak of the Korean War, a blood bank system was implemented on the basis of expediency. Again, in 1962, a call for whole blood for a military exigency resulted in some disappointing experiences. Trained technical and supervisory personnel were not available in the numbers needed to satisfactorily staff the blood program. Supplying whole blood to US forces in Vietnam presented a number of logistic problems of enormous proportion: communications, transportation, handling of cargo, notification of arrival and departure, in-transit delays, and other unforeseen circumstances. Each one may have had an *appreciable* effect on the life of the blood and its usability upon delivery.

Today an emergency could very well expose a weak underdeveloped and ill-supported part of the blood banking system where quality blood and blood products are often sacrificed, that is, packaging and shipping. Because blood banking operations are so complex and interlaced by so many facets, it is imperative to maintain uniform progress in all segments of blood banking. Herein lies the purpose of this report.

With the advent and growing popularity of component therapy arise new problems of packaging and transporting. The efficacy of this kind of therapy is in a large measure dependent on proper temperature maintenance for the blood fractions, from phlebotomy to transfusion. General Kendrick's comment (1) during World War II remains a classic, when he reminds us that "blood and blood products are not commodities that can be collected and stored for extended periods. It must be made available when the need arises and the point of collection is seldom the point of administration." Even though blood banking has been revolutionized since this observation was made, the concept is as modern and valid as the day it was pronounced. For example, during World War I blood was collected within a 6- to 8-mile area, transported by ambulance over rough roads to a storage icebox and used within 10 to 14 days. In contrast, present-day blood banks provide blood and blood products with an increased shelf life to American and allied armies many miles from the collection point. Major problems common to both blood banking periods, which have become more specialized recently by the accepted practice of component therapy, are that of cargo coding, mechanical transport, and maintenance of

critical temperatures for preservation of the lifesaving product. With the addition of component therapy new packaging techniques must be developed.

MATERIALS AND METHODS

In the current practice of blood transfusion therapy, the trend is toward the replacement of the blood fraction or component deficient in the patient. The goal is to avoid overloading the patient with substances he does not need, to reduce his exposure to risks such as hepatitis, and at the same time to save the remaining fractions for other patients who have specific needs for them. Because blood is so complex and some deficiencies so rare, it would be an economically unsound practice to fractionate blood into all its components and hold them for routine clinical use. Nevertheless, even at the elementary level of considering blood as composed of three components (red cells, plasma, and platelets) the specific requirement for packaging and transporting is very much different.

Figure 1 indicates the extent of the Armed Forces blood program during the Southeast Asia conflict. Figure 2 shows the contribution made to this endeavor by the US Army Medical Research Laboratory at Fort Knox.

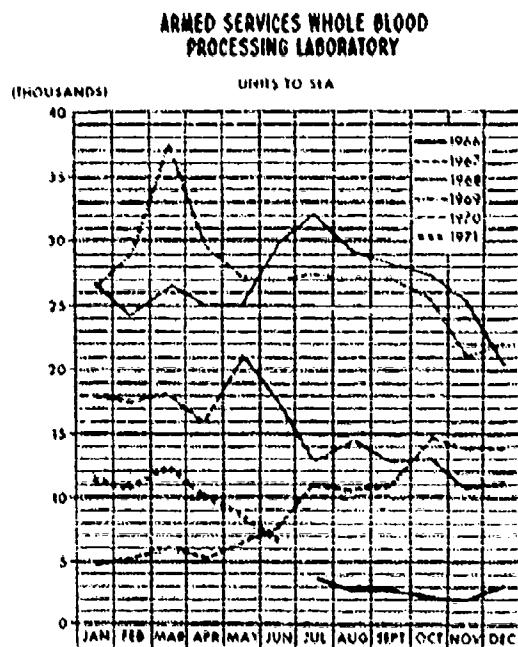


Fig. 1. Units processed for overseas shipment at the Armed Services Whole Blood Processing Laboratory, McGuire Air Force Base, New Jersey.

