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Temperature Management of Red Blood Cell Solution Transported by Car for Transfusion at Home

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Abstract

Objective: In Japan, red blood cell (RBC) solution is usually transported by car from a medical institution to the patient's house for home transfusion. However, there are no regulations for transporting blood by car in the medical setting. Therefore, we assessed and compared the methods (containers) used for transporting the RBC solution by car. **Materials and Methods:** Irradiated RBC solution samples (280 mL) supplied by the Japan Red Cross Society were each divided into two bags. The quality of blood transported by car (1 - 2 hours) in an active transport refrigerator (ATR) (control group) was compared with that transported in a cooler, or styrofoam box (study group). We tested the hemolytic effects of transportation by car, storage, and filtration through a transfusion set on the lactate dehydrogenase (LD) levels in the RBC solutions. **Results:** Post-filtered LD levels were significantly higher in the RBC solutions transported in a cooler-box with inadequate temperature control when compared to those transported in an ATR with optimal temperature control. However, under conditions of optimal temperature control, the post-filtered LD levels were comparable in the control and study (both cooler and styrofoam boxes) group RBC solutions. **Conclusion:** Temperature management is critical for the maintenance of the quality of the RBC solution transported by car.

Keywords

Car Transport, Red Blood Cell Solution, Hemolysis

Letter to the Editor

In Japan, the required temperature during storage and transportation of red

blood cell (RBC) solution is 2˚C - 6˚C. We have previously reported that an active transport refrigerator (ATR) (FUJIFILM Toyama Chemical Co. Ltd., Tokyo, Japan), is optimal for the long-distance transportation of RBC solution from Tokyo city to the Ogasawara islands by ship [1]. However, blood is usually transported by car from a medical institution to the patient's house for home transfusion, but there are no regulations for transporting blood by car in the medical setting. In this study, we compared the transportation of RBC solution by car using an ATR, a cooler box (Campers Collection, Yamazen, Corp., Tokyo, Japan), and a styrofoam box. Irradiated RBC solution samples (280 mL) obtained from the Japan Red Cross Society, were each divided into two bags. We assessed and compared the quality of these solutions after being transported by car (1 - 2 hours) in an ATR (control group), and cooler or styrofoam box (study group). While the ATR has a system of recording the inside and outside temperature, the cooler or styrofoam box has an electronic watch logger (TR-5i, T&D Co. Nagano, Japan) that records the temperature. A solid coolant (Cold-packs Type 3, JSP Corp., Tokyo, Japan) that changes to a liquid state at approximately 4˚C was used to control the temperature of the RBC solution in the cooler or styrofoam box with a cold storage agent (−20˚C) attached under the lid.

The present study design involved six car-driven trials and blood tests. The study was approved by the Institutional Review Board of the Tokyo Metropolitan Bokutoh Hospital.

We compared the quality of the transported blood in the control and study groups based on levels of lactate dehydrogenase (LD), aspartate aminotransferase (AST), potassium, blood sugar, lactate, ammonia, and hematocrit. While the LD measurements were most specific and sensitive for comparison, the other measurements showed no significant differences between the control and study groups (data not shown).

Table 1 shows the hemolytic effects of transportation and filtration through a transfusion set (Terumo Co. Ltd., Tokyo, Japan) on the LD levels in the RBC solutions. In addition, we also examined the LD levels in the RBC solutions stored for five days after being transported by car (Table 1). Compared to the control group, the RBC solutions transported in a cooler-box with inadequate temperature control showed increased post-filtered LD levels (120 ± 4 IU/L vs. 140 ± 2 IU/L, $p < 0.05$). However, under conditions of optimal temperature management, the post-filtered LD levels in the RBC solutions were comparable in the control and study (cooler box) groups (131 ± 8 IU/L vs. 130 ± 7 IU/L, not significant). Similar results were seen in a comparison of the post-filtered LD levels between control and Styrofoam box groups (94 ± 2 IU/L vs. 105 ± 3 IU/L, not significant). Additionally, five days of storage after the car-drive had no effects on the LD levels in both the control and study groups. However, the post-filtered LD levels in the RBC solutions transported in the cooler box declined in comparison with those transported in the Styrofoam box (Table 1, experiments 1 - 4). The post-filtered LD levels in the RBC solutions after five days of storage were significantly lower when transported in the styrofoam box compared to in

