REVOLUTIONIZING BLOOD DELIVERY : PNEUMATIC TUBE SYSTEM FOR BLOOD COMPONENTS TRANSPORT

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BACKGROUND

Pneumatic tube system (PTS) is a widely used method of transporting blood samples in hospitals. Blood components transport from the blood centre to patient care areas of hospitals is a key step in the transfusion chain. Urgent blood component transfusion may be life saving for patients with cardiac disease. Transport time is one of the factor in delay in transfusion in urgent need. So use of PTS is helpful to shorten the transport time of blood components. At our blood centre, we receive blood requisitions via the PTS so we considered using PTS for transporting blood components. Since, there are reports of hemolysis in blood samples through the PTS, delivery of blood units at wrong place, leakage of blood, no proper cold chain maintenance during delivery of blood units through PTS system. We evaluated this system for transporting all blood components i.e. PRBC, FFP, Platelets and cryoprecipitate.

As a 1251-bed tertiary cardiac care hospital, our centre issues an average of 130 different blood components for transfusion each day. Timely and accurate delivery of blood products is crucial to ensuring quality care for our patients. To assess the impact of the newly implemented pneumatic tube system on blood component quality, we conducted a thorough evaluation following its introduction.

AIM: To find efficiency of logistic management and to validate the use of PTS for transportation of blood components within the hospital.

MATERIALS AND METHODS

Description of pneumatic tube system :

The PTS was installed at our centre in March 2020 and has been commissioned in six zones, comprising a Total of 59 stations within the hospital premises. This has a computer controlled network of tubes (6 inches diameter] supplied by Swisslog Germany. System specifications are described in Table 1. The system requires negative and positive air pressure generated by a motor located at the pneumatic station hub for the transportation of the carriers, which traverse in 3 blocks of hospital premises A, B and C. The “tube carriers” are made of high impact resistant u-polycarbonate material [pvc material] which are 4.5 inch in diameter and 17.5 inches length with RFID System. Sponge carrier insert was used for protection of blood bags during transportation. The allowable maximum load that could be transferred in one carrier at a time was 3 kg. Upon arrival at the destination station, the carrier is decelerated by an air cushion and dropped gently into a receiving basket. Once the carriers are sent through the tubes, its movement can be tracked from the computer control room. The time of dispatch and the time of delivery can be monitored and the time taken between two stations can be calculated.

We divided the PTS connectivity inside the hospital premises in three zones in meters from the blood centre.

1. Zone 1 : Distance from blood centre to A block approx 250 m (Intensive Care Unit, adult general ward,pediatric general ward, PICU, NICU, Special room, CTOT,PCTRR,ACTRR, Paediatric OT and SICU.]

2. Zone 2: Distance from blood centre to B block approx 250 m (Cath lab, MICU, Cardiology ward 1 to 3, special room]

3. Zone 3 : Distance from blood centre to C block approx 250 m [cardiology 4 and 5, General ward].

Location of pneumatic tube system “station hub/ controlroom”

PTS station hub/control room is situated about 100 m away from the blood centre. At our centre, in case the carriers get stuck in the tubes, it can be visualized in this computer control room. This helps in quickly identifying the route where there is blockage so that necessary repairs can be undertaken immediately.

STUDY METHODOLOGY

We had taken trial run to compared the time taken by the PTS and the HBT [Human blood transport] to deliver the blood components from the blood centre to the bedside. The TAT was defined as the total time taken from the point of issue of blood till it reaches the patients’ bedside. The TAT for HBT was calculated by measuring the mean time taken by 10 different individuals to reach their respective destinations. The TAT for PTS was the time of sending the carrier and reaching the desired destination, which was obtained from the computerized display. As per our departmental policy, whenever there was any delay in receive back of pts carrier at blood centre for more than 10 min, a phone call was made to the wards for the confirmation of receipt of the carrier. Therefore, any technical error or failure of the delivery of blood units by the carrier to its destination was also tracked and subsequently noted for further action if a need for any such situation arose. We have biomedical dept 24X7 working for immediate action on priority basis for any issue in PTS system. We prepared a standard operating procedure on transport of blood components through PTS and got it approved by the hospital transfusion committee before the process standardization.

In a tertiary cardiac institute with 1251 beds, 100 blood components were transported using the Pneumatic Tube System (PTS) (Swisslog GmbH, Germany), which spans 59 stations across 3 blocks and 8 floors. The PTS operates at an average speed of 4-5 m/s, and the study assessed the transport of various blood components, including PRBCs, thawed fresh plasma, cryoprecipitate, and platelet concentrate (RDP). Pre- and post-transport evaluations of transport time, visual appearance, and quality control parameters were compared to determine the system's effect on these components.

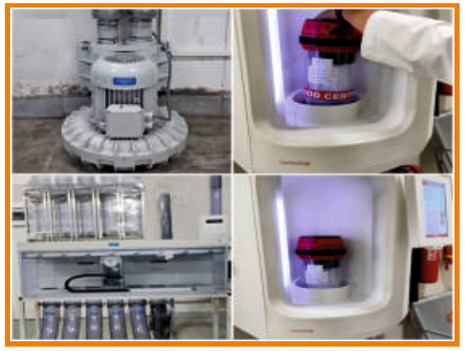

Figure 1 Parts of pneumatic tube system: [a]Blower[b] pneumatic tube system carrier with blood bag and receiving basket [c] Polyvinylchloride tubes [d] leak proof pts carrier with cushion with attached computer screen.