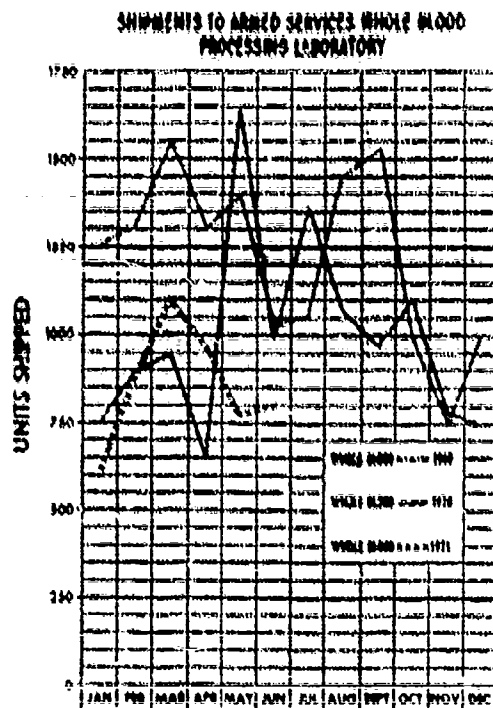


Fig. 2. Units shipped from US Army Medical Research Laboratory, Fort Knox, Kentucky, to McGuire Air Force Base, New Jersey.

As a result of these experiences in supplying blood, both stateside and overseas, it has been discovered that delivery of good quality whole blood, maintained between 4 and 10 C during shipment (2,3), is not insured merely by the presence of unmelted ice in the box upon arrival at the receiving terminal (4).

Figure 3 shows that when only half of the ice is melted the temperature of the blood may have exceeded the safe range. Previously, the assumption was that if ice was still present in the box, the blood had been maintained at a safe temperature (between 4 and 10 C).

It is also significant that re-icing the blood does not lower the temperature, but merely causes the temperature to plateau for a few hours. The need for a better insulated shipping box is clearly indicated. As a consequence, the old cardboard box was replaced with a styrofoam shipping box which provides protection from temperature fluctuations for longer periods.

Also, shipments of fresh frozen plasma were being destroyed because the plastic container became brittle when frozen and fragmented when

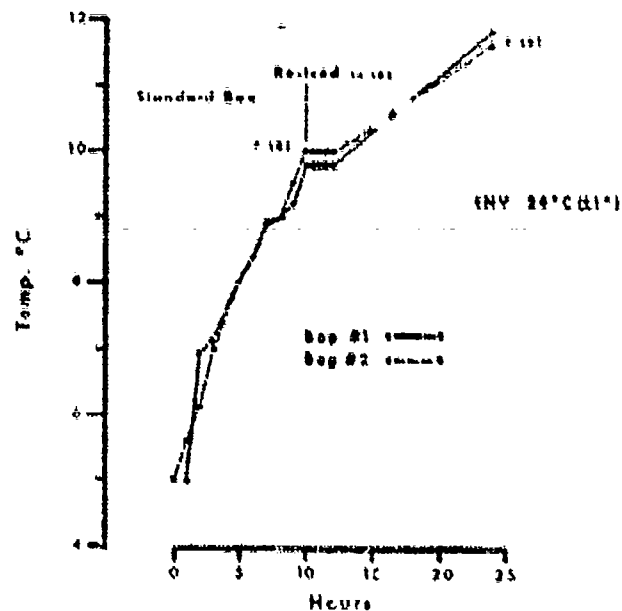


Fig. 3. Temperature plateau following re-icing of the blood box.

improperly handled. Lack of attention to the problem of cargo coding played an important role in the loss. A twofold effort was made by our laboratory to achieve a better percentage of delivery of this blood component. A material made up of trapped air bubbles between two plastic sheets* provided the cushioning needed and also had the unique properties of remaining flexible even at low temperatures. An article by McPeak et al which appeared recently in *Military Medicine* gives a pictorial detailed description of a very effective packaging technique (5).

Platelets (as PRP and PC) are another component continually playing a more prominent role in the therapeutic armamentarium of those caring for patients with hematologic disorders. With the advent of plastic phlebotomy equipment which allows safe manipulation of blood in a sterile closed system, platelets have been separated from other blood components and utilized either in the form of platelet rich plasma or platelet concentrates. The principal clinical indication for platelet infusion is in the treatment of the bleeding thrombocytopenic patient.

The best source of platelets is platelet concentrates. A 25 ml unit contains 70 to 80% of the platelets found in a unit of fresh whole blood.