the ATR (Table 1, experiment 4). During transportation, the RBC solution was placed vertically in the ATR, while it was placed horizontally in the styrofoam box. We speculate that an increase in LD levels in the blood transported in the ATR could be due to the oscillation during the car ride. Five days after transportation, the post-filtered LD levels were significantly higher in the RBC solutions that were transported by car compared to those that were transported by means other than a car (137 ± 3 IU/L vs. 119 ± 4 IU/L) (Table 2, experiment 5). In addition, we examined the effects of the placement of the RBC solution during transportation on LD levels. The RBC solution, when placed vertically, had significantly higher LD levels compared to when it was placed horizontally (99 ± 3 IU/L vs. 56 ± 3 IU/L) (Table 2, experiment 6). The LD levels in the vertically placed solutions remained higher than the horizontally placed ones, even five days after being transported (142 ± 4 IU/L vs. 80 ± 3 IU/L) (Table 2, experiment 6).

Table 1. Effects of transporting red blood cell solution under different conditions by car on lactate dehydrogenase levels.

Experiment No.	Driving time (hours)	Box used for transportation	Temperature (˚C)	LD (IU/L) After trans port	LD (IU/L) Post-filtered	LD (IU/L) After storage for five days	LD (IU/L) Stored and post-filtered
1	1	Control	2 - 6	84 ± 9	120 ± 4	120 ± 6	137 ± 4
		Cooler-box	>6	89 ± 5	140 ± 2*	115 ± 7	157 ± 6*
2	2	Control	2 - 6	106 ± 2	131 ± 8	128 ± 6	145 ± 2
		Cooler-box	2 - 6	93 ± 5	130 ± 7	135 ± 7	166 ± 11*
3	1	Control	2 - 6	55 ± 4	78 ± 2	54 ± 4	77 ± 5
		Styrofoam box	2 - 6	54 ± 3	72 ± 2	54 ± 3	71 ± 3
4	2	Control	2 - 6	69 ± 4	94 ± 2	96 ± 9	131 ± 3
		Styrofoam box	2 - 6	77 ± 3	105 ± 3	108 ± 1	111 ± 11*

LD levels were measured by Biomedical Laboratories Company (Tokyo, Japan). Data (N = 4) are expressed as group mean ± standard error. All statistical calculations were performed using JMP version 8.0 software (SAS Institute, Inc., Cary, NC). We tested for differences in the baseline characteristics between control group vs. study group using the Wilcoxon's test. A *P*-value < 0.05 was considered significant (*). RBC solution was placed vertically in the ATR, and horizontally in the cooler or Styrofoam box.

Table 2. Effects of different modes of transportation and the placement of the RBC solution bag during transportation on lactate dehydrogenase levels.

Experiment No.	Driving time (hours)	Mode of transportation using an active transport refrigerator	Temperature (˚C)	LD (IU/L) After transport	LD (IU/L) Post-filtered	LD (IU/L) After storage for five days	LD (IU/L) Stored and post-filtered
5	2	Car-driven#					
		RBC 5-1	2 - 6	102 ± 2	NE	NE	NE
		RBC 5-2	2 - 6	158 ± 6	NE	NE	NE
		RBC 5-3	2 - 6	73 ± 2	NE	92 ± 4	137 ± 3
		No transport#					
		RBC 5-1	2 - 6	94 ± 3	NE	NE	NE
		RBC 5-2	2 - 6	179 ± 52	NE	NE	NE
		RBC 5-3	2 - 6	76 ± 6	NE	92 ± 5	119 ± 4*
6	1	Car-driven					
		Vertically placed	2 - 6	99 ± 3	150 ± 5	142 ± 4	NE
		Horizontally placed	2 - 6	56 ± 3*	112 ± 22	80 ± 3*	NE

#Three samples of irradiated RBC solution (280 mL each) supplied by the Japan Red Cross Society were divided into two bags each, (RBC 5-1, 5-2, and 5-3). Data (N = 4) are expressed as group mean ± standard error. All statistical calculations were performed using JMP version 8.0 software (SAS Institute, Inc., Cary, NC). We tested for differences in the baseline characteristics between the car-driven group (vertically placed group) vs. no transport group (horizontally placed group) using the Wilcoxon's test. A *P*-value < 0.05 was considered significant (*). NE: not examined.

In conclusion, we have shown that inadequate temperature management during transportation by car can increase the risk of hemolysis of RBC solution. In addition, oscillations during the car ride can also induce hemolysis, which is consistent with previous studies that have reported the hemolysis of erythrocytes caused by oscillation [2]. We have also previously reported that transportation by drones and cars can increase the LD levels in RBC solutions due to oscillation [3] [4]. Therefore, RBC solutions should be transported from the medical institution to the patient's house at the optimal temperature without oscillations, using an ATR or a styrofoam box.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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