Table 1: Pneumatic tube system design

Specifications	Details
Blower [Figure 1a]	Three-phase blower propels the carrier by means of vacuum created via centrally controlled air-switch
Receiving baskets [Figure 1b]	Positioned throughout all facilities to receive the carriers smoothly as they reach their destination
PVC tubes [Figure 1c]	Available in 6”(inches) diameter and mounted inside ceilings and mechanical rooms adapted for high-speed travel of carriers
PTS carrier [Figure 1d]	The tube carriers are made up of highly resistant u-polycarbonate material and contain removable foam carrier inserts for added cushioning of blood components and samples. Velcro belts are placed on a carrier and help the carrier to move smoothly and avoid friction during movement
Three-way diverter	These are switching devices allowing diversion of carriers from one zone to another as they travel to their respective destination
Carrier tracking computer station	Central computer is located in pneumatic hub for tracking all carrier traffic. To help manage this traffic, flow tubes are divided into six zones each containing few stations. Diverters help this interzonal diversion of the carriers

PTS: Pneumatic tube system, PVC: Polyvinylchloride

PTS CARRIER WITH RECEIVING BASKET

RESULTS

A total 100 different blood components 50 units PRBCS, 20 units FFP, 25 Platelet concentrate ,5 Cryoprecipitate were consider in this study. No statistically significant differences were found between pre and post transport result of quality parameters. All blood components transported evaluated matched regulatory requirements for quality criteria. The transport time via PTS was shorter as compare to human blood transport which is key factor for urgent need for transfusion.

A total of 50 units of packed red blood cells (PRBC), 25units of fresh frozen plasma, 30 units of platelets, and 5 units of cryoprecipitate are sent through PTS to 59 connected destinations. The mean transport time taken by PTS was 1.740 ± 0.70 (1–2.5 min) and for manual delivery of blood components was 11.6 ± 3.400 (8-15 min). The mean latent time was 4.85 ± 1.15(3-6min).

Conveyance in the PTS did not have any negative impact on the quality of any of the blood component and hence were considered for transfusion. We compared pre and post transportation laboratory values and there was statistically no significant change in these parameters.

Quality parameters of blood components

Component					
FFP (n=25)	Mean	PT	INR	APTT	Fibrinogen
	Pre PTS	14.5±1.58	1.09±0.12	30.53±5.32	374.87±75.44
	Post PTS	13.5±1.01	1.06±0.08	28.10±4.08	354.68±73.79
Cryoprecipitate (n=5)	Mean	PT	APTT	Fibrinogen	
	Pre PTS	13.24±2.76	25.26±3.44	633.54±97.44	
	Post PTS	13.1±1.94	23.02±3.14	604.7±85.20	
Platelet concentrate (n=30)	Mean	MPV	WBC*10^3/bag	RBC/bag (ml)	Yield (*10^{10})/bag
	Pre PTS	9.56±1.68	0.48±0.21	0.44±0.28	5.34±1.04
	Post PTS	9.46±1.36	0.35±0.22	0.37±0.13	5.32±1.03
PRBC (with SAGM) (n=50)	Mean value	Hb conc(g/dl)	K+(mmol/L)	LDH(U/L)	
	Pre PTS	17.87±0.01	24.74±9.25	405±83.44	
	Post PTS	16.12±0.06	26.19±9.15	445±88.05	

DISCUSSION

Time is critical when transporting blood. Blood products must be delivered from refrigeration to the right patient’s vein within minutes. Speed of delivery for patient specimens can be equally as pressing.

There was no significant rise in temperature inside the carrier due to heat of friction or travel in the tube network, thus making it a blood component friendly carrier system.

Apart from its swiftness to carry blood products bedside, we also looked into the capacity of PTS to act as a potential source of any negative impact on the quality of these blood components.

Similar to the findings of Tanley et al., we did not find any difference in the quality parameters of the blood components following PTS transport. In accordance with the study done by Sandgren et al., we also propose that stored platelets can be transported with the PTS and this would go on to increase the efficiency of fulfilling the ever rising demand for them. Another study done by Fernandes et al. (Canada) shows that conveyance in PTS did not cause hemolysis rather it reduced the overall TAT. However Kara et al. have noticed a greater frequency of hemolysis, greater mean serum potassium, median creatinine, aspartate aminotransferase, and lactate dehydrogenase levels among blood samples that were transported through PTS than in samples transported manually. They had measured the above parameters following the transport and not compared it with the pretransport values, which appears to be the limitation of their study.

We have noticed a latent time of 4 min, which was mainly due to the busy schedule of the nursing staff in the wards. However, it was well within the allowable time frame for starting of blood transfusion. Technical errors are imminent part of automation in any field. There were two instances when the delay was around 8 and 10min, respectively, due to mechanical error in the automated PTS. Moreover, once it took 15 min due to the jamming of their carriers which also included one carrier that was carrying PC. However, without any further delay, corrective action was taken and PCs were able to reach beds. Also for prevent such thing in future our biomedical dept has keep blood centre carrier in priority in PTS system so that when there is jam blood centre carrier transport kept in priority and other carrier go on hold. Initially there is issue of leakage but that also corrected by special leak proof carrier with cushion.

CONCLUSION

The use of PTS for the transport of blood components was found to be rapid and reliable in the present study and implementation of this facility will help our centre to reduce the TAT to a greater extent.

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