* AIRCAP® - Presque Isle Paper Products, Inc., Louisville, Kentucky.

Platelets are processed from an individual donation of fresh whole blood and should be infused within 6 hours of donation for maximum benefit; however, they are still of therapeutic value up to 24 hours from time of donation. Assuming that the pretransfusion platelet count is virtually zero, platelets from at least 5 units of blood are required to provide an adult recipient with a platelet count of approximately 60,000/mm³. Thus, the expensiveness and need for preserving the platelet during shipment are apparent.

Murphy and Gardner (6) demonstrated the critical nature of temperature in platelet preservation. The optimal storage temperature is 22 C with a marked change at lower temperatures. Therefore, it is obvious that the technique for packaging and transporting this component is quite restricted. Platelets transported within a metropolitan area, where the "jiffy bag" is the common transporting container, may be totally inadequate.

Figure 4 shows the rate of temperature rise with platelets packed in the regular shipping container subjected to a controlled temperature of 31 C ± 0.5. The ideal temperature for preservation with respect to yield and life-span, according to Murphy and Gardner, has been exceeded by approximately 6 C in approximately 5 hours, resulting in a 10 to 20% loss.

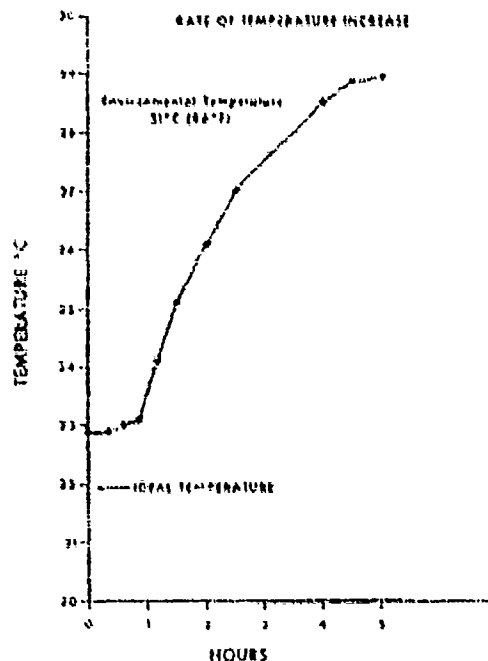


Fig. 4. Platelet shipment subjected to 31 C controlled environment.

Figure 5 shows results of the same insulated box containing platelet concentrates when subjected to a controlled environmental temperature of 5 C. A 9 C drop in temperature occurred in less than 2 hours, causing a 10 to 20% loss.

