Original Article

Evaluation of the pneumatic tube system for transportation of packed red cell units

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Abstract:

Background: Pneumatic tube system (PTS) is commonly used in hospital settings to transport blood samples to diagnostic laboratories. At our blood center, we receive blood requisitions via the PTS, but units are carried to the ward by human courier. Recently we considered using the PTS for transporting blood units. Since, there are reports of hemolysis in blood samples sent through the PTS, we evaluated this system for transporting red cell units. **Aims:** The aim was to assess the effect of PTS transport on the quality of packed red cell units. **Materials and Methods:** A total of 50 red blood cells units (RBC), (25 non-irradiated and 25 irradiated) were subjected to transportation through the PTS. The control arm in the study was age-matched RBC units not subjected to PTS transport. Each RBC unit was evaluated for hemoglobin (Hb), lactate dehydrogenase, potassium and plasma hemoglobin (Hb). The paired *t*-test was used to compare these parameters, and the *P* value was calculated. **Results and Conclusion:** The percentage of hemolysis after transportation through PTS was below the recommended guidelines. Delivery of the blood unit to the wrong station, bags lying unattended at the destination were few of the problems that had to be addressed. To conclude, though the PTS is a safe means of transporting blood products with reduction in the turn-around-time, it must be validated before use.

Key words:

Hemolysis, pneumatic tube system, transportation of red cell units, validation

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Introduction

Blood product transport from the blood bank to the patient care areas of hospitals is a key step in the transfusion chain. During the transportation of blood products, there must not be any alteration in its quality and the transport must be safe and error free. The pneumatic tube system (PTS) is a rapid, simple, secure, and reliable way for transportation of blood samples in hospital settings. It is commonly used to transport blood samples to diagnostic laboratories and has less often been used to transport blood products. Reports on the use of PTS for blood product transportation are very limited.

Various factors in the PTS can affect the quality of the blood product. These include the type of transport carrier, the transportation speed and number of bends within the system.[1] During the transit, the blood product is subject to acceleration and deceleration forces which can further exacerbate the biochemical and functional changes caused by processing and storage. Mechanical forces on a packed red cell unit can result in red cell hemolysis, which can cause non-immune hemolytic transfusion reaction in the recipient. Hence, it is necessary to validate the transport system before it is used to transport blood products.

Since the inception, our transfusion services have been receiving blood product requisitions (from emergency, day care and wards) through the PTS. Recently, there was a proposal to start sending blood components using this transport system.

The objective of our study was to validate the use of our PTS for the transportation of packed red blood cells (PRBC) within the hospital.

Materials and Methods

A total of 50 RBCs prepared from triple 450 ml SAGM (saline, adenine, glucose and mannitol) bag (Terumo penpol), were subjected to transportation via the PTS. These included 25 non-irradiated RBC units and 25 irradiated RBC units. The storage periods of the former category ranged from day of collection to 42 days of storage and for the latter category storage periods ranged from day of collection to 28 days or date of expiry whichever was earlier. The blood bag was wrapped in a double plastic pack to contain any potential spills and then placed in the transport canister. Ours is an hemoto-oncologic center with a bone marrow transplant unit and majority of our blood products are irradiated. Since irradiation is known to be associated with increased hemolysis, we included irradiated blood units as a separate category to ensure that there is no increased hemolysis when such units are subjected to PTS transport. PTS system used in our hospital is from Aerocom, Germany, Indian Partner: Protos

Engineering Pvt. Ltd. This connects a total of 26 stations. The air compressor pump at each of the stations can suck or blow air. When it sucks, it pulls canisters along the tube toward the station; when it blows, it pushes the canisters in the opposite direction. The speed of Canister during transit is 6 m/s. The blood irradiator used for the irradiation of RBC units was cobalt radio-isotope irradiator, model BI-2000 which delivered a dose of 25 Gy over 3 min 15 s.

The control arm in our study was similar aged blood units, stored in the blood bank. Practically, it was not possible to sample the blood unit after such transport to the various wards and so we presumed that the changes after transport by human courier (HC) would be the same as changes due to storage as the transportation of the blood product was done using insulated transport boxes maintaining the cold chain. The units were assessed for hemoglobin (Hb) concentration, lactate dehydrogenase (LDH), potassium and plasma Hb. Hb was measured using the Beckman Coulter-LH 780. For measuring plasma Hb, Hemo Cue Plasma/Low hemoglobin (Hb) System was used. Lactate dehydrogenase (LDH) was measured using ultraviolet kinetic, pyruvate, automated dry chemistry auto-analyzer. Potassium estimation was done using the ion-sensitive electrode, direct potentiometry, automated dry chemistry auto-analyzer. All the equipment used were regularly calibrated, and controls were used as appropriate. Validated protocols were used for the assessments.

