Temperature Changes in Donor Blood under Different Storage Conditions

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Units of whole blood freshly collected in plastic bags or conventional bottles required up to 2½ hr at refrigeration temperature before the core temperature fell below 10 C. Subsequent incubation at room temperature raised the core temperature of the blood units past an acceptable 10 C limit within 45 to 60 minutes.

IT IS generally agreed that donor blood should be maintained at temperatures which are slightly above 0 C to avoid actual freezing with subsequent damage to the red blood cells. For example, Parpart *et al.*[6] have reported the optimum storage temperatures for donor blood to be within the range of 4 C to 10 C.

It has also been shown that brief interruption in the refrigeration of stored blood can have deleterious effects such as breakdown of adenosine triphosphate in the erythrocytes.[5] Although the effect of warming is not great, it becomes cumulative as the blood is alternately warmed and cooled.

The present study was undertaken to determine, under closely controlled conditions, the actual thermal changes occurring when freshly drawn donor blood is cooled and then incubated at room temperature.

Materials and Methods

Temperature Measurements

Units of whole blood were collected in plastic bags or conventional bottles containing acid–citrate–dextrose solution (ACD). A thermistor, protected from the environment, telethermometer probe was attached to the outside and a second probe was inserted into the center of each blood container to measure temperature changes at desired times.

To evaluate the rate of cooling, both core and surface temperatures were taken at 15-minute intervals starting with units of blood withdrawn from donors and placed immediately in the refrigerator (1 C). The units of blood were then allowed to equilibrate to refrigeration temperature. Once a steady temperature state in the refrigerator was obtained, the containers were removed from the refrigerator and placed at room temperature. At room temperature, temperature measurements were taken at 15-minute intervals for a period of 180 minutes. Temperature increases of seven donor blood units drawn in plastic bags were measured and compared with temperature increases of 12 donor units stored in conventional bottles. Both bottles and plastic bags were placed at room temperature and handled in a similar manner, as is often done during matching tests. An additional 14 units of blood drawn in plastic bags were placed at room temperature and left unhandled. Temperature readings of these blood units were recorded as above. The room temperature during these experiments varied between 22.2 C and 24.4 C.

Results

Core and Surface Temperature Reduction when Blood Units Obtained from Donors were Placed in the Refrigerator Immediately

Figure 1 shows a typical pattern of core and surface temperature changes when a blood unit, collected from a donor in a plastic bag, was refrigerated immediately. A recommended internal storage temperature of less than 10 C was not reached for several hours. The core and surface temperatures were lowered in a comparable manner, with the temperature depression being slightly greater on the outside

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TABLE 1. *Effect of Room Temperature Storage on Surface and Core Temperatures of Blood Containers*

	Storage Time (min)												
	0*	15	30	45	60	75	90	105	120	135	150	165	180
Average temperature of 14 units of unhandled blood stored in plastic bags													
Core temperature (C)	0.6	4.1	7.1	9.6	11.5	13.2	14.6	15.7	16.7	17.6	18.3	18.9	19.4
Surface temperature (C)	3.6	9.4	11.5	13.2	14.5	15.8	16.8	17.6	18.3	19.0	19.5	20.0	20.5
Average temperature of 12 units of handled blood stored in glass bottles													
Core temperature (C)	0.3	3.5	6.5	8.9	11.0	12.7	14.0	15.2	16.2	17.1	17.7	18.4	18.9
Surface temperature (C)	0.5	8.9	11.0	12.7	14.0	15.1	16.2	17.0	17.1	18.4	19.0	19.4	19.9
Average temperature of 7 units of handled blood stored in plastic bags													
Core temperature (C)	0.5	3.3	6.9	8.6	10.3	11.7	13.1	14.2	15.0	16.0	16.7	17.3	17.8
Surface temperature (C)	2.7	8.3	10.5	11.8	13.3	14.5	15.6	16.2	17.0	17.8	18.4	18.8	19.3

* All containers initially were stored in the refrigerator until equilibration at refrigeration temperature had occurred. The containers were then removed from the refrigerator and placed at room temperature. Measurements were taken at the stated time intervals.

than on the inside of the container. For example, the surface temperature reached 5 C after about 170 minutes, whereas this was not attained in the core until 240 minutes had elapsed.

Core and Surface Temperature Increases when Blood Units were Removed from the Refrigerator and Placed at Room Temperature

Table 1 gives the results of tests in which blood units in plastic bags or conventional bottles were removed from refrigeration and left at room temperature. Individual core temperatures of the specimens showed a surprising degree of uniformity, ranging from 0.3 C to 0.8 C (average 0.5 C) for plastic bags and —0.1 C to +1.4 C (average 0.3 C) for the bottles immediately after they were taken from the refrigerator. There was a prompt rise in core temperature of all the units upon standing at room temperature. For example, after 15 minutes, core values rose to a mean of 3.3 C (range 2.8 C to 4.4 C) for plastic bags and 3.5 C (range 1.7 C to 4.7 C), respectively, for bottles. By 45 minutes, average core readings of plastic bags and bottles were 8.6 C and 8.9 C, respectively. At the end of the 180-minute observation period the core temperatures had risen on the average to 17.8 C for plastic bags and 18.9 C for bottles.

Temperatures on the surface of units of blood in plastic bags were higher than those of the core, varying from 1.9 C to 3.1 C (average 2.7 C), but they were similar —0.1 C to 1.4 C (average 0.5 C) to the surface temperatures noted for bottles upon removal from the refrigerator. In the ensuing 15 minutes, surface readings rose to an average of 8.3 C (range 7.6 C to 8.8 C) for plastic bags and an average of 8.9 C (range 6.6 C to 10.3 C) for bottles. By 60 and 180 minutes the differential between surface temperatures remained at 0.6 C for both containers.

Handling of donor units of blood in plastic bags, contrary to expectation, did not increase the temperature of the core or surface over that observed with the unhandled bags. In fact, the core and surface temperature remained on an average between 1 C and 2 C below that of the undisturbed plastic bags at each time interval observed.

Discussion

It has been reported that a sustained moderately rapid rate of cooling of donor blood is an important determinant of

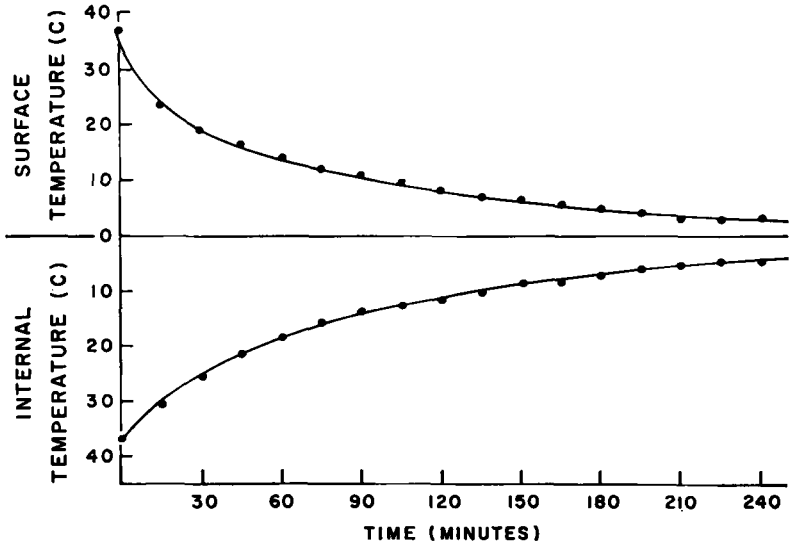

FIG. 1. Core and surface temperature changes of a unit of blood drawn from a donor and immediately refrigerated (1 C).

erythrocyte survival.[2] Our findings demonstrate that the core and surface temperatures decrease in a parabolic manner when units of blood are placed at 1 C and that about two and one half hours at this temperature is required before the internal temperature of the blood unit falls below 10 C. However, this slow progressive rate of cooling may be desirable since it has been reported that too rapid cooling may impair natural ability of blood to eliminate contaminating microorganisms.[3, 4]

Most authoritative groups, including the American Association of Blood Banks, share the view that donor blood should never be allowed to rise above 10 C during storage. It has been demonstrated that the viability of erythrocytes is diminished significantly when blood is allowed to approach 10 C.[1] Our findings show that donor blood, whether stored in plastic or glass containers, is subject to rather rapid increases in temperature when removed from refrigeration, and that core temperatures of blood regardless of the container will exceed 10 C between 45 minutes and 1 hour during storage at room temperature. A reasonable degree of handling within this time period does not markedly alter the pattern of thermic changes.

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