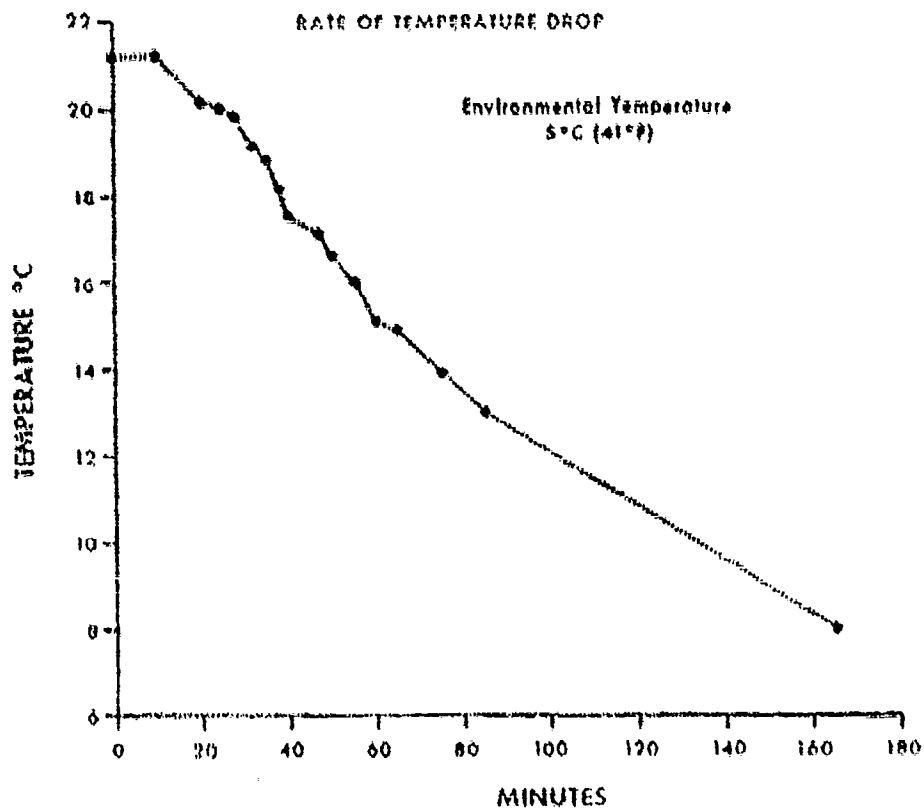


Fig. 5. Platelet shipment subjected to 5 C controlled environment.

Figure 6 shows the temperature recorded within a styrofoam shipping container packed with 60 units of platelet concentrates at Fort Knox, Kentucky, and shipped to Walter Reed Army Community Blood Center. This shipment was made on a typical Kentucky January day, with the highest ambient temperature reaching 22 C at 1430 hours and a low of 12 C at 0600 hours. You will note a marked decrease in temperature from 22 C to approximately 12 C. This occurred in the time interval between the processing laboratory and plane onloading. Later in the course of shipment the temperature approximated 10 C. The survival of platelets in this shipment, according to Murphy and Gardner (6), would be 20%.

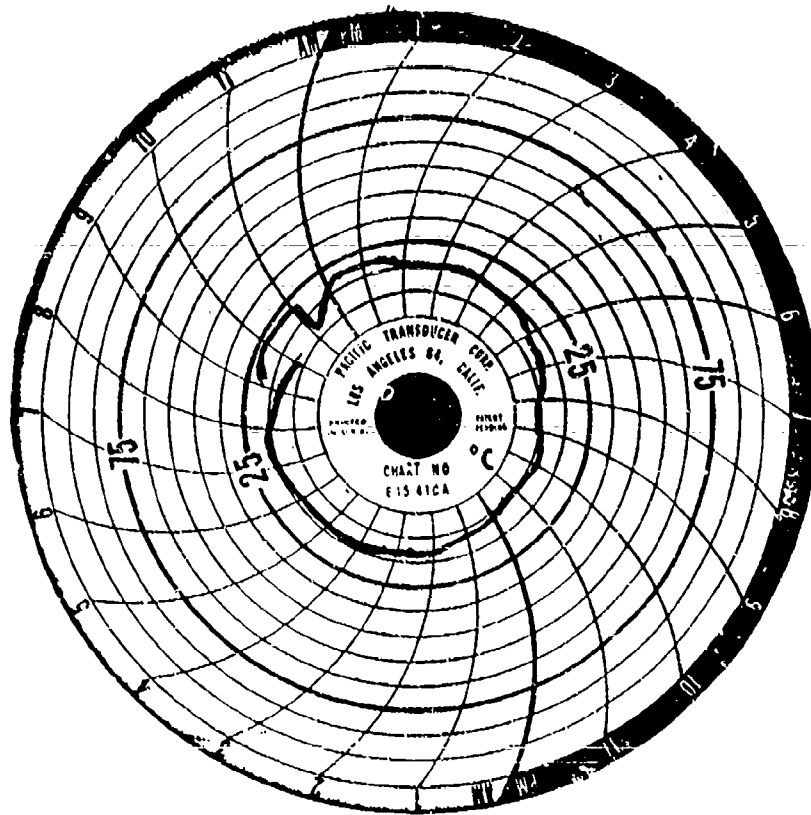


Fig. 6. Temperature as recorded in an actual shipment of platelets from US Army Medical Research Laboratory, Fort Knox, Kentucky, to Walter Reed Army Community Blood Center, Washington, D. C.

DISCUSSION

The findings in this study clearly point out that the quality of blood and components received by the patient is dependent, to a considerable degree, upon the manner in which the product is packed and expedited through shipping channels. An aggressive research effort directed toward updating the latent cargo coding system, along with the many other often overlooked aspects of blood component logistics, is imperative if satisfactory progress is to be achieved.

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