Statistical analysis

Paired *t*-test was used to assess the statistical difference between the groups. $P < 0.05$ was considered to be statistically significant.

Results

Results of each of the parameters, Hb, plasma Hb, potassium and LDH for both the categories, were compared before and after transportation through PTS [Tables 1,2,4,5]. The *P* value, which was determined using thea paired *t*-test was statistically not found to be significant (<0.05).

Using the above parameters, the percentage of hemolysis was calculated [Table 3]. Percent hemolysis was calculated using the formula: (100-hematocrit) × free plasma Hb/total Hb. The percentage of hemolysis was well below the recommended guidelines. The permissible hemolysis as per FDA guidelines is 1%[2] and as per European guidelines is 0.8%.[3]

Discussion

The PTS also called capsule pipelines, or Lamson tubes are transport systems in which cylindrical containers are propelled through a network of tubes by compressed air or by partial vaccuum.[4] Studies pertaining to the transportation of blood products through the PTS are very limited and to the best of our knowledge there are no reports from India.

The effect of PTS transport on blood samples has frequently been reported in the literature. Cui *et al*, assessed the influence of PTS transport on serum LDH and potassium of blood specimens. They observed that when samples were sent with no carrier insert (either sponge-rubber/plastic-bag) and when samples were subjected to multiple transportation (9 times) serum potassium and LDH was

Nonirradiated units

Table 1: Comparison of parameters in control arm and postPTS transport

Parameters	Control	PostPTS	*P*
Hemoglobin (g/dl)			
Range	15-24.5	15.4-26	0.49
Mean (SD)	18.68 (2.62)	19.23 (3.00)	
Potassium (mmol/l)			
Range	6.06-18.8	5.85-18.64	0.97
Mean (SD)	12.99 (3.92)	13.01 (4.23)	
Plasma hemoglobin (g/dl)			
Range	0.05-0.57	0.02-0.64	0.83
Mean (SD)	0.22 (0.16)	0.23 (0.17)	
Plasma LDH (μ/L)			
Range	338-1902	299-1925	0.92
Mean (SD)	737.4 (411.46)	748.76 (421.65)	

SD: Standard deviation; PTS: Pneumatic tube system; LDH: Lactate dehydrogenase

Irradiated units

Table 2: Comparison of parameters in control arm and postPTS transport

Parameters	Control	PostPTS	*P*
Hemoglobin (g/dl)			
Range	16.1-24.8	16.3-26.3	0.68
Mean (SD)	21.27 (2.50)	21.58 (2.78)	
Potassium (mmol/l)			
Range	10.7-24.5	10.3-26.4	0.79
Mean (SD)	15.42 (4.04)	15.74 (4.27)	
Plasma hemoglobin (g/dl)			
Range	0.02-0.58	0.03-0.60	0.83
Mean (SD)	0.23 (0.16)	0.24 (0.16)	
Plasma LDH (μ/L)			
Range	300-1758	300-1815	0.91
Mean (SD)	814.6 (385.07)	826.8 (405.76)	

SD: Standard deviation; PTS: Pneumatic tube system; LDH: Lactate dehydrogenase

Table 3: Percentage hemolysis in control arm and postPTS transport in nonirradiated and irradiated units

Percent hemolysis	Nonirradiated		Irradiated	
	Control %	PostPTS %	Control %	PostPTS %
Range	0.15-0.90	0.14-0.76	0.07-0.63	0.07-0.8
Mean	0.4	0.3	0.28	0.32

A comparison of each of the four parameters in the control arm and PTS arm (blood units sent through the pneumatic tube system), for the irradiated and non-irradiated categories was performed on different storage days; The results are as follows:

Nonirradiated unit

Table 4: Day wise comparison of parameters in the control arm and postPTS transport

Day	Hemoglobin	Potassium	LDH	Plasma hemoglobin	Percentage of hemolysis
Day 7					
Control	17.3	13.7	580	0.19	0.52
PostPTS	17.2	13	578	0.17	0.47
Day 15					
Control	22.5	17.7	751	0.36	0.52
PostPTS	24.5	17.1	815	0.37	0.40
Day 25					
Control	17.9	16.5	1716	0.21	0.54
PostPTS	17.7	18.5	1733	0.18	0.47

PTS: Pneumatic tube system; LDH: Lactate dehydrogenase

Irradiated unit

Table 5: Day wise comparison of parameters in the control arm and post PTS transport

Day	Hemoglobin	Potassium	LDH	Plasma hemoglobin	Percentage of hemolysis
Day 7					
Control	21.4	12.1	578	0.15	0.25
PostPTS	22.2	11.6	586	0.19	0.28
Day 15					
Control	19.8	10.2	914	0.18	0.36
PostPTS	20.3	9.8	934	0.19	0.36
Day 25					
Control	23.3	16.6	929	0.3	0.38
PostPTS	23.7	16.9	1039	0.32	0.39

PTS: Pneumatic tube system; LDH: Lactate dehydrogenase

affected. They also noted that levels of LDH and potassium were altered in under-filled or un-clotted specimens sent via PTS, and that serum LDH was more affected than potassium.[1] In a study by Kara *et al*, it was seen that blood samples transported by PTS had a greater frequency of hemolysis; with increased potassium and LDH levels as compared with samples transported manually.[5] In another similar study, Sodi *et al*. evaluated the effect of PTS induced hemolysis on clinical biochemistry samples and found plain serum samples more susceptible to hemolysis than the other sample types.[6]

In the literature, studies on the use of PTS for transportation of blood components are limited, and no adverse effects on the component quality have been observed. Hellkamp *et al*. found no deterioration in quality of PRBC units subjected to PTS transport.[7] In a similar study by Liebscher *et al*., no significant changes were noted.[8]

The effect of PTS transport on PRBC, platelet concentrates, and fresh frozen plasma was studied by Tanley *et al*. They found that post PTS transport, quality parameters of these blood components were within the normal reference range.[9] Sandgren *et al*. studied the effect of pneumatic tube transport on fresh and stored platelets in additive solution. No adverse effects on the platelet quality were observed.[10] Hardin *et al*. in their study of transportation of 14 units of AS-1 RBCs by PTS, found negligible hemolysis and also found it to be time and labor saving.[11] Tiwari *et al*. in their study evaluated whether the speed of sample transportation through PTS affected the degree of hemolysis. They found that LDH was elevated in PTS arm in the "short distance and high speed" phase and in the "long distance and high speed" phase, all three indices of hemolysis-Hb, K+ and LDH-showed elevation in the PTS arm. However, at "short distance and slow speed" phase, there was no hemolysis in the PTS arm.[12]

In the present study, PRBC units were assessed for hemolysis after transportation through the PTS. We also included irradiated PRBC units, as many of the PRBC units issued are irradiated this being an oncology center, and it is known that irradiation can potentiate potassium leak across the red cell membrane.[13] However, we found no evidence of any increase in hemolysis in the irradiated PRBC units subjected to PTS transport, and the parameters for hemolysis were comparable to those for the non-irradiated PRBC units.

Our study highlighted certain practical problems, which required to be addressed before we could routinely implement the system. These included delivery of the blood unit to the wrong station, bags stuck in transit and bags lying unattended at the destination. Each of these issues had to be addressed separately. The Biomedical staff maintaining the PTS helped resolve some of the issues. The nursing staff in the wards and day care center was sensitized for safe transfusion practices. Emphasis was laid on handling of the blood bags at the receiving station as there could be deterioration in the red cell quality if the blood bag lies unattended (out of the refrigerator) for more than ½ h.

In addition, the Blood bank staff had to be trained for appropriate packing of the blood bag into the canister and timely coordination with the delivery station staff. Besides a standard operating procedure describing the protocol for requesting and receiving blood components via PTS has also been framed. Hospitals that use PTS for delivery of blood components like the Massachusetts General Hospital have their own PTS guidelines.[14]

The speed of the PTS is 6 m/s, and the distance from the blood bank to various delivery stations ranged from 10 m to 665 m. Hence, the transit time through the PTS ranged from 1.6 s to 1 min 50 s. Human courier is normally used in our hospital to transport units within the hospital premises using insulated transport boxes. In contrast to PTS, blood units that were transported by HC, took around 5 to 10 min depending on the distance of the ward from the blood bank. At times, the HC would stop over at some other station for another errand leading to unnecessary delay. Therefore, the turn-around-time was indeed much less with PTS when compared to the HC transports system. Besides this, the use of the PTS allowed better use of manpower for other tasks.

Conclusion

The PTS is a very effective means of transport for blood products. The turn around time is less with better utilization of manpower. However, inherent differences may exist among different PTS, and mechanical forces can induce hemolysis in red cell bags. Hence, to ensure safe transfusion, it is recommended that validation of the transport system be undertaken before it is used to transport blood products for patient